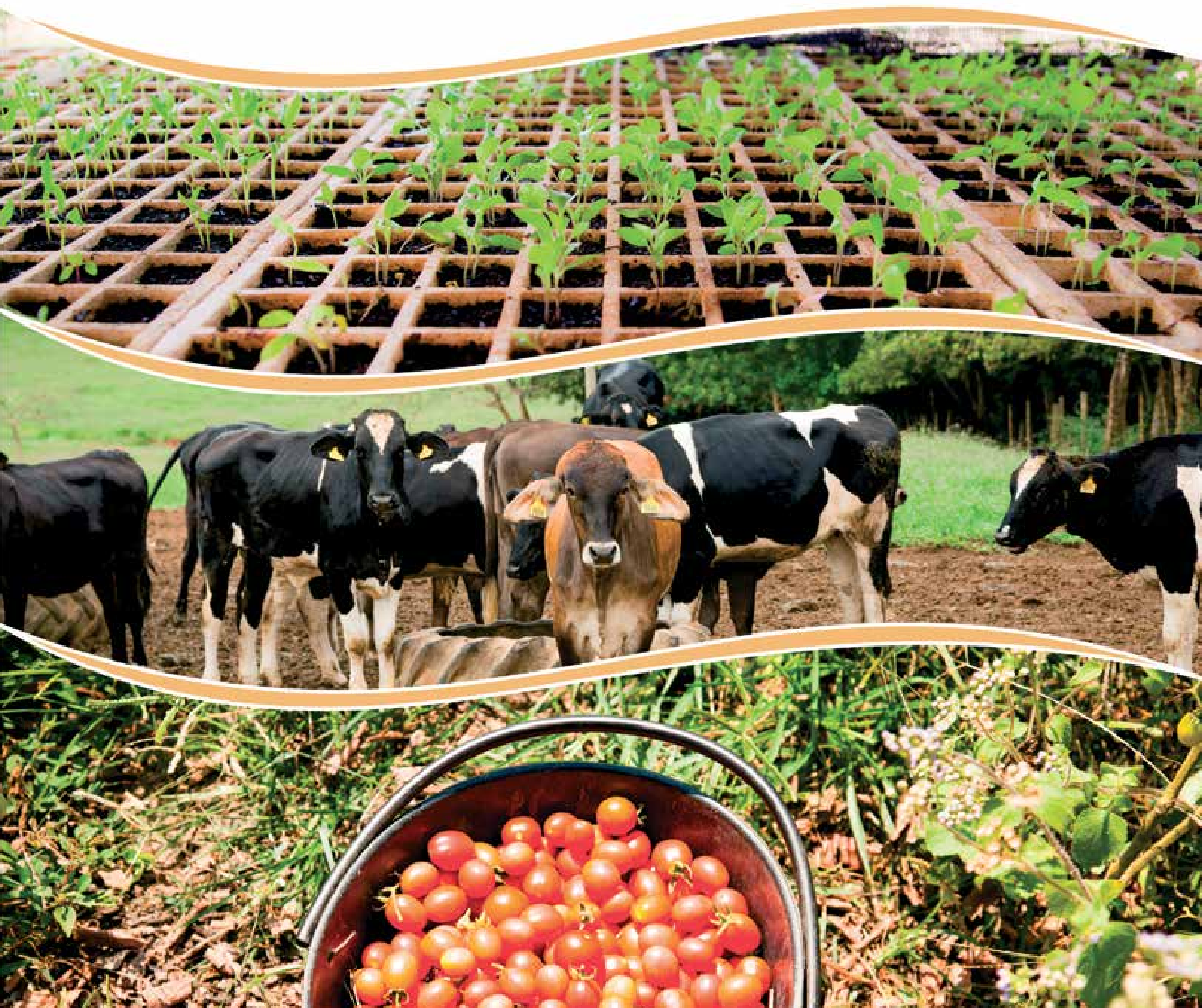
ICAS VI

SIXTH INTERNATIONAL CONFERENCE ON AGRICULTURAL STATISTICS

23-25 October 2013
Rio de Janeiro, Brazil

Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development.
Linking statistics with decision making.

Proceedings



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Foreword

The International Conference on Agricultural Statistics (ICAS) is organized every three years, starting from 1998, under the auspices of the International Statistical Institute (ISI) Committee on Agricultural Statistics. The Conference convenes senior agricultural statisticians from all over the world, mainly representatives from national statistical offices and ministries of agriculture. ICAS Conferences are open to all producers, suppliers, trainers and users of agricultural statistics, such as economists, statisticians, agronomists, researchers, analysts and decision-makers from government entities, the academia, development partners and international organisations. They are as well open to the private sector, including the business community.

Previous ICAS Conferences were the following:

- ICAS-I: USA, 1998 – Agricultural statistics 2000.
- ICAS-II: Italy, 2001 – Agricultural and environmental statistical applications.
- ICAS-III: Mexico, 2004 – Measuring sustainable agriculture indicators.
- ICAS-IV: China, 2007 – Advancing statistical integration and analysis.
- ICAS-V: Uganda, 2010 – Integrating agriculture into the national statistical system.

The VI International Conference on Agriculture Statistics (ICAS-VI) was hosted by the Brazilian Institute for Geography and Statistics (IBGE) from 23 to 25 October 2013, in Rio de Janeiro, Brazil. The Organizing Committee of ICAS-VI was chaired by IBGE, while the Scientific Program Committee was co-chaired by IBGE and the US Department of Agriculture (USDA). Its main theme was "Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development. Linking statistics with decision making ". ICAS-VI took part in the World of Statistics (Statistics2013) campaign.

Before the Conference, the USDA organized and conducted two-day training sessions for 54 young statisticians working in the field of agricultural statistics or statisticians new to the field of agricultural statistics, and FAO organized the event

“Deriving Food Security Indicators from Household Surveys using the ADePT Food Security Module. Country experiences”.

The Conference brought together 247 people from 54 countries around the world. The Conference program was divided into three main themes: Analytical and Policy Needs (APN), Institutional Development and Capacity Building (IDCB) and Statistical Production Process (SPP), each with 7 parallel technical sessions, totalizing 89 papers presented in 21 technical sessions. There were also 13 speakers divided into five plenary sessions. The poster session presented 61 posters from authors from 18 different countries. 7

From the 261 abstracts submitted, 150 papers were selected to be presented either in a technical or in a poster session.

This volume contains the proceedings of the Conference: the papers submitted for the technical sessions, the papers presented in some of the plenary sessions, and the abstracts related to the posters. The presentations as well as the full papers related to the posters can be found at the Conference website: http://eventos.ibge.gov.br/en/icas2013 or www.fao.org/economic/ess/ess-events/ess-icas/icas-vi/en.

The Editors

Opening ceremony at Velasquez Auditorium.

Welcome Remarks

On behalf of the acting director of the United Nations Statistics Division, Mr Stefan Schweinfest, and myself, as chair of the Agricultural Committee of the International Statistics Institute, it is both a privilege and a great pleasure to welcome you all to this sixth International Conference on Agriculture Statistics.

Firstly, I would like to thank the Government of Brazil for hosting the conference. We are very grateful to IBGE and the Department of Agriculture of the US Government, for their remarkable efforts to make this event possible and for taking care of all the organisational and logistic arrangements.

This Conference follows a very successful event in Kampala where the Action Plan to implement the Global Strategy to Improve Agricultural and Rural Statistics was reviewed and endorsed by more than 300 senior experts from around the world. This Plan is now being fully implemented and we will hear the important results achieved so far during the Conference in various dedicated sessions.

It is not the intention of my short intervention to recall all our achievements over the last three years. I would just like to remind everyone that we have come a long way, covered a lot of ground, and are well positioned now to make a difference in advancing rural and agricultural statistics at global level.

This conference and its core theme of "Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development. Linking statistics with decision making" takes this agenda forward, emphasizing that the Global Strategy, this extraordinary effort of capacity development in agricultural statistics, has a strong user perspective. In fact, the final goal of the GS is to substantially increase the capacity of national statistical systems to respond to emerging data requirements and to better inform decision-making processes and policies in the critical areas of food security, sustainable agriculture, and rural development.

This conference could not come at a more opportune moment. Nor could we have chosen a more appropriate venue. It was, after all, here in Rio that the global community came together – twice – to formulate its joint vision and commitment for sustainable development in the future. The outcome document of the Rio+20 Conference reconfirmed that integrated social, economic, and environmental data are crucial to decision-making processes. Therefore, statistics will have to play a central

role, and the United Nations are now working towards the formulation of a concrete post-2015 sustainable development agenda, enshrined in a framework of sustainable development goals and targets. Only with the help of sound and comprehensive 'sustainable statistics', will we be able to monitor the progress towards our future Sustainable Development Goals.

This Conference also joins the celebrations around the globe of the International Year of Statistics in recognition of the important achievements of official statistics and the core values of Service, Professionalism and Integrity.

We are all aware that agricultural statistics do not exist in a vacuum. At this moment there are other statistical domains being developed further and other global initiatives, such as the integration of geospatial and statistical information, the implementation of the 2008 System of Environmental Economic Accounting (SEEA) and the Global Gender Statistics Programme, to name just a few. I hope this conference will also provide yet another opportunity to reflect upon the important challenge of how we can establish the necessary synergies between all these programmes.

Partnership is an essential element of all these initiatives and it as at the core of the Global Strategy, which is a broad multi-stakeholder programme implemented in collaboration with many international and regional organizations. The objective of the Global Strategy — to build solid national statistical information systems in support of policy decision making — is comprehensive and ambitious; but I am confident that it is possible to realize this vision, especially with a strong partnership with international and regional stakeholders and the essential contribution of countries.

This conference is an important platform to forge this kind of partnership. I commend the Organizing Committee for bringing together such a diverse audience, consisting of experts from national statistical offices and ministries of agriculture, analysts and decision-makers from government entities, the academia, resource and development partners, the private sector and international organisations.

We, at the UN Statistics Division and FAO, are working to support your efforts in all these areas, and I would like to reiterate our commitment to continued close cooperation with all stakeholders, at the national and international level.

I would like to conclude now by wishing you all a successful and enjoyable conference.

Mr. Pietro Gennari
Chief Statistician, FAO

Institutional Development and Capacity Building (IDCB)

Plenary Sessions

Plenary Session 1

Progress in Implementing the Global Strategy

Organizer: Christophe Duhamel, FAO

Chair: Arturo Blancas Espejo, INEGI, Mexico

The Global Strategy to Improve Agricultural and Rural Statistics, developed by FAO and the World Bank in intensive consultation with all stakeholders all over the world, is a groundbreaking effort to improve agricultural statistics. Endorsed by UNSC at its 41st session in February 2010, the Global Strategy was followed by an Action Plan to implement it. The Acton Plan was developed by FAO and the World Bank following the same intensive consultation process. The implementation of the Action Plan has already started.

This Session will discuss the progress in implementation of the Global Strategy as of the time of the conference, good practices and lessons learnt at both global and regional levels. The focus of the session will be on general organizational and implementation issues. Technical issues will be covered by several other sessions of ICAS VI. The papers will be dedicated to the progress, best practices and experiences at the global level as well as in selected regions.

Possible topics for both global and regional level papers:

- Lessons learnt from the process of developing of Action Plans
- Progress in implementation of Action Plans
- Experiences of implementation of individual components (technical assistance, training, research) of Action Plans
- Experiences of functioning of governance mechanisms

Speakers:

- Christophe Duhamel (FAO), "Overview of the Implementation of the Global Strategy"
- Oliver Chinganya (AfDB), Joseph Ilboudo (UNECA), "Implementation of the African Action Plan"
- Mukesh Srivastava (FAO), "Implementation of the Asia-Pacific Plan"

Technical Sessions

IDCB 1

Indicators on Country Capacity to Produce Agriculture Statistics

Organizers: Mukesh Srivastava, FAO and Mark R Miller, USDA/NASS

Chair: Mukesh Srivastava, FAO

It is recognized that the capacity to produce agriculture statistics has declined over a period of time in many developing countries, while the demand of reliable statistics in increasing both at national and international level. Realizing the need for a global effort to build the national capacity, the Global Strategy to Improve Agriculture and Rural Statistics has been launched. The very first step of the Strategy is get a panoramic view of existing country capacity to produce agricultural statistics to serve as benchmark for monitoring the progress.

The capacity is intrinsic to a system and does not lend itself to direct measurement. Efforts have been made in recent past to measure capacity indirectly through the performance of the statistical system, often ignoring the quality of the results or their long-term impacts on capacity building. Nonetheless, it is well understood that an expression of capacity needs an enabling environment, and that capacity building should address not only individuals but also the organizations in the system and the environment in which they operate.

FAO and its partner institutions have developed a framework and a standard tool which has a sound conceptual basis and can be applied uniformly across all countries, of course, with some regional adaptations. The tool comprises collection of data on a standard self-reporting questionnaire and calculation of indicators based on the data. The indicators on different dimensions and elements present a profile of country capacity to produce agriculture statistics. Under the Action Plan of the Global Strategy this exercise is referred as Initial Country Assessment. The session will focus on conceptual basis of the proposed Country Assessment framework and the experience of its application in different regions.

Papers:

- Mukesh K. Srivastava (FAO), Michael Trant (Canada), "A Framework for Assessing Country Capacity to Produce Agricultural and Rural Statistics"
- Oliver Chinganya, Vincent Ngendakumana, Ben Kiregyera (Tunisia), "Assessing the Capacity and Needs of Countries to Produce Agricultural Data – the African Experience"
- Jairo Castaño (FAO), "Assessing Country Capacity for the Production of Agricultural Statistics in Asia and the Pacific"
- Veronica Boero (FAO), "Countries Capacity to Produce Agricultural and Rural Statistics in Latin America and the Caribbean"
- Irina Goryacheva (CISSTAT), Giorgi Kvinikadze (FAO), "Experiences of Initial Country Assessment in the CIS (Commonwealth of Independent States)"

A Framework for Assessing Country Capacity to Produce Agricultural and Rural Statistics

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Abstract

This paper presents the results of global effort made during the last two years to establish a standard framework for assessing country capacity to produce agricultural and rural statistics. The country assessments are the first step in implementing the *Global Strategy to Improve Agricultural and Rural Statistics*. The *Global Strategy Action Plan* envisages the collection of baseline information on an identified set of objectively verifiable indicators to measure the impact, outcome, and output of the *Action Plan(s)* at global and regional level. The initial indicators, based on the data from a self-administered standard questionnaire (SQ) for country assessment, are to be the basis for monitoring improvements in statistical capacity over time in the countries.

The standard questionnaire (SQ) serves as the key source of information on a country's agricultural and rural statistics capacity and more specifically its legislative and institutional infrastructure, available human and financial resources, statistical methods and practices, and the availability of core data.

The initial assessments based on responses to the questionnaire and the resulting indicators of capacity, will allow the regional and global coordinators to orient consultants working on in-depth assessments to probe deeper on particularly weak areas, and to serve as the basis for the development of country-based strategic plans to strengthen statistical capacity through technical assistance and training. Second-stage in-depth assessments by external experts will provide additional information for assessment of the human and financial resources a country needs to seek in order to build a sustainable statistical system, besides methodological improvements ongoing activities.

Keywords: statistical capacity; objectively verifiable indicators; capacity assessment framework.

1. Introduction

This paper presents an introduction to the *Framework for Assessing Country Capacity to Produce Agricultural and Rural Statistics*, a forthcoming two-volume FAO publication. The publication outlines a standard methodology for carrying out the first-stage assessments of a country's capacity to produce agricultural and rural statistics, a key component of the *Action Plan of the Global Strategy to Improve Agricultural and Rural Statistics* (FAO, 2012). The framework provides the necessary structure to record, document and assess the statistical capacity of national agricultural and rural statistics systems and establish objectively verifiable indicators, with respect to their prevailing legislative and institutional pre-requisites, inputs, throughputs, and outputs.

Agricultural development is vital to achieving the Millennium Development Goals (MDGs) related to poverty, food security, and the environment because three out of four poor people in developing countries live in rural areas and depend on agriculture for their livelihood. Commitment to these goals has taken on growing urgency in the global context of the rising food prices and falling food reserves caused by droughts, higher oil prices and the use of food products to produce biofuels. Meanwhile, the quantity and quality of agricultural statistics to monitor progress in achievement of these goals has witnessed a decline (FAO, 2006).

A number of recent studies and evaluations have noted that many of the countries in the developing world lack the basic capacity to produce and report even the minimum set of agricultural data necessary to monitor national trends (FAO, 2008). Furthermore, "the quantity and quality of data coming from national official sources has been on a steady decline since the early 1980s, particularly in Africa, and the quality and availability of official statistics from countries in Africa are at their lowest level since before 1961,

with only one in four African countries reporting basic crop production data." (FAO, 2008).

The main criticism of past statistics assistance programs relates to the unsustainability of gains of many of the interventions. Development initiatives have too often been directed to address urgent short-term data needs. Statistics programs that were supported were often those that were established to monitor and evaluate large donor-supported agriculture development programs, but did little to develop a sustainable national statistical system or build the intrinsic capacity of the aid recipient to produce reliable and timely agricultural statistics needed for management of the sector. Sometimes assistance even diverted critical and scarce country resources, weakening the country capacity to meet its core data requirements and the needs of government policy-makers.

Historically, there has also been a lack of coordination and prioritization of technical assistance among development partners. In many instances, technical assistance did not develop skills, know-how, technical expertise and statistical capacity among the national staff in the counterpart countries. The assistance projects also seldom addressed the importance of enhancing the effective demand for data at political levels in order to enlist sustainable funding and other expressions of commitment from national governments and avoid chronic under-resourcing for statistical operations (FAO, 2012).

In comparison, the work done under the umbrella of the Partnership in Statistics for Development in the 21st Century (PARIS21) during the last decade for development and monitoring of the National Strategies for Development of Statistics (NSDS) has met with considerable success, providing a sense of direction to the process of development of official statistics in general.

The Action Plan of the Global Strategy for Agricultural and Rural Statistics, endorsed by the United Nations Statistical Commission (UNSC), February 2010, establishes a comprehensive technical assistance and training program for the target countries, and also a well-targeted research agenda to resolve methodological issues faced by the agricultural statistical systems. The Action Plan follows a new approach for statistical capacity development for agriculture and rural data, and is grounded in the five principles of the "Paris Declaration on Aid Effectiveness" (OECD, 2005) and in the "Accra Agenda for Action" (OECD, 2008).

The country assessments are the starting point for the implementation of the Global Strategy and are to be carried out in two stages. The first stage establishes the baseline information on a countries' statistical capacity, using a self-administered standard questionnaire. The questionnaire, used in the first stage, collects information from the national statistics offices and statistical offices in the ministries of agriculture and other institutions with statistical responsibilities in the agriculture sector.

The foundations of the Statistical Capacity Assessment Framework originate in the Data Quality Assessment Framework (DQAF)[1] developed by the International Monetary Fund (IMF), and the assessment framework proposed in 2002 by the Task Team set up by Partnership in Statistics for Development in the 21st Century (Paris21)[2] on *statistical capacity building* as well as the periodic reviews of statistical systems carried out by FAO statutory bodies on agriculture statistics in Asia and Africa[3].

The country assessments are the means to monitor the growth in country capacities as result of implementation of the Global Strategy and are proposed as the main data source for building objectively verifiable indicators identified in the *Global Strategy's Results-Based Logical Framework*. The country assessments are carried out to gather country level information on the legal and institutional infrastructure, statistical activities, statistical methods and practices, resource deployment, and data availability using a standard questionnaire. The questionnaire based assessments will be used to build a suite of indicators that will reflect countries capacity with regard to agricultural and rural statistics. This information will also provide objective baseline data against which the performance of projects, programs and other statistical capacity-building initiatives could be evaluated. These indicators will also serve the stakeholders in the statistics system in grouping countries according to their statistical capacity, prioritizing interventions, and for supporting efficient investment decisions for building statistical capacity.

2. Statistical Capacity Assessment Framework

Historically, the effectiveness of statistical programs was largely evaluated based on: 1) the statistical inputs, evidence being the use of sound statistical

methods and practices, and 2) the statistical outputs, based on an assessment of the regularity in production and dissemination of data. These were not really evaluations of statistical capacity, though they provided a reasonable basis for making comparisons among countries and documented the ups and downs of statistics programs over time.

The PARIS21 Task Team initiative was the first systematic attempt at the international level to develop indicators of statistical capacity building that would be applicable across countries. The Task Team project on statistical capacity building indicators was prompted by the pressing demand over the last 10 to 15 years to assess statistical capacity building and development. Among the trends that converged to creation of demand for a better assessment method to assess the capacity to produce reliable statistics, was the greater emphasis put on statistics by the new evidence-based approach to implementing the internationally agreed MDG development goals to reduce poverty.

The Task Team indicators are structured according to six criteria or *"dimensions"*:

1) Institutional Prerequisites
2) Integrity
3) Methodological Soundness
4) Accuracy and Reliability
5) Serviceability
6) Accessibility

The investigations into statistical capacity and capacity building, for developing better strategies to improve statistics, also prompted a realization that much more needs to be known about statistical capacity, related constraints, and the needs of the government offices with responsibility for statistics. This is especially so for technical assistance that needs to be accountable for:

1) Resource capacity: human, financial, and physical infrastructure (offices, information technology, communications, equipment, and transport)
2) Information on the measurable improvements wanted by,
    - Development partners, and
    - Developing country governments that want to know whether the benefits from improvements in data quality and timeliness warrant sustained investments from their own limited resources.

The proposed capacity assessment framework places the focus the on results chain of *INPUT - THROUGHPUT- OUTPUT*, and it recognizes that realization of capacity into performance also needs an enabling environment, which is captured by the *"PREQUISITES"*, mostly characterized by the prevailing institutional infrastructure. The framework thus defines statistical capacity as having four dimensions:

1) Institutional infrastructure Dimension (Prerequisites),
2) Resources Dimension (Input),
3) Statistical Methods and Practices Dimension (Throughput), and
4) Availability of Statistical Information Dimension (Output).

Each of these four dimensions represents a set of characteristic elements of capacity, which within a particular country may be quite independent of each other and may be at different levels of development. For example, a country may have a legal framework that is adequate for the collection of statistics and may be maintaining a user interface that is adequate for the production of relevant statistics, but it may lack the strategic vision for integrating its agricultural statistics survey program with the national survey program or even building an integrated database covering social, economic and environmental dimensions of human activities in the agriculture sector.

This framework can be used for establishing a profile of the country capacity at a point time or for building a single index representing the country capacity. Repeated assessment over a period of time will provide inputs for monitoring the impact of program and projects, which may target building capacity on one or more dimensions or focus on any one element of element of the capacity. Aggregation of the indicator values at the element level will provide indicators on the four dimensions, which can then be aggregated to get overall capacity indicator.

Table 2 in Section 3 presents the structure of the proposed capacity framework. Table 1 below shows how the *Dimensions* and *Elements* of the proposed country capacity assessment framework relate to the *"pillars"* of the *Global Strategy*.

Table 1: Pillars of the Global Strategy and the Capacity Assessment Framework.

Pillar I Establishing a Minimum Set of Core Data	Pillar II Integrating Agriculture into the National Statistical System	Pillar III Fostering Sustainability of the Statistical System through Governance and Statistical Capacity Building
IV. Availability of Statistical Information	I. Institutional infrastructure	I. Institutional infrastructure
4.1 Core Data Availability 4.2 Timeliness 4.3 Usability of data 4.4 Data Accessibility	1.2 Coordination in the Agricultural Statistical System 1.3 Strategic Vision and Planning for Agricultural Statistics 1.4 Integration of Agriculture in the National Statistics System	1.1 Legal Framework 1.5 Relevance of data (user interface)
	III. Statistical Methods and Practices	II. Resources
	3.1 Statistical Software Capability 3.2 Data Collection Technology 3.3 IT infrastructure 3.4 General Statistical Infrastructure 3.5 Adoption of International Standards 3.6 General Statistical Activities 3.7 Agricultural Market and Price Information 3.8 Agricultural Surveys 3.9 Analysis and Use of Data 3.10 Quality of survey	2.1 Financial Resources 2.2 Human Resources: Staffing 2.3 Human Resources: Training 2.4 Physical Infrastructure

3. Indicators for assessing Statistical Capacity

The new assessment method based on *Standard Questionnaire (SQ)* and Country Capacity Indicators replaces the earlier system of reporting progress in the biennial meetings of the regional statutory bodies of FAO such as, the Asia and the Pacific Commission on Agricultural Statistics (APCAS) and the African Commission on Agricultural Statistics (AFCAS) and preparation of country assessments based on these. *The Action Plan for the Global Strategy* proposes that summaries of the responses to the SQ received from countries be made available to the relevant regional commission or similar international bodies on agricultural statistics.

The scope of the new SQ is also broader than those previously used in Africa and Asia. The *Global Strategy* uses a broader concept of *agricultural statistics*, which covers statistics not only on the crop and livestock sub-sectors, but also the sub-sector of fishery, forestry, and water resources as also other rural income earning activities. Responding to the questionnaire will almost require a collaborative effort of various ministries and agencies of government at the country level, with statistical responsibilities for crop, livestock, fishery, forestry, water resources or rural statistics. However, it is expected that the Ministry of Agriculture and/or the National Statistics Office will play a significant and co-ordinating role in providing consolidated responses.

Country Capacity Indicators are built on a common understanding of the concept of capacity; follow an internationally agreed framework for its assessment; and ensure a meaningful comparison of capacities of countries to produce agricultural and

rural statistics, both cross-sectionally and over time. Generally, the proposed indicators are objectively verifiable. However, as some of the elements of the capacity are qualitative, the indicators on these are not as precise as physical measurements, but are at least *sensitive* enough to capture differences across countries and are *valid* in sense that they measure what they are purported to measure, and not something else. *Consistency and reliability* of the indicators relate to how well they reflect changes in reality over time. *Prima facie* the proposed indicators have this quality, but limitations observed in implementation over time can be addresses in future versions of this tool.

An indicator is proposed for each *element* of statistical capacity. The indicators have the same name as the element of the capacity they represent. Table 2 presents the key issues that have been considered in building of capacity indicators. Simple questions, which could be answered in a self-reporting questionnaire, have been prepared around each of these key issues. The responses to the questions on key issues are synthesized according to well-defined scoring criteria. The synthesized score is the value of the indicator for that country obtained on the basis of responses to the relevant self-reporting questions.

The indicators are presented on a scale of zero to one hundred, though a few indicators can take only three or four possible values on this scale. This limitation on sensitivity arises due to the nature of phenomenon being assessed and the number of questions available in the standard questionnaire to build the indicator. Nonetheless, based on experiences on testing the questionnaire in Asia and Africa, the indicators appear sensitive enough to distinguish between various levels of development.

The scoring criteria generally assign equal weight to all questions in the indicator. However, depending upon the number of questions on specific domain used to support a specific indicator, there may exist some implicit weighting. For a few indicators some weighting has been deliberately introduced to get a balanced picture or to transform the responses from various types of questions into a single indicator.

Twenty-eight capacity indicators can be created using the data in the standard questionnaire. Of these, twenty-three indicators, one for each of the elements of statistical capacity, are built on the basis of responses in the standard questionnaire. These element-level indicators can then be aggregated using simple averaging to build indicators on each of the four dimensions. The four dimension-level indicators can be combined for an overall capacity indicator. It is also possible to construct a variety of composite indicators using element-level indicators by assigning user defined weights to the various element-level indicators, depending upon the purpose for which they are compiled.

4. Using and interpreting Country Capacity Indicators

One of the expectations from the statistical capacity assessments is that these should allow country groupings that reflect the various levels of statistical development. That is a key part of the effort to identify countries that have limited statistical capacity and likely to be a major beneficiary from a capacity building initiative. The challenge is to obtain agreement on the most useful methodology for classifying and grouping countries.

The Action Plan for Global Strategy proposes a five-group system for classifying and grouping countries according to the extent of their statistical capacity, as measured by the degree to which their agricultural and rural statistics comply with the three pillars of the Global Strategy (1) establish a minimum set of core data, (2) Integrate agriculture into the national statistics system using sound statistical methods and procedures, and (3) establish the foundation for a sustainable agricultural statistics system by means of governance and the necessary resources.

The following five groupings based on the proposals in the Global Strategy could be useful for monitoring the progress of agricultural statistics systems (FAO, 2012).

Like any other indicator, the *country capacity indicators* too have limitations. While there are some strong, proven and robust indicators in the suite, it also has some indicators that are new and untested. Coordination of the country's response often appears to be a challenge when two or more ministries take responsibility to answer part of the same question(s) but provide different information. This is particularly true for information on financial resources and budgets for agricultural statistics, which is distributed across line ministries and departments within a country. Experiences with early versions of the questionnaire in Africa and Asia have indicated difficulties in coming up with consistent and reliable indicators for this dimension.

Table 2: Capacity Dimensions, Elements and Underlying Issues.

Capacity indicators (dimensions)	Capacity sub-indicators (elements)	Key issues underlying the indicators
Capacity Indicator I Institutional Infrastructure (PREREQUISITES)	1.1 Legal framework	Existence, operation and adequacy of a legal framework
	1.2 Coordination in the Agricultural Statistical System	Existence of an active coordinating body Span of coordination
	1.3 Strategic Vision and Planning for Agricultural Statistics	Existence of a strategy and/or a plan for agricultural statistics
	1.4 Integration of Agriculture in the National Statistics System	Existence of strategy and plan for agricultural statistics and its integration in the NSDS Span of coverage of sub-sectors of agriculture by the strategy Use of population census for collecting agricultural information and common cartography for agricultural and population censuses Coverage of sub-sectors in agricultural census
	1.5 Relevance of data	Existence and extent of data user interface in agricultural statistics, and channels for receiving user feedback Span of representation in the data user bodies Functioning of data user bodies
Capacity Indicator II Resources (INPUT DIMENSION)	2.1 Financial resources	Existence of separate budget lines for agricultural statistics Percentage of agricultural statistics activities funded by government budget General perception of resource constraint
	2.2 Human resources: Staffing	Occupancy rate of statistical posts Perception about frequent staff turnover of staff as a constraint
	2.3 Human resources: Training	Policies and facilities for training of statistical staff Proportion of staff trained in-country and abroad
	2.4 Physical Infrastructure	Availability of office space, office equipment and transport for statistical activities
Capacity Indicator III Statistical Methods and Practices (THROUGHPUT DIMENSION)	3.1 Statistical Software Capability	Types of software used for data processing, data analysis and databases
	3.2 Data Collection Technology	Use of digital technologies and equipments for the field data collection and transmission
	3.3 IT infrastructure	Extent of availability of computers to staff Installation of computer servers for data storage and communication
	3.4 General Statistical Infrastructure	Existence and availability of digital cartographic material to enumerators Availability of up-to-date lists, registers and frames for sample surveys
	3.5 Adoption of International Standards	Version and extent of adoption of international classifications
	3.6 General Statistical Activities	Extent of undertaking of key statistical activities like population census, national accounts, price indices etc. and availability of data from these.
	3.7 Agricultural Market and Price Information	Existence of systems for collecting agricultural prices Extent of representation of agriculture in market price information systems
	3.8 Agricultural Surveys	Number of agricultural surveys covering the crop, livestock, fishery, aquaculture, forestry sub-sectors.
	3.9 Analysis and Use of Data	Compilation of economic accounts for agriculture, food balance sheet, agri-environmental indicators, and terms of trade indices for agriculture
	3.10 Quality of Surveys	Use of good practices in designing, conducting, disseminating and archiving agricultural surveys
Capacity Indicator IV Availability of Statistical Information (OUTPUT DIMENSION)	4.1 Core Data Availability	Extent of availability of relevant minimum core set of data
	4.2 Timeliness	Time lag in available data
	4.3 Usability of available data	Overall assessment on quality, reliability and consistency of available data
	4.4 Data Accessibility	Existence of websites and databases for agricultural statistics

Table 3: Proposed Global Strategy Country Groupings.

Level 5: ADVANCED COUNTRIES
The country ● is supplying more than 80 percent of the minimum set of core data on a regular basis, ● has conducted an agricultural census or population census with questions on agriculture during the last ten years, ● has an existing NSDS (or similar strategic document or plan) with an agriculture component, ● has a functioning system for coordination of agricultural statistics in place, and ● has elements of a master sampling frame from the completion of an agricultural census or use of area frames.
Level 4: PROGRESSIVE COUNTRIES
The country ● produces 70–80 percent of the core data items, and ● has at least three of the other four elements noted for Level 5 in place.
Level 3: DEVELOPING COUNTRIES
The country ● produces 50-70 percent of the core data items, and ● has at least two of the other four elements noted for Level 5.
Level 2: LESS DEVELOPED COUNTRIES.
The country ● produces less than 50 percent of the core data items, and ● has maximum of two of the other four elements noted for Level 5.
Level 1: LEAST DEVELOPED, FRAGILE AND POST-CONFLICT COUNTRIES
The country does not fall in any of the above four categories. Few, if any, core data items are available, and little or no statistical infrastructure is in place. Resources are very limited or non-existent.

More objective and reliable assessments of the resource dimension should, however, be available from the proposed in-depth assessments, and in the subsequent rounds with additions of more questions in the revised versions of the standard questionnaire. For example, the proposed indicator for financial resource deployment, in the current questionnaire, relies on the responses to a set of proxy questions, which were not part of the pilot testing. It is also expected that more information on budgets and financial resources will be obtained through the in-depth assessments to enhance the reliability and validity of this indicator.

The element level-indicator on the *"usability of available data"*, based on overall quality perception, is also far from being perfect as it entails an element of reporting bias, depending upon the level of knowledge and objectivity of the respondents. Furthermore, the perceptions of *data users community* may be substantially different from those of the *data producer community* that are currently foreseen as responsible people for providing the questionnaire responses.

5. Conclusions and way forward

Assessing country capacity to produce agricultural and rural statistics is a critical component of the *Global Strategy Action Plan* for improving agricultural and rural data. The country assessments provide the benchmark data for monitoring change over time with objectively verifiable indicators, and for evaluating the impact of interventions to improve statistical capacity.

Strengthening statistical capacity in developing countries is a long-term initiative, with its implementation proceeding in stages that depend on each country's initial statistical capacity. The statistical capacity of countries will range from those already providing the set of core data from an integrated statistical system to those that essentially have no system in place. In between are the countries that are at various stages of development and whose requirements for technical assistance will range over a wide continuum.

The Global Strategy Action Plan is a long run effort to develop sustainable agricultural statistical systems in developing countries, and it is recognized that significant external support and funding will initially be required to begin the process. It should also be noted that the *Global Action Plan* focuses on capacity development and not on funding actual data collection activities such as censuses and surveys. Therefore, statistical development will continue

to be heavily dependent on continued support from developing countries and their development partners.

Although a comprehensive effort has been made through a global consultative process and pilot testing to come up with standard framework and questionnaire for country assessment, at this stage it is expected that there will be future versions of the standard questionnaire which will improve upon experience gathered in implementing the tools developed in this round.

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Endnotes

1 The generic DQAF of IMF of July 2003 serves as an umbrella for seven dataset-specific frameworks. The DQAF, July 2003 was introduced at the Fifth Review of the Fund's Data Standards Initiatives. The DQAF is at the centre of the IMF Data Quality Program (DQP). The DQP, comprising applications of the DQAF, is a set of well-integrated initiatives and projects to support and promote good statistical practices identified in the DQAF, and the maintenance and development of dataset-specific DQAF's.

2 The Paris21 Consortium is a partnership of national, regional, and international statisticians, policymakers, development professionals, and other users of statistics. This Consortium was launched in 1999 and its purpose is to promote, influence, and facilitate capacity-building activities and the better use of statistics. Its founding organizers are the UN, OECD, World Bank, IMF, and EC.

3 The two Statutory Bodies of the FAO in Asia and Africa are known as Asia and Pacific Commission on Agricultural Statistics (APCAS) and African Commission on Agricultural Statistics (AFCAS). The FAO member nations from respective regions can seek membership of these Commissions as well. These regional commissions meet every two years and their proceedings provide guidance to the statistical development activities of FAO.

Assessing the Capacity and Needs of Countries to Produce Agricultural Data – the African Experience

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Abstract

Africa has designed an Action Plan (2011-2015) titled – *Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development* – to guide the implementation of the Global Strategy for Improving Agricultural and Rural Statistics. One of the constraints faced in formulating the African Action Plan was a lack of comprehensive and up-to-date information of requisite quality on countries' statistical capacity and needs. This information is required in order to establish: (i) baselines for target-setting and performance measurement, (ii) country statistical profiles, which would allow the grouping and ranking of countries by their level of capacity/development of their agricultural statistics systems, (iii) a technical assistance program for Africa as a whole, as well as for each country, and (iv) a monitoring and evaluation (M&E) system to track progress and guide the implementation of the plan. Accordingly, the need to undertake country capacity and needs assessments was identified as the first critical activity needed for implementation of the Action Plan.

The information from the Country Assessments (CAs) will feed into the design of appropriate technical assistance, training and research interventions, which comprise the technical components of the Action Plan.

This paper underscores the importance of the Country Assessment approach. It also presents the preparatory activities undertaken for the CAs, including: (a) forging agreeing on the approach to be used; (b) designing tools for use in the assessment, including questionnaires and a web-based application tool for data transmission; (c) organizing regional training workshops for personnel from National Statistical Offices and Ministries of Agriculture; and (d) disseminating experience gained and lessons learnt from the CA process for future similar exercises. Finally, the paper uses Uganda case to show (through charts) some selected key preliminary results from the assessment: (i) profile of agricultural statistics capacity and (ii) ranking the country's Capacity Indicators vis-à- vis other reporting countries.

Keywords: agricultural statistics; capacity building; Country Assessment; Agriculture Statistics Capacity Indicators (ASCIs).

1. Preparatory work of the Country Assessment process and instruments

Africa was the first region to develop its Action Plan (2011-2015) titled – *Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development.* The Africa Action Plan forms part of the wider *Global Strategy to Improve Agricultural and Rural Statistics*, endorsed in 2010 by the international community.[1] The Action Plan for Africa has contributed significantly to the design and elaboration of the Country Assessment (CA) process and standard instruments for use in the process. These instruments have been adapted to African needs and specificities and have been field-tested. It should be borne in mind that at the time of developing the African Action Plan, updated and comprehensive baseline information as well as tools for the measurement of performance and target indicators were lacking. In other words, the approach to be used for establishing the current state of the agricultural and rural statistics system in Africa had not at that point been defined. Such information though was essential to measure progress over time. It therefore became clear that, as an initial step, a comprehensive assessment of the statistical needs and capabilities of African countries was required, to examine the status of the data they currently produce and disseminate, the methodology they use, and their readiness to begin implementing activities of the Action Plan. This assessment process therefore needed to be undertaken prior to the implementation of the technical components of the Global Strategy.[2]

Before undertaking full CAs, similar initiatives undertaken in the past and other existing data sources were checked to see if they could be used in

lieu of conducting a comprehensive and systematic CA across all African countries. It was hoped that this might significantly reduce administrative costs and speed up the process.

1.1 Review of previous CA initiatives

In Africa, national assessments of statistical development have been undertaken in the past by various institutions, often with slightly different statistical perspectives. The main initiatives comprise the following:

- The African Development Bank's (AfDB) Country Assessments in the context of the 2005 International Comparison Program for Africa (ICP-Africa) covered 48 countries over the period 2002-2003. The objective of the ICP country assessments were to produce an inventory of strengths, weaknesses, problems and challenges in each country, and identify solutions that could be put in place through the ICP.
- Assessments have been undertaken by countries themselves in the context of formulating National Strategies for the Development of Statistics (NSDSs). These examined the current state of the National Statistical Systems (NSSs) in terms of legal and institutional frameworks, linkages and coordination arrangements, current and future user needs, existing capacity to meet these needs and fill existing data gaps, statistical methods and procedures in use, adherence to international standards, constraints and problems, as well as the processing, analysis and archiving of data, etc.
- FAO biennial country assessments in Africa have been carried out within the framework of the African Commission on Agricultural Statistics (AFCAS), looking at the current state of agricultural statistical systems in member countries. The most comprehensive CA was undertaken in 2007, covering 49 countries.
- Since the early 1990s, the FAO Statistics Division has been developing data quality frameworks and concepts relating to agricultural statistics. Data quality is assessed according to the quality of official data versus semi-official and FAO estimates, as contained in FAOSTAT. More recently, the FAO Statistics Division has begun using data quality dimensions very similar to those of Eurostat (2000) and has consolidated a statistical metadata component within the Agricultural Bulletin Board on Data Collection, Dissemination and Quality of Statistics project.
- The World Bank assesses statistical capacity in countries and publishes the results on its Bulletin Board on Statistical Capacity. The objective is to improve the measurement and monitoring of statistical capacity of IDA countries, in close collaboration with countries and users.
- The IMF Data Quality Assessment Framework (DQAF), updated in 2003 from the original version of 2001, identifies quality-related features of statistical systems governance, statistical processes, and statistical products. The DQAF's coverage is organized around a set of prerequisites (legal and institutional environment, relevance, resources and quality management) and five dimensions of data quality—assurances of integrity, methodological soundness, accuracy and reliability, serviceability, and accessibility. For each dimension, the DQAF identifies 3-5 elements of good practice, and for each element, several relevant indicators.
- Eurostat's Data Quality Assessment Methods and Tools were proposed in the early 2000s.
- The scope is limited to the statistical products and certain aspects of the processes leading to their production, as well as the user perception of statistical products.
- The OECD quality framework has benefited from the work carried out in recent years by the IMF, Eurostat, Statistics Canada, and other national statistical offices (NSOs). It has avoided reinventing the wheel by adapting existing definitions and approaches to the OECD context. It views data quality in terms of seven dimensions: relevance, accuracy, credibility, timeliness, accessibility, interpretability, and coherence.

The literature review of previous similar CAs was based on the following main information sources: the report produced for AFCAS 2007 and 2009, (ii) FAOSTAT data, (iii) PARIS21 (for data on the existence of NSDS), and (iv) the WB Bulletin Board on Statistical Capacity. Indicators that are available for all countries and for the same year (2007) have been filtered to inform Input and Output elements of country statistical capacity. An Agricultural Statistics Development Composite Indicator (ASDCI) was thereafter generated from this source.

1.2 Agreement on the approach to be used (Concept Note and Framework)

From the above summary of past and recent similar CA initiatives, it appears that significant progress has been made by different institutions in assessing national statistical capacities. However, in many cases, the work has been limited to the strict analysis of the data quality (in particular the Eurostat and OECD frameworks). In the case of the IMF, the – Prerequisites[3] do not cover the agricultural statistics system as a whole. The bulk of all background documents is developed around the description/analysis of the data quality. Another important question that the earlier models of data quality assessment fail to address is how they can be used for grouping and/or ranking countries in terms of their developmental level of agricultural statistics systems in general. Another issue that tended to be overlooked how the models could be used for monitoring the trend of data quality.

Furthermore, the required dimensions and elements to comprehensively inform the needs and capacities of national agricultural statistical systems have been insufficiently reported. Indeed, important data on the financial and, human resources and equipment allocated to agricultural statistics activities, country commitment and political will, etc. were not available for all countries and for same reference period.

It became evident that a comprehensive Country Assessment model was needed to go beyond the simple data quality assessment framework and cover the entire agricultural statistics systems. This would then allow the calculation of a composite indicator (similar to the World Bank's Capacity Building indicator), as well as the establishment of a M&E system over time.

1.3 Design, process and instruments[4] of the First Stage of the CA[5]

For the Africa Action Plan, accumulated experience and lessons learned from previous regional initiatives were capitalized upon to inform the standard Country Assessment questionnaire being sent out to countries. In this way, the questionnaire was adapted to the needs and specificities of the African context, while also complying with the objectives and framework of the Global Strategy. Data to be gathered from National Bureaux of Statistics and statistical agencies in agricultural sub- sectors will be compiled through three different modules, to avoid the omission and/or duplication of required information. The modules are: (i) *Module I* on the Overview of the National Statistical System, (ii) *Module II* on Ongoing Statistical Activities and Constraints, and (iii) *Module III* on information on Agricultural Sub-sectors (to be duplicated/repeated for each subsector of a given country). To facilitate the completion of the questionnaire, guidelines were included with it. Furthermore, two Excel templates were developed to report on the minimum core data sets and their quality respectively.

Three pilot countries (Ghana, Rwanda, and Uganda) were identified to field-test the questionnaire and Excel templates. Based on the findings and lessons learnt from this exercise, the tested questionnaire was thereafter reviewed, revised, finalized and translated into French.

A web-based application for data input and submission was developed in English and then translated into French. The standard guidelines for compiling the Agricultural Statistics Capacity Indicators (ASCIs) have been reviewed to align to the Africa CA questionnaire (Mapping the variables, modalities and indicators: Standard vis-à-vis Africa).

The tabulation and analysis plans have been elaborated and data processing system and calculation of ASCIs developed.

1.4 Training on the Country Assessment process and instruments

Two training and launching workshops on the *Action Plan for Africa (2011-2015) for Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development* in general, and on the CA instruments and process in particular, were successfully organized in June and August 2012, in Kigali, Rwanda and Addis Ababa, Ethiopia respectively.

In total, 89 officials from 48 countries were trained at these workshops. Forty-one countries were able to send both required representatives – one from their National Statistics Office (NSO) and another from their Ministry of Agriculture (MOA), whereas 7 countries were represented by only one such delegate, and 6 countries did not send anybody.

Both workshops agreed on a roadmap for the way forward regarding the process of the CA as well as other related activities, particularly operational arrangements for data compilation. The first priority activity to be carried out by each country was to establish national governance structures (where these did not yet exist). This entailed the setting

up of a National Agricultural Statistics Committee and National Technical Working Group, and the designation of a National Strategy Coordinator (NSC) in each country.

2. Data collection

2.1 Country Assessment follow-up missions

It was determined that follow-up missions to countries should be undertaken without delay. The missions were tasked to ensure, among other things, that: (i) operational structures were in place, (ii) CA data were being effectively compiled; (iii) minimum core data sets were being reported and their respective quality evaluated; and that (iv) challenges and constraints faced by countries in carrying out the CAs as well as required concrete solutions to address them were identified and implemented.

To date, such missions have been fielded in 31 countries and where this has not been possible, the follow-up has been carried out virtually (by phone and/or emails).

The main outcomes of the follow-up missions can be summarized as follows:

- 44 countries have nominated their National Strategy Coordinator (NSCs), which constitutes an important component of recommended governance structures at the country level. NSCs are responsible for coordinating the CA data collection in their respective countries, and ensuring their consolidation, validation and submission to the AfDB.
- The collected data have been carefully checked, validated, and submitted for 42 countries.
- Existing data sources of the minimum core data sets were identified and related documents/reports/files (hard and/or soft copies) collected.
- The quality of the minimum core data sets was evaluated and recorded using the template designed for the purpose.
- Challenges and constraints faced by countries in carrying out CAs were reported and suggestions of concrete steps to address these challenges were proposed.
- Mission reports were produced.

2.2 Setting up national governance structures

As stated above, the CA follow-up missions have helped countries to establish the national governance structures, including terms of reference, identification of relevant institutions and respective representatives/members. Briefly, the established national coordination mechanism of agricultural statistics includes the following structures:

- National Agricultural Statistics Coordination Committee (NASCC) chaired by a data user, usually a senior policymaker at the Ministry of Agriculture. NASCC oversees the design and development of the National System of Agricultural Statistics (NSAS), ensuring its integration into the National Statistics System (NSS);
- National Coordinator of the Strategy (NC) responsible for the administrative and technical work in the implementation of the plan in the country; and
- Technical Working Group (TWG) covering different areas of agriculture tasked to assist the NC.

2.3 Data reporting status

In addition to helping establish national governance structures, the follow-up missions assisted in speeding up the first stage of the CA process and data collection. So far 42 questionnaires used for assessing statistical capacity and needs as well as for obtaining minimum core data have been received (out of the 54 assessed countries). This represents a response rate of 78%, which is lower than that in 2007 but higher than in 2009 (see Chart 1 in Annex A). It has to be noted, however, that for this latest assessment, greater efforts have been made by countries to respond to questions which in the past were often ignored (e.g. on financial and human resources) although that this is still missing in some cases.

3. Data verification and validation

Due to technical difficulties experienced by some countries in the use of the web application, questionnaires were generally submitted to the AfDB by email. Received questionnaires were carefully verified, while any missing and/or inconsistent information was reported back to countries concerned for completion and/or correction. In other cases, corrections were carried out using complementary data from alternative sources. By adopting this approach, only validated questionnaire data were passed on for data input and processing.

4. Data capture and processing

Data were captured and processed using two different means:

- An Excel model was formulated to capture relevant information for the calculation of the ASCIs; and
- Epi-Data software was used to capture all data for comprehensive results tabulation.

4.1 Calculation of ASCIs

The ASCIs are grouped into four categories in accordance with the global standard guidelines developed for that purpose (FAO, 2013). The categories are as follows: (i) *Prerequisites* – Indicators on Institutional infrastructure; (ii) *Input Dimension* – Indicators on Resources; (iii) *Throughput Dimension* – Indicators on Statistical Methods and Practices; and (iv) *Output Dimension* – Indicators on Availability of Statistical Information. The Excel Model to generate ASCIs has been based on the above four dimensions, and takes account of respective elements within each of them. The four dimensions have been aggregated into a composite indicator to enable country ranking according to the level of development of the national agricultural statistical systems as a whole. Furthermore, the ASCI Model allows automatic generation of Radar and Histogram charts to ease the analysis of resulting indicators.

4.2 Epi-Data software

A comprehensive data input system has been designed with Epi-Data, a software which is used to capture the data and enables the necessary checks and value labels to produce high data quality. Validated data have been exported to SPSS for further processing and generation of result tables.

5. Data tabulation and analysis

Data have been comprehensively tabulated and analyzed using SPSS, whilst MS-Excel was used in graphical analysis. A tabulation plan (list of possible tables) was previously prepared to report on the frequencies of facts by country and/or correlation between them. A comparative analysis of the assessment results over three successive cycles (2007, 2009 and 2012) was also conducted to compare the agricultural statistics activities or performance on the African continent over the period.

Furthermore, country profiles, grouping and ranking have been established and analyzed exhaustively (using the ASCI Model) to depict the development level of the national agricultural statistical systems on the African continent vis-à-vis the above-mentioned four dimensions and their respective elements.

6. Some selected key preliminary results: Case of Uganda

6.1 Profile of the agricultural statistics capacity of Uganda

Charts 2 to 6 presented in Annex B show the profile of Uganda through its ASCIs level in terms of: (i) the four statistical dimensions (Chart 2) and (ii) the elements within each of the dimensions (from Charts 3 to 6). They also reveal Uganda's level of statistical capacity compared to the average of all reporting countries.

6.2 Ranking of Uganda's Capacity Indicators vis-à-vis other reporting countries

Charts 7 to Chart 11 show the ranking of Uganda in terms of its composite capacity indicator (Chart 7) as well as for each Capacity Dimension (Charts 8 to 11) compared to other reporting countries.

7. Experience and lessons learnt

7.1 Requirement to adapt the standard CA instruments to the regional context and specificities

In Africa, the CA standard questionnaire has been reviewed to take account of lessons learnt from previous similar assessments as well as the African context and specificities. In that context: (i) the main questionnaire has been structured into three modules to report on information of a general nature, from the National Bureau of Statistics, and from specific subsectors of agriculture individually, hence avoiding possible omission and/or duplication of data (e.g. on financial and human resources); (ii) key guidelines, concepts and definitions have been incorporated directly into the questionnaire to ease the completion of the questionnaire and ensure a common

understanding of what is required; (iii) standards and African questions (variables and modalities) have been mapped to ensure an easy interpretation of the resulting ASCIs for Africa, as well as their comparability with those of other regions; (iv) two Excel templates have been developed to report on an extended list of the Minimum Core Data sets and on their quality respectively, hence going beyond what is required by the standard questionnaire (e.g. data reported exclusively for major selected commodity groups: crop production, livestock production, etc.); (v) the three CA instruments have been prepared in both English and French, so that countries can use them in their respective official languages.

7.2 Importance of field-testing the CA instruments

The field-testing of the CA instruments has proved very useful for their fine-tuning and finalization, and to ensure that they are adapted to the context and real needs of the exercise. The field-testing also helped to identify potential problems and constraints in advance, so that these may be resolved as quickly as possible.

7.3 Development of a web-based application for data submission

A web-based application has been developed for the CA questionnaire model and Excel template, to enable timely country data capture and submission. The application allows access to a flexible, graphically rich navigation tool. It includes rules to avoid and/or mitigate any possible manual data capture. Authorized users are able to fill in the three instruments in English or French.

However, given that some countries encountered difficulties in achieving uninterrupted access to internet connectivity, allowance was made for these countries to submit their data by email. This has required centralizing the data capture at regional (AfDB) level.

However, for any future CA cycles, the web-based application will be the only tool available for data submission. It is envisioned that this tool will be enhanced to include features for data checking and validation by countries. At the regional level, additional data management features will need to be incorporated in the application to enable automatic generation of ASCIs and standard results tables.

7.4 Usefulness of the training workshop on CA instruments and process

The selection and training of representatives from two key institutions in each country (Ministry of Agriculture and the National Statistical Office) has established good collaboration and coordination of the work program. Concepts and definitions were well explained and understood, and guidance on conducting the CA process as a whole was provided. This has significantly improved the quality of collected data, while ensuring awareness of the importance of the CA exercise to those most directly involved.

7.5 CA follow-up missions (including virtual follow-up through emails and telephone calls), data checks and the validation process

Follow-up missions have helped to boost the CA process by (i) assisting countries to set up national governance structures, (ii) ensuring that the national Technical Working Groups are well established (with representatives from all agricultural subsectors), functioning appropriately (by submitting their respective CA data) and well-coordinated (by the National Strategy Coordinators who organize meetings for data consolidation and validation). This has helped to foster an excellent teamwork spirit among officials, while ensuring the required quality of the compiled data. However, some countries have encountered difficulties in securing funding for their Technical Working Group meetings. Some other countries have had difficulty in completing the questionnaire within the stipulated deadline, simply because the National Statistical Offices and line ministries responsible for each agricultural subsector are not housed at the same location. Furthermore, some of the requested data were considered sensitive and were being detained by non-statistical units (e.g. financial and human resources information, etc.), which explains the difficulties in procuring them on time.

In any case, regular follow-ups and interactions with countries through emails and telephone calls have proved to be very useful in finding solutions to problems encountered by national staff carrying out statistical work. Continuous communications have also allowed countries to gain clarification on how to complete the questionnaire and/or to

feedback missing information in real time, thereby ensuring data quality and completeness.

However, it should be noted that the follow-up and monitoring to ensure timely responses from countries proved to be necessary in many cases. A lot of pressure was therefore exerted on the countries to respond in a timely, comprehensive and consistent manner to all questions. Every completed questionnaire was indeed considered valid after it was thoroughly checked before data capture and processing.

7.6 Development of an adapted Excel Model to generate ASCIs (single and aggregated/composite indicators) and related charts

The ASCI model is very simple and useful in the sense that it provides a framework for data capture and automatic generation of all indicators (for each element and dimension, and the composite indicator of all dimensions). The model also allows the formulation of charts that highlight country profile and development level of national agricultural statistics system by element and dimension.

The lack of the final official version of the standard guidelines at the time of calculating the ASCIs for Africa was a constraint. However, the established mapping between standard and Africa variables and questions is transparent enough to enable a good understanding, interpretation, and comparability of relevant indicators.

7.7 Going beyond the simple ASCI calculation: Trend and comparative analysis of CA cycle data

In addition to generating the expected ASCIs, Africa has been able to produce results tables that have proved similar to those of previous CA cycles. This has enabled analysis and comparison of trends over time. A comprehensive report of the ASCIs results and trends over time is being prepared.

7.8 Need for a workshop for countries to review, endorse, and own the ASCI results

A workshop is planned to enable African countries to share and discuss the ASCI results. This will be an opportunity for them to endorse and own the results of the exercise.

8. Conclusions

The preliminary ASCIs shown in Charts 2 to 11 at the end of this paper illustrate some of the CA results. A comprehensive report is being prepared and will be published in due course. Yet, even a brief perusal of these charts shows how useful they are in profiling the current development level of a country's agricultural statistics systems, in terms of the capacities of their institutional infrastructure, resources, statistical methods and practices and availability of statistical information. The ASCIs exercise represents the first such analysis for the continent and the experience and lessons learnt in the process should be utilized to inform and improve future similar exercises. When these ASCIs are published regularly, it will facilitate the M&E of progress achieved in implementing the Africa Action Plan.

It cannot be emphasized enough that the quality of the ASCIs relies heavily on the information reported directly by countries, particularly in terms of accuracy and completeness. This package of composite indicators plays a crucial role in contributing to the establishment of robust national agricultural statistical systems. For this reason, countries need to be made aware of the importance of responding in a more timely and comprehensive manner to future country assessments of this kind.

References

AfDB, AUC, ECA and FAO (2011) *Improving Statistics for Food Security, Sustainable Agriculture, and Rural Development: An Action Plan for Africa 2011-2015*.

FAO (2013) *Assessing Country Capacity to Produce Agricultural and Rural Statistics.*

FAO, UNSC and WB (2012) *Action Plan of the Global Strategy to Improve Agricultural and Rural Statistics.*

Endnotes

1 The Global Strategy document was first published by the Food and Agriculture Organization (FAO), the World Bank/IBRD, and the United Nations in September 2010. The Africa Action Plan was subsequently published in May 2011 by AfDB, AUC, ECA and FAO.

2 The three technical components comprise: Training, Technical Assistance, and Research.

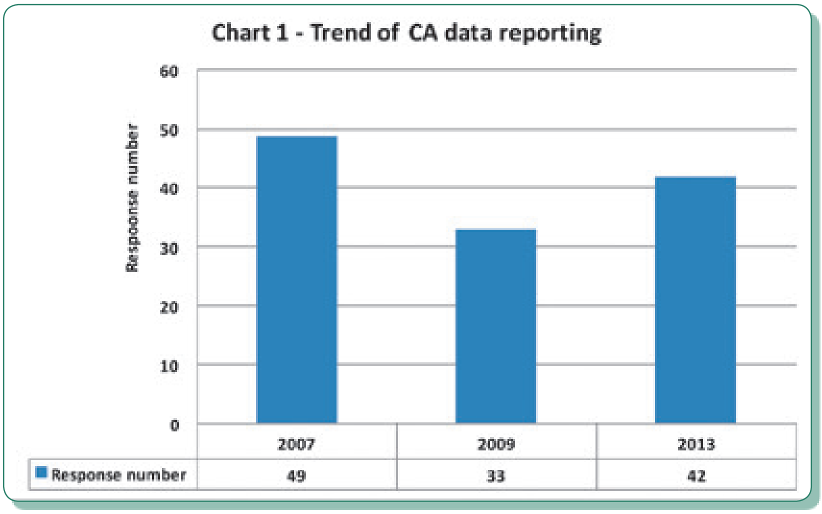
3 By Prerequisites, we mean all the institutional infrastructure like the legal framework, strategic vision and planning for agricultural statistics, etc.

4 By Instruments we mean all those tools that were used for carrying out the CA process: questionnaire, guidelines, data processing tools, tabulation and analysis plans, etc.

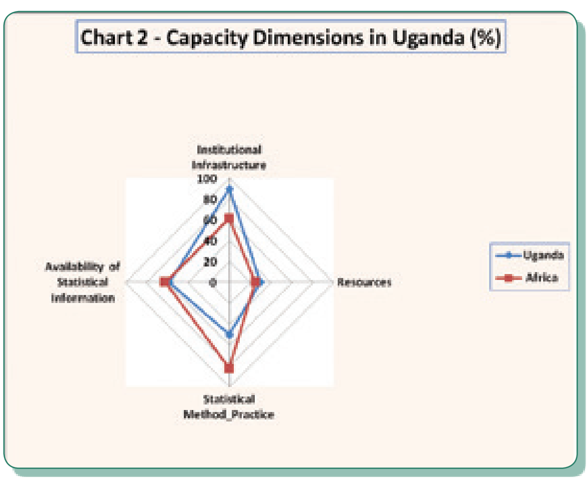
5 The CA process includes two stages: the 1st stage is a quick one using the standard questionnaire; the 2nd one is an In- Depth CA that will culminate in developing Country Proposals for improving agricultural statistics.

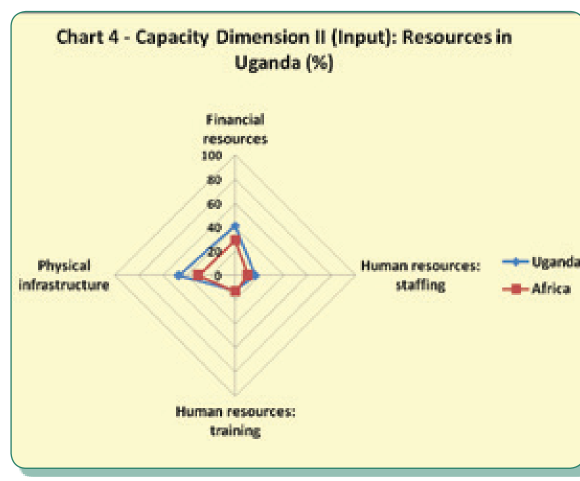
Annexes

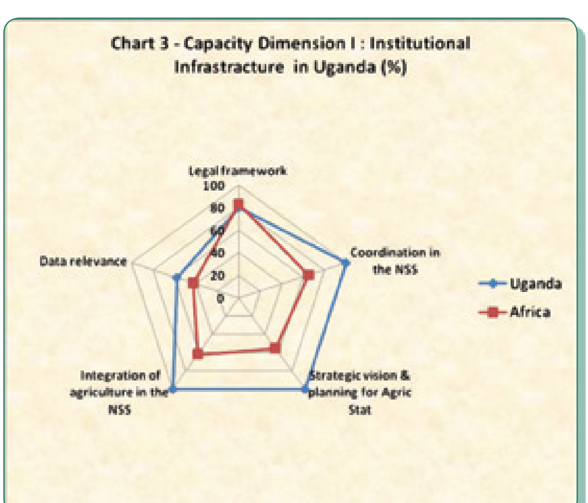
Annex A – Reporting status of different CA cycles.

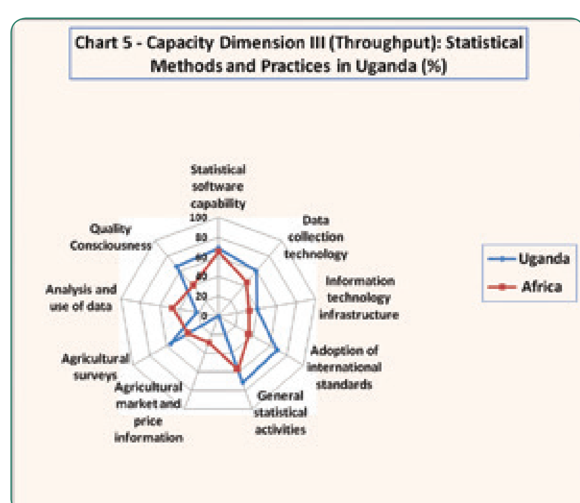


Annex B – Example of Charts representing ASCI.









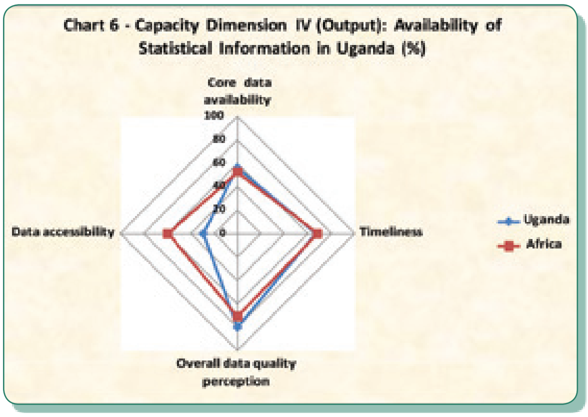


Chart 6 - Capacity Dimension IV (Output): Availability of Statistical Information in Uganda (%)
Core data availability
Timeliness
Overall data quality perception
Data accessibility
100
80
60
40
20
0
Uganda
Africa

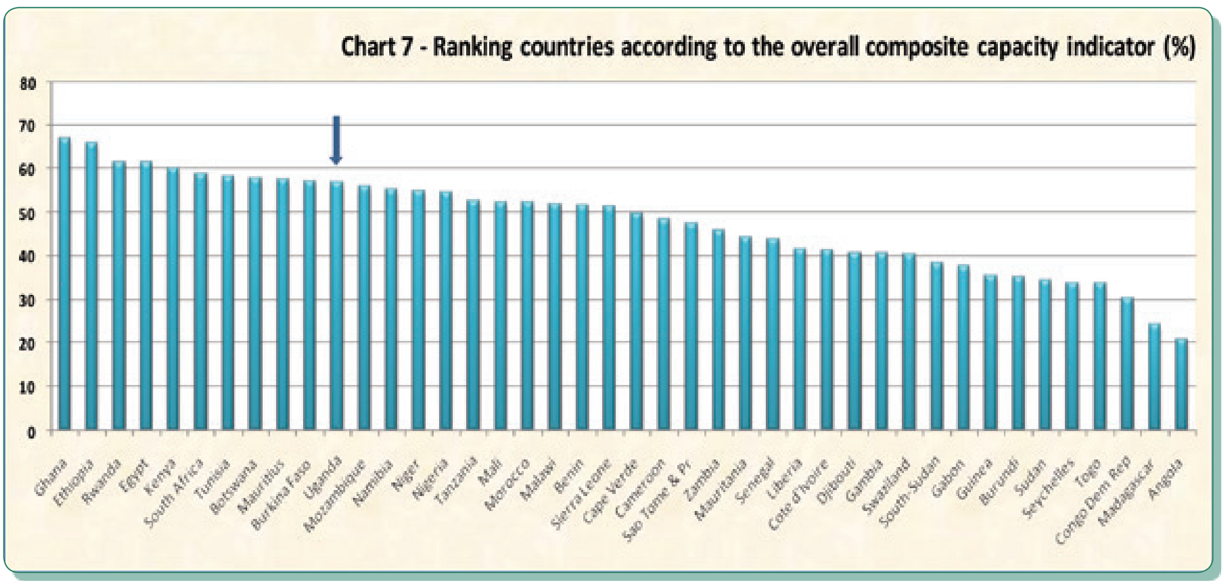


Chart 7 - Ranking countries according to the overall composite capacity indicator (%)
80
70
60
50
40
30
20
10
0
Ghana
Ethiopia
Rwanda
Egypt
Kenya
South Africa
Tunisia
Botswana
Mauritius
Burkina Faso
Uganda
Mozambique
Namibia
Niger
Nigeria
Tanzania
Mali
Morocco
Malawi
Benin
Sierra Leone
Cape Verde
Cameroon
Sao Tome & Pr
Zambia
Mauritania
Senegal
Liberia
Cote d'Ivoire
Djibouti
Gambia
Swaziland
South-Sudan
Gabon
Guinea
Burundi
Sudan
Seychelles
Togo
Congo Dem Rep
Madagascar
Angola

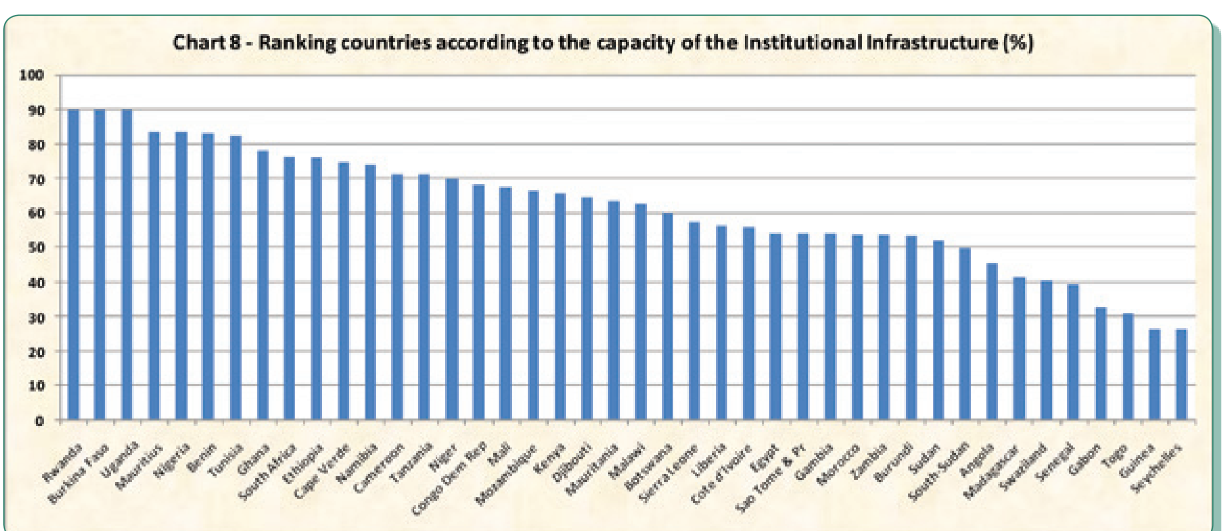


Chart 8 - Ranking countries according to the capacity of the Institutional Infrastructure (%)
100
90
80
70
60
50
40
30
20
10
0
Rwanda
Burkina Faso
Uganda
Mauritius
Nigeria
Benin
Tunisia
Ghana
South Africa
Ethiopia
Cape Verde
Namibia
Cameroon
Tanzania
Niger
Congo Dem Rep
Mali
Mozambique
Kenya
Djibouti
Mauritania
Malawi
Botswana
Sierra Leone
Liberia
Cote d'Ivoire
Egypt
Sao Tome & Pr
Gambia
Morocco
Zambia
Burundi
Sudan
South-Sudan
Angola
Madagascar
Swaziland
Senegal
Gabon
Togo
Guinea
Seychelles

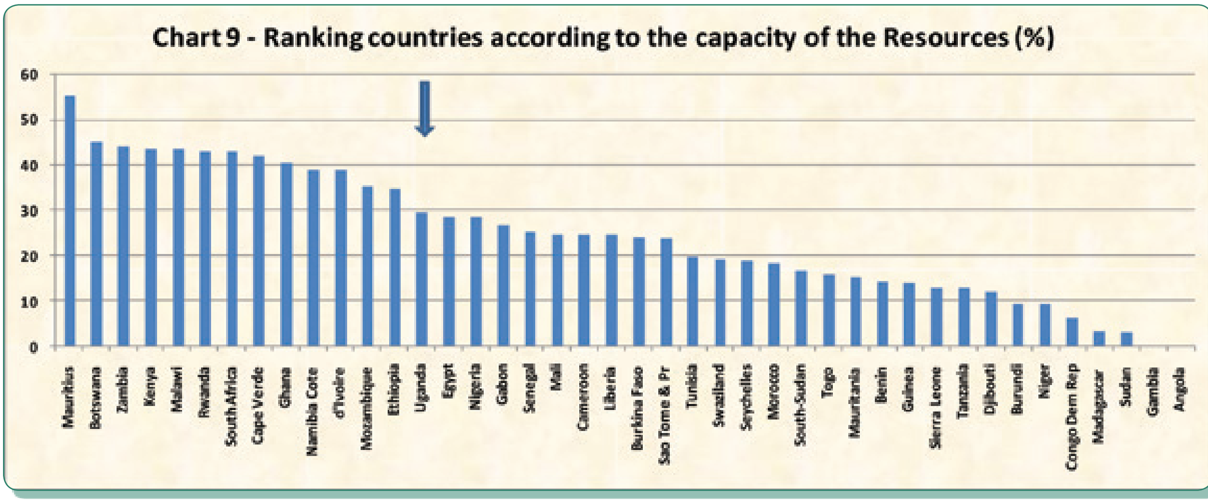


Chart 9 - Ranking countries according to the capacity of the Resources (%)

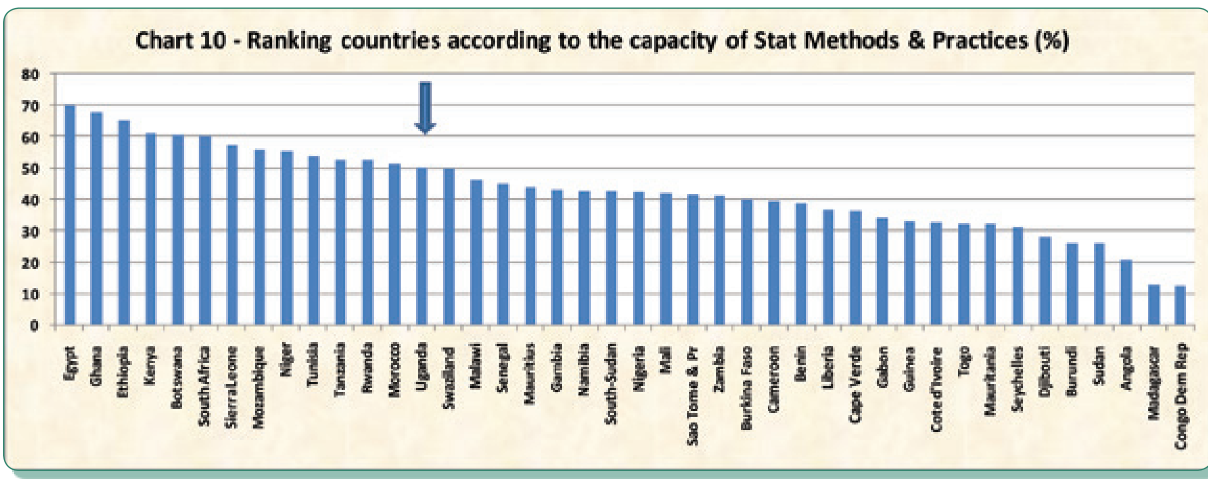


Chart 10 - Ranking countries according to the capacity of Stat Methods & Practices (%)

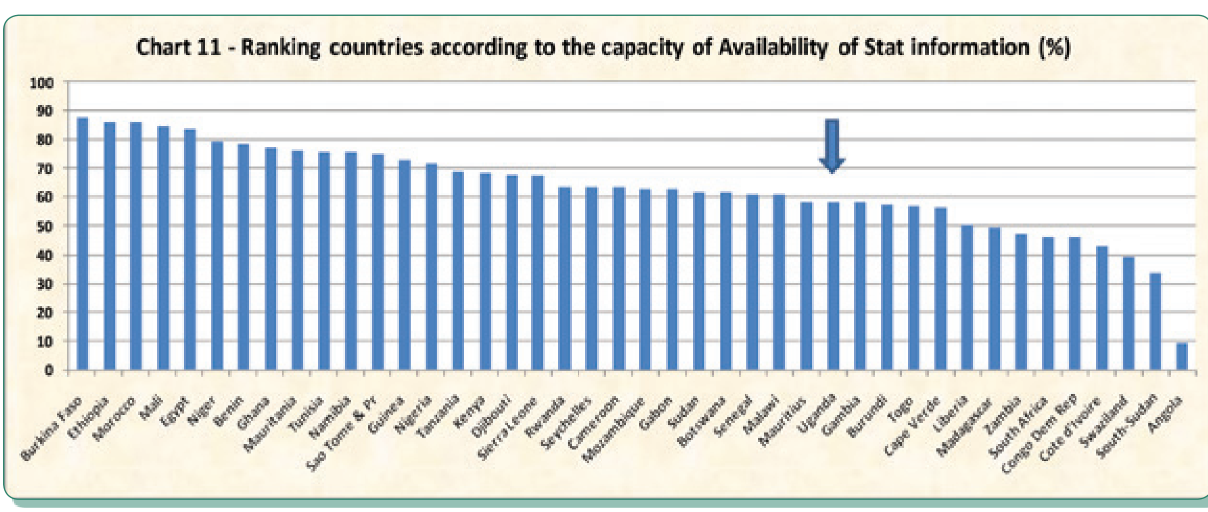


Chart 11 - Ranking countries according to the capacity of Availability of Stat information (%)

Assessing Country Capacity for the Production of Agricultural Statistics in Asia and the Pacific

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Abstract

The Global Strategy to Improve Agricultural and Rural Statistics initiative involves the development of a Regional Action Plan that provides guidelines for strengthening the capacity of national statistical systems to produce information for informed decision-making related to food security, sustainable agriculture and rural development. This global and regional initiative involves a concerted effort from data producers, data users and partners in development. In line with these goals, the Regional Office of the Global Strategy for Asia and the Pacific (hereafter referred to as the Regional Office) initiated efforts in late 2011 to evaluate the capacity of countries in the region and to identify areas where inputs would be helpful. This paper presents the results of the country assessment questionnaire (CAQ) distributed in late 2011/early 2012 to assess the capacity of national statistical systems in Asia and the Pacific to produce a minimum set of core indicators as outlined in the Global Action Plan of the Global Strategy.

Keywords: Global Strategy; Asia Pacific.

1. Background of the Country Assessment Questionnaire

The immediate objective of the country assessment questionnaire (CAQ) was to establish a monitoring and evaluation baseline for countries in the Asia Pacific region and by association serve as an indicator for the selection of countries to pursue further in-depth assessment. This in turn would serve as preparation for comprehensive technical assistance, training and research programmes in later stages of the Global Strategy initiative.

In line with these objectives, the CAQ was distributed in late 2011/early 2012 by FAO and its partners, ESCAP and ADB, to 58 countries in the Asia Pacific region to focal points within both the national statistics office (NSO), Ministries of Agriculture and other line ministries relevant to the production of agricultural statistics. CAQs were partially prefilled by the partner organizations with information available about the countries, to facilitate the filling up. In total, 43 country responses were received during this period with broad representation from all sub-regions including North and Central Asia, South-east Asia, South and South-west Asia, East Asia, and the Pacific. While the initial CAQ sample covered five sub-regions, it was later decided under the preparation phase of the Global Strategy that the North and Central Asia sub-region would be separated from the mandate of the Asia Pacific region and reorganized under the Commonwealth of Independent States (CIS) – barring an exception for Georgia which later requested to be under the mandate for Asia Pacific. For this reason, the analysis of the following paper will be limited to 38 countries in the four sub-regions of South-east Asia, South and South-west Asia, East Asia, and the Pacific. Georgia was conveniently included within the East Asia sub-region.

The standard CAQ was based on an adaptation of the data quality assessment framework (DQAF) produced by the International Monetary Fund (IMF), which has also served as a starting point to assess data quality in other sub-disciplines including national accounts, debt, and balance of payments statistics. Using this DQAF framework as a baseline to develop an agricultural data quality framework, the CAQ set to assess data quality for agricultural and rural statistics in four key dimensions comprising of: institutional infrastructure, resources, statistical methods, and statistical information and availability. The sub-framework for each of these dimensions was carefully put together using inputs from statisticians and development practitioners globally and is presented in Table 1 for reference.

Table 1: Composite Indicators of the Agricultural Data Quality Framework.

Capacity Indicator I (Prerequisites: institutional infrastructure)	Capacity Indicator II (Input: resources)	Capacity Indicator III (Throughput: methods and practices)	Capacity Indicator IV (Output: availability of statistical information)
• Legal framework • Coordination in statistical system • Strategic vision and planning • Integration of agriculture in the national statistical system • Relevance (user interface)	• Financial • Human resources	• Statistical software capability • Data capture technology • IT infrastructure • International classifications • General statistical activities • Agricultural market and price information • Agricultural surveys • Analysis and use of data	• Core data availability • Timeliness • Quality, reliability and consistency of data • Data accessibility • Quality consciousness

The first capacity indicator titled *Institutional Infrastructure* seeks to assess the pre-conditions that are needed for a smooth and efficient statistical system to produce agricultural and rural statistics. The compilation of this indicator requires information related to the legal framework to produce agricultural and rural statistics and an understanding of all relevant stakeholders. The compilation of this indicator also extends to an understanding of agricultural statistics within the national statistical system.

The second capacity indicator titled *Resources* is a critical indicator that seeks to show whether a country has and is deploying adequate resources to undertake the statistical activities dictated by the minimum set of core indicators. This indicator in scope covers both financial and human resources and seeks to understand how they relate to the final execution of activities related to agricultural and rural statistics.

The third capacity indicator titled *Statistical Methods and Practices* is tasked with exploring the range of statistical activities undertaken by the country and how advanced the methods and practices used are for these activities. The first four sub-elements of this indicator focus on technical capabilities of the statistical organizations in the country and the later sub-elements focus on statistical activities, and the use of the data collected.

Lastly, the fourth capacity indicator titled *Availability of Statistical Information* seeks to observe the availability of the minimum set of core agriculture and rural data as well as its timeliness, general quality perception, and its accessibility.

It is to be noted that based upon the data available through the CAQ (Initial Assessment), it was not possible to compile the two indicators for Capacity Indicator II in Asia and the Pacific which related to human and financial resources. This indicator should be compiled at the in-depth assessment stage in-country as it needs information from various sources.

In general, the initial results of the CAQ in Asia and the Pacific showed several critical limitations in responses received from the countries including:

- The CAQ was a long questionnaire and despite prefilling efforts, responses to some sections of the EXCEL worksheets for the CAQ were left blank. It was not always clear whether blanks indicated a lack of information or represented a “no”, “none” or “not applicable” response. For example, it is known that some countries do collect and publish core data items, but did not report it on the CAQ.

- Similarly, the reported capacity of some statistical systems did not correspond to the perceptions of organizations working in these countries. These countries were contacted to verify the responses on the questionnaire and some replied that they misunderstood the meaning of the responses. It should be noted that the CAQ responses are preliminary and must be validated when combined with information from other sources and from in-depth country assessments.

- Perceptions about the content of the questionnaire and the means to obtain the necessary feedback are dependent on the reader as are the interpretations

of the actual questions on the CAQ. There are several items on the questionnaire where non-native English speakers might have difficulty in answering the questions as they were intended. Even for English speakers some of the questions in the worksheets may be mis-interpreted.

- In many cases, the responses related to only the National Statistics Office or Ministry of Agriculture and do not reflect the totality of the country situation.
- National or sub-regional training workshops on how to fill up the CAQ would have been ideal. However, this demanded resources that were not available to the partner organizations.

2. Assessment of the initial CAQ results for Asia and the Pacific

Despite the limitations in the responses, the available data could be utilized to draw some meaningful conclusions about the situation in Asia and the Pacific, and indications on the level of statistical development in the countries. The following section will review the results of each computable capacity indicator: (1) Institutional Infrastructure, (2) Statistical Methods and Practices, and (3) Availability of Statistical Information.

Each capacity indicator is quantitatively measured on a scale of 0 to 100, where a score of 100 represents a perfect representation of the defined capacity indicator criteria. The capacity indicator is mathematically a geometric average[1] of related sub-indicators as listed in Table 1. Each of these sub-indicators is then further based on a series of weighted questions in the CAQ, which directly relate to the definition of the corresponding sub-indicator. The results of these indicators are presented below in Tables 2, 3, and 4 and are organized by country and sub-region.

The *institutional infrastructure composite indicator* is the most robust indicator of those presented in this paper based on the completeness of responses received in our CAQ responses. Based on the compilation guidelines created by the Global Strategy, an institutional infrastructure indicator was compiled for 38 countries. On average, the Institutional Infrastructure composite indicator measured 34 and had a median score of 30.5.

In comparison with the other two indicators, country capacity in institutional infrastructure is highly variable both between and within sub-regions. However, indicator scores tend to be comparatively higher in South-east Asia and South and South-west Asia, and lower in the Pacific. It is apparent that many countries still suffer from coordination issues and lack the necessary mechanisms to integrate agriculture into the overall national statistical system. These are major concerns across all sub-regions and will require the most attention in the initial implementation phase of the Global Strategy initiative for Asia and the Pacific.

The *Statistical Methods and Practices composite indicator* is the most data intensive of three capacity indicators representing a broader spectrum of data quality framework that covers both technical ability and to some extent quality of statistics. Based on the compilation guidelines created by the Global Strategy, a statistical methods and practices indicator was compiled for 38 countries. On average, the Statistical Methods and Practices composite indicator measured 30 and had a median score of 28. Compared to the other two indicators, the distributions of scores showed more consistency across the different sub-regions, but indicator scores tend to be comparatively higher in South-east Asia and lower in the South and South-west Asia and the Pacific.

At the sub-indicator level, major concerns across the sub-regions tend to skew towards issues with technical capacity, specifically IT infrastructure and data capture technologies. These issues are seen to be consistent across all sub-regions.

Lastly, the *Availability of Statistical Information composite indicator* more or less presents a snapshot into the status of the current agricultural system representing the coverage of agricultural statistics in terms of the minimum set of core indicators and also to some extent data quality. Based on the compilation guidelines developed by the Global Strategy, the Availability of Statistical Information indicator was compiled for 38 countries. On average, the Availability of Statistical Information composite indicator measured 42 and had a median score of 36. Compared to the other two indicators, this indicator shows higher scores across the sub-regions. Despite this fact, scores in the Pacific are comparatively lower.

At the sub-indicator level, major concerns across the sub-regions tend to skew towards the available coverage of the minimum set of core indicators, timeliness of data, and the overall quality consciousness.

Table 2: Capacity Indicator I: Institutional Infrastructure.

East Asia		South-east Asia		South and SW Asia		Pacific	
China	31	Cambodia	5	Afghanistan	34	Australia	68
Hong Kong, SAR, China	7	Indonesia	11	Bangladesh	36	Cook Islands	5
Japan	67	Lao PDR	61	Bhutan	48	Fiji	10
Macao, SAR China	2	Malaysia	98	India	61	Kiribati	10
Mongolia	33	Myanmar	8	Iran (Republic of.)	61	Micronesia	3
Republic of Korea	28	Philippines	98	Maldives	54	Nauru	2
Taiwan, PoC	36	Thailand	58	Nepal	63	New Zealand	92
Georgia	58	Viet Nam	37	Pakistan	4	Niue	30
				Sri Lanka	2	Palau	3
						Papua New Guinea	2
						Samoa	24
						Timor Leste	2
						Vanuatu	24
Mean	**33**		**47**		**40**		**21**
Median	**32**		**48**		**48**		**10**

Table 3: Capacity Indicator III: Statistical Methods and Practices.

East Asia		South-east Asia		South and SW Asia		Pacific	
China	20	Cambodia	6	Afghanistan	14	Australia	42
Hong Kong, SAR, China	37	Indonesia	36	Bangladesh	58	Cook Islands	39
Japan	23	Lao PDR	36	Bhutan	15	Fiji	51
Macao, SAR, China	11	Malaysia	55	India	27	Kiribati	23
Mongolia	50	Myanmar	14	Iran (Republic of.)	41	Micronesia	5
Republic of Korea	29	Philippines	67	Maldives	62	Nauru	5
Taiwan PoC	45	Thailand	39	Nepal	12	New Zealand	64
Georgia	29	Viet Nam	53	Pakistan	5	Niue	19
				Sri Lanka	7	Palau	35
						Papua New Guinea	4
						Samoa	25
						Timor-Leste	20
						Vanuatu	27
Mean	**31**		**38**		**27**		**28**
Median	**29**		**38**		**21**		**25**

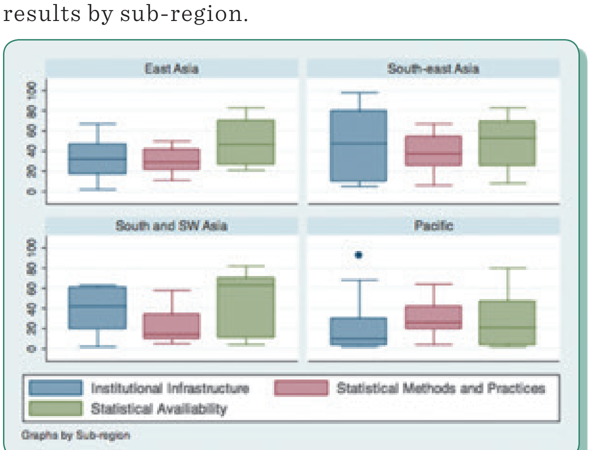
On a sub-regional level, however, the results of the country capacity indicators are deemed to be more or less in line with expectations based on experience. Some outliers are observed, but it must be noted that the compilation of these indicators is tentative and is still subject to more intensive validation during the later stages of the in-depth assessment in-country. For instance, scores tend to be lower in Macao, SAR China, Hong Kong, SAR, China and Taiwan PoC where the importance of agriculture is more limited. Some of this variation is graphically presented in Figure 1, where the box plots show how the distribution of country capacity indicator results differs by sub-region. For this exercise, it is important to note the large variation not only between sub-regions, but also more importantly within the sub-regions themselves. One example of this is the variability of institutional infrastructure in the Southeast Asia sub-region. Here, the scores are seen to range from 5 in Cambodia to a high of 98 in Malaysia and the Philippines. The range of the variation here

Table 4: Capacity Indicator IV: Availability of Statistical Information.

East Asia		South-east Asia		South and SW Asia		Pacific	
China	29	Cambodia	24	Afghanistan	4	Australia	76
Hong Kong, SAR, China	25	Indonesia	72	Bangladesh	70	Cook Islands	17
Japan	32	Lao PDR	42	Bhutan	59	Fiji	80
Macao, SAR,China	21	Malaysia	66	India	82	Kiribati	7
Mongolia	83	Myanmar	8	Iran (Republic of.)	71	Micronesia	3
Republic of Korea	73	Philippines	83	Maldives	35	Nauru	2
Taiwan PoC	68	Thailand	64	Nepal	67	New Zealand	79
Georgia	60	Viet Nam	28	Pakistan	11	Niue	47
				Sri Lanka	11	Palau	25
						Papua New Guinea	3
						Samoa	37
						Timor Leste	4
						Vanuatu	15
Mean	**49**		**48**		**46**		**30**
Median	**46**		**53**		**59**		**17**

also alludes to differences in the level of economic development in the region, which is partly reflected in the Pacific where Australia and New Zealand are considered outliers for the sub-region. This in proxy supports the notion that countries overall should be grouped by levels of statistical development and the implementation of the Global Strategy should use these groupings as a basis for country selection in the implementation phase. South and South-west Asia, in turn, shows below average scores in statistical methods and practices while the Pacific countries present the lowest scores for all indicators across the board.

Figure 1: Box-plot of country capacity indicators results by sub-region.



Source: Country Assessment Questionnaire 2013, FAO Regional Office for Asia and the Pacific.

2.1 Critical constraints in agricultural statistics system

In addition to three main country capacity indicators, respondents of the CAQ were also asked to rank on a scale the most pressing constraints of their respective statistical agencies. Fifteen constraints were listed in the CAQ questionnaire with a request for the NSO and MOA to rate separately each constraint's impact on agriculture statistics. A dominant constraint was rated as "5" while a no constraint was rated as "1". The average of country reported levels of constraints is found in Table 5.

Based on the rating of critical constraints as reported by the countries, the field programme for agriculture statistics had significant shortcomings namely, funds for field-oriented statistical activities and human resources in the field. The implementation of sound methodologies for agricultural surveys, and more specifically the level of demand for statistics in the Pacific region also appeared as significant constraints.

3. Classification of country statistical systems

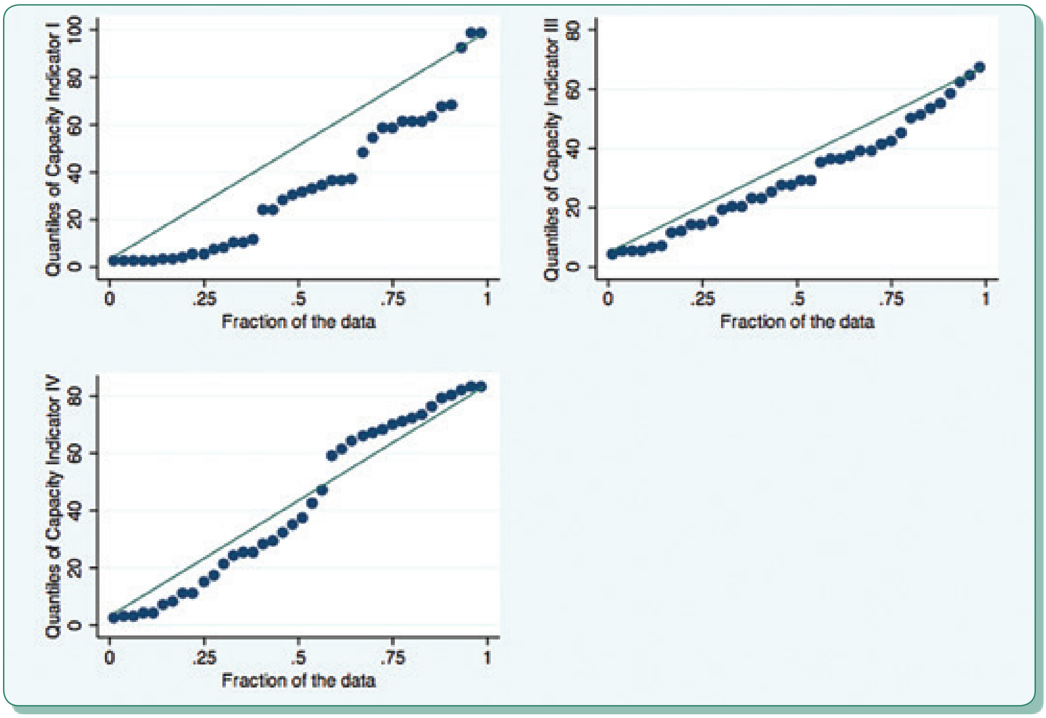
For the implementation of the Global Strategy to begin in the Asia Pacific region, it was recommended to group countries by levels of statistical capacity in order to facilitate the identification of countries with the highest needs of assistance. For these purposes,

Table 5: Constraints on Agricultural Sector Statistics.

	East Asia	Southeast; Asia	South and SW Asia	Pacific	Regional Mode
Number of professional staff at headquarters for statistical activities	2.1	2.8	3.2	3.1	3.0
Technical skills of the available statistical staff	2.2	3.1	2.2	2.6	2.0
Turnover of professional staff	2.5	3.7	3.3	2.9	3.0
Transport equipment for field activities	2.6	3.7	3.2	2.7	2.0
Funds for field-oriented statistical activities vis-à-vis plans.	2.3	3.8	3.0	3.1	3.0
Up-to-date information technology hardware	2.5	2.3	3.2	2.8	1.0
Up-to-date information technology software	2.4	3.0	1.7	3.3	2.0
Number of field workers for statistical activities	2.7	3.8	2.0	3.0	3.0
Number of professional staff in the field for statistical activities	2.5	3.6	2.3	3.1	3.0
Sound methodology implemented for agricultural surveys	2.9	3.5	3.4	2.4	3.0
Building space for office	2.5	3.1	3.2	2.4	2.0
Appreciation at the policy-making level for importance of statistical activities	2.4	1.9	2.9	2.7	1.0
Support at political level in the Government for statistical activities	1.6	3.0	2.9	3.2	2.0
Number of support staff at headquarters for statistical activities	2.3	2.8	1.8	2.9	1.0
Level of demand for statistics	2.7	2.7	2.8	3.1	3.0
Sub-regional Mode	**2.5**	**2.8**	**3.2**	**3.1**	**3.0**

Note: 1=No constraint; 2=Little constraint; 3=Relative constraint; 4=Significant constraint; 5=Dominant constraint; Averages refer to an arithmetic average of 38 reporting countries across FAO/UNESCAP defined sub-regions.

Figure 2: Quantile Distributions of Country Capacity Indicator results.



Source: Country Assessment Questionnaire 2013, FAO RAP

the guidelines of the Global Strategy for country assessment recommend two methods, which will be discussed in the following section.

Before the grouping methodologies can be discussed, however, the statistical characteristics of our results must first be understood for the purposes of identifying any potential bias that may affect the overall grouping methodology. For this analysis, the Regional Office of the Global Strategy has employed the use of quintile distribution figures to examine the skewness of the regional level data across the three computable composite indicators (Figure 2). In general, we note that a large fraction of the indicator results skew towards the lower quintile groups, representing roughly a quarter of all data points. While this skewness may be characteristic of the region as a whole, it must also be noted that many of the lower groupings are the result of missing or incomplete information. As these indicators will be further validated through the in-depth assessment process in-country, it is expected that the distribution of these indicators will change and become more closely aligned with expectations.

The first method for grouping is based on a geometric average score of the three capacity indicators based upon a certain threshold. For purposes of illustration, arbitrary thresholds of 30 and 60 were chosen and are presented in Table 6. Structurally, it is noted that this methodology suffers due to the use of an aggregate number that is relatively arbitrary and has no foundation on which conclusions about country statistical capacity can be made.

The second method for grouping focuses only on the bottom 50 percent of countries (18 countries) in terms of core data availability and reclassifies them as follows:

- Group 1: Countries with weak institutional infrastructure and methods and practices
- Group 2: Countries with weak institutional infrastructure
- Group 3: Countries with weak methods and practices
- Group 4: Unclassified

For the purposes of this analysis, a country with a score of less than the median is referred to as "weak". The results of this exercise are presented in Table 7 and are shown to have mixed results based on experience of the Regional Office. While we acknowledge that it is useful to identify countries that have insufficient coverage of the minimum set of core indicators, it is noted that the set of core indicators varies on a country by country basis which makes it difficult for cross country comparison - especially for grouping purposes such as this.

Noting the insufficiency of these grouping methodologies in practice for the Asia and the

Table 6: Country grouping by geometric average of computable composite indicators.

GROUP 1 (with average scores below 30)	Afghanistan (13), China (25), Cambodia (9), Cook Islands (18), Micronesia (4), Hong Kong SAR China (21), Kiribati (13), Sri Lanka (5), Macao SAR China (8), Myanmar (10), Nauru (3), Niue (28), Pakistan (6), Palau (17), Papua New Guinea (3), Samoa (22), Timor Leste (6), Vanuatu (22)
GROUP 2 (with average scores between 30 and 60)	Australia (57), Bangladesh (53), Bhutan (30), Fiji (37), Georgia (43), Indonesia (31), India (46), Iran (53), Japan (34), Republic of Korea (37), Lao PDR (43), Maldives (51), Mongolia (51), Nepal (30), Taiwan PoC (48), Thailand (50), Viet Nam (40),
GROUP 3 (with average scores above 60)	Malaysia (68), New Zealand (75), Philippines (79)

Table 7: Country grouping based on Core Data Availability, and level of statistical capacity in Institutional Infrastructure and Statistical Methods and Practices.

Group 1	Micronesia, Kiribati, Sri Lanka, Macao SAR (China), Myanmar, Niue, Nauru, Pakistan, Papua New Guinea, Samoa, Timor Leste, Vanuatu
Group 2	Cook Islands, Hong Kong SAR (China), Indonesia, Palau
Group 3	Afghanistan
Group 4	Lao PDR

Pacific region, it is recommended that further grouping methodologies be explored that can better discriminate the large diversity of the region. The Asia–Pacific region as a whole is incredibly diverse with many characteristic extremes based on geography, climate, and economic development. This makes it difficult to compare, for instance, a country in the Pacific that is heavily reliant on fisheries with a land locked country that is dependent on more traditional agricultural crops. For further analysis, it is the recommendation of this paper that the issue of grouping should be considered at the sub-regional level. It is our opinion that by viewing these scores in the context of the sub-region, both policy makers and development practitioners would be able to more accurately compare their country's capacity relative to a sub-region which may be characteristically more consistent in terms of agriculture.

Groupings based on a sub-regional level were presented to the Regional Steering Committee (RSC) to guide the selection of the first set of countries for implementation of the Regional Action Plan of the Global Strategy. The RSC also took into account the countries' political will, commitment, importance of agriculture, and the general level of statistical development. Since this is the first year of the initiative, the RSC also decided to select countries to cover a range of statistical systems (centralized or not), main sources of data (survey or administrative data) and existence or otherwise of a National Strategy for the Development of Statistics.

4. Conclusions and way forward

Considering the outcomes of the initial CAQ in Asia and the Pacific we note a number of considerations that must be made during subsequent phases of the Global Strategy. It is noted by the Regional Office that the selection of indicators for the assessment of capacity through standard questionnaires is mixed. While it does possess characteristics to produce some strong, proven, and robust indicators, it also has some that are new and untested. Given this concession, we note the following to be the most pressing issues in the current country assessment methodology.

Coordination of the country's response often appears to be a challenge when two or more ministries take responsibility to answer part of the same questions but provide different information. This is particularly true for information on financial resources and budgets for agricultural statistics which is distributed across line ministries and departments within a country.

The indicator providing a "perception of quality" under capacity indicator IV *Availability of Statistical Information* is far from being perfect as it may entail an element of reporting bias.

We note that the weights assigned to some indicators could be considered arbitrary and can be questionable but in general efforts were made to assign every questionnaire response an equal weight.

The criteria used to assess countries using the methodology proposed by the Global Action Plan emphasizes the regular production of a large percentage of a minimum set of core items. This is not relevant for some countries in the region where the agricultural sector is comparatively small. An approach that emphasizes monitoring food security has more impact on assessing the contribution of agriculture as measured by the national statistical system. However, it is also necessary to determine the integration of agricultural statistics into the national statistical system and the requirements to achieve collection, processing and dissemination of the minimum set of core items on a regular basis.

Constraints in funds for data collection and processing and the overall availability of staff, both professional staff and support staff, and the level of commitment of national resources to sustain an integrated national statistics system are serious issues to be assessed during the in-depth assessments in-country.

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Endnotes

1 The CAQ assessment guidelines, which were being revised at the time of submission of this paper, proposed an arithmetic mean.

Countries Capacity to Produce Agricultural and Rural Statistics in Latin America and the Caribbean

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Abstract

The international community has formulated a Global Strategy to Improve Agricultural and Rural Statistics to provide a framework and methodology that will lead to the improvement of national and international food and agricultural statistics to guide policy analysis and decision making in the 21st century.

The starting point in the implementation of the Global Strategy is to carry out country assessments which will involve two stages. This first stage will establish baseline information on a country statistical capacity. It will involve all countries of the LAC region and it will be undertaken through a standard questionnaire (Country Assessment Questionnaire (CAQ)). This paper refers to this first stage.

This first stage assessment will give the opportunity to learn from those countries whose stage of statistical development includes many of the principles described in the GS and they will identify the weakest or least developed systems of agricultural statistics in order to define where and when technical assistance and training could be needed. This first stage of the country assessment will also provide information on what other statistical development activities are under way at country level and at the same time, they should provide the global and regional coordinators with the information they need to finalize development of statistical standards and guidelines for the technical assistance and training programs.

Keywords: Global Strategy; country assessments; countries capacity.

1. Global Strategy country assessments in LAC

The starting point in the implementation of the Global Strategy is to carry out country assessments which will involve two stages.

This first stage will establish baseline information on a country statistical capacity. It will involve all countries of the LAC region and it will be undertaken through a standard questionnaire (Country Assessment Questionnaire (CAQ)) prepared by the Global Office and discussed and adapted to the Region at the Regional Steering Committee (RSC) Meeting in September 2012 in Aguacalientes, Mexico. The information generated will be used for selecting a group of countries to apply the second, more in-depth stage of the country assessment which will be the basis for preparation of a country proposal for technical assistance and training based on the choice of the appropriate methodologies.

The CAQ will collect information from the national statistical offices and statistical offices in the ministries of agriculture and other institutions producing agricultural and rural statistics using the well-established channels of the Regional Office, the Regional Executive Board or other bodies.

The CAQ is structured in four sections designed to assess the situation of the agricultural statistics in the country referred to its institutional framework, the extent to which each country is producing the minimum set of core data, the main statistical activities of the country and critical constrains:

- Section 1: Institutional environment:
  - Administrative structure of the country;
  - Legal and administrative framework for the collection of statistics;
  - Structure of the National Statistical System;
  - Strategic framework;
  - Dialogue with data users.
- Section 2: Core data availability.
- Section 3: Main statistical activities:
  - Population census;
  - National Accounts Statistics;
  - Adoption of classifications;
  - Price Indices;
  - Food and Agricultural Surveys Conducted;
  - Household Budget Survey;
  - Availability of derived statistics and indicators in the country;
  - Quality consciousness in statistics;
  - Information technology;
  - Transport Infrastructure;

- Financial resources;
- Human resources and training for statistical activities;
- International cooperation in agricultural statistics.

- Section 4: Critical constraints in the Agricultural Statistical System.

The assessment at this stage will give the opportunity to learn from those countries whose stage of statistical development includes many of the principles described in the GS. For example countries with SSPARS integrated to the NSDs or countries with sound methodologies for estimating main agricultural parameters or countries that have included questions related to agriculture in their population census. Those countries could provide inputs for the components of the implementation plan by assisting other countries.

The assessments will identify the weakest or least developed systems of agricultural statistics in order to define where and when technical assistance and training could be needed.

The first stage of the country assessment will also provide information on what other statistical development activities are under way at country level.

The first stage of the country assessment should provide the global and regional coordinators with the information they need to finalize development of statistical standards and guidelines for the technical assistance and training programs. It will also identify countries in which technical assistance will require developing a basic infrastructure that include the preparation of statistical laws and regulations. The findings of the first stage should be provided to donors who have interest in specific countries or types of countries on their statistical capacity (FAO 2012).

2. Results Country Assessments in LAC

In the first RSC Meeting in Mexico in September 2012, the committee decided to test the questionnaire as originally was (without the changes introduced in the meeting) in three countries in the Region present at the meeting. Colombia, Mexico and Peru volunteered and committed themselves to complete the questionnaire and send it to FAO for its evaluation. Ecuador also sent the questionnaire completed for evaluation later on.

In June 2013, the final questionnaire was sent to the 33 FAO member countries in the Latin America and Caribbean region. Unfortunately, there was not enough time to include the final assessments in this paper, so this paper includes the results of four countries pilot assessments.

2.1 Legal and administrative framework for the collection of statistics

All four countries have a legal and administrative framework for the collection of statistics and the government agencies specified in the legislation to undertake statistical activities are their National Statistical Offices (NSO); in Colombia the Departamento Administrativo Nacional de Estadística (DANE), in Ecuador the Instituto Nacional de Estadística y Censos (INEC), in Mexico the Instituto Nacional de Estadística y Geografía (INEGI) and in Peru the Instituto Nacional de Estadística e Informática (INEI).

Colombia, Mexico and Peru also have an active legal framework for Agricultural Statistics, Ecuador does not mention one. In Colombia and Mexico the government agencies specified in the legislation to undertake agricultural statistical activities are their respective NSO while in Peru is the Ministry of Agriculture. However, in Mexico the Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA) also performs a large proportion of the agricultural statistical activities.

Also, in Colombia, Mexico and Peru exist an active National Statistics Committee that covers agricultural statistics activities in the broad sense of the word agriculture. Ecuador has not answered this question.

2.2 Structure of the National Statistical System

Colombia and Ecuador have a statistical system with a main operating office for general statistics but partially decentralized by sector and an established coordinating mechanism to gather statistics from other sectors, including agriculture. Also, there is a functioning mechanism to establish coordination among different agencies producing statistics.

In the case of Mexico and Peru, they have a statistical system fully decentralized by sector, with a formal coordinating authority. Also both have a functioning mechanism to establish coordination among different agencies producing statistics.

2.3 Strategic framework

All four countries have active National Strategies for the Development of Statistics (NSDS) Colombia's strategy is for the period 2010 – 2014 and covers

crops and livestock statistics. Ecuador's strategy is for the period 2008 -2012 and covers crops, livestock, fisheries, aquaculture, forestry, environmental and rural development statistics. Mexico's strategy is for 2012 and covers crops, livestock, fisheries, aquaculture, forestry, environmental and water resources. While Peru's strategy is for the period 2008 – 2012, it also has developed a National Strategy specific for agriculture statistics for the period 2013 – 2017.

2.4 Dialogue with data users

While in Colombia, Ecuador and Mexico exist formal forums for dialogue among suppliers and users of agricultural statistics; in Peru this forum is informal. Colombia and Ecuador considered this dialogue to be moderately adequate while Mexico and Peru considered it adequate.

2.5 Availability of core data

All four countries report that they have data on crops (production, area sown and harvested, and yield) and livestock (total numbers by species) that is at least reliable. While Colombia and Ecuador rely on probabilistic surveys to produce this data, Mexico and Peru used special studies, expert informants and administrative records.

All countries but Colombia reported to produce reliable fisheries and forestry products data. Ecuador also reported to produce reliable aquaculture data.

All countries have between reliable and very reliable external trade (including prices) monthly data from administrative records.

All countries indicated that they do not produce environmental data. Only Mexico reported to have land degradation data for 2007.

For all the other data items mentioned in the questionnaire, the countries assessed reported different levels of data reliability, periodicity and collection methods.

2.6 Statistical methods and practices

The four countries assessed had population censuses regularly every ten years (Colombia, Ecuador and Peru) or every five years (Mexico). The last census was in Colombia in 2005, Ecuador and Mexico in 2010 and Peru in 2007. While Colombia included questions about agricultural activities in the population census, Ecuador, Mexico and Peru did not.

Colombia has not done an agricultural census in the last 20 years but there is one planned for 2013. Ecuador has done the last agricultural census in 2000, but it was not complete enumeration and it was done using multiple frames; they are planning the next agricultural census in 2014. Mexico has agricultural censuses regularly every five years more or less; the last one was done in 2007 and the next one is planned for 2013. Peru had its agricultural census in 2012 after 18 years since the previous one which was done in 1994.

All countries in this assessment use international standard classifications, calculate the consumer price index and have national account that include agriculture in some form. Also these countries have agricultural, fisheries and forestry surveys although these do not seem to be done regularly. These countries also perform regular household budget surveys.

2.7 International cooperation in agricultural statistics

While Colombia and Ecuador reported that they have not received any kind of international cooperation for agricultural statistics during the last three years, Mexico and Peru reported to have received significant technical assistance covering agricultural statistics manly from FAO and from the Interamerican Development Bank (only Peru).

2.8 Critical constraints

- Up-to-date information technology hardware and software: all four countries put this constrain as relevant or higher level of importance.
- Lack of availability of funds for planned field-oriented statistical activities: all four countries put this constrain as relevant or higher level of importance.
- Number of staff in all categories: all four countries put this constrain as relevant or higher level of importance.
- Low level of demand for statistics: three countries put this constrain as relevant or higher level of importance. One country put it as a dominant constrain.
- Sound methodology implemented for agricultural surveys: three countries put this constrain as relevant or higher level of importance. One country put it as a dominant constrain.

- Office space: three countries put this constrain as relevant or higher level of importance.
- Transport equipment for field activities: three countries put this constrain as relevant or higher level of importance.
- Lack of appreciation of importance of statistical activities at the policy-making level: two countries put this constrain as relevant or higher level of importance. One country put it as a dominant constrain.
- Lack of support at political level in the Government for statistical activities: two countries put this constrain as relevant or higher level of importance. One country put it as a dominant constrain.
- Turnover of professional staff: two countries put this constrain as relevant or higher level of importance. One country put it as a dominant constrain.
- Technical skills of the available statistical staff: two countries put this constrain as relevant or higher level of importance.
- Development and update of Sampling Frameworks: two countries put this constrain as relevant or higher level of importance.
- Interagency Coordination: One country put it as a dominant constrain.

Also, depletion of information sources and refusal or no answer were put as relevant or higher level of importance by one of the four countries.

3. Conclusions

From the analysis of these assessments common strengths and weaknesses in countries agricultural statistics start to emerge. For example, the four countries evaluated here have fairly strong statistical legal frameworks, while they need further development in agricultural surveys.

They also have similarities in the critical constraints, with seven constrains shared by three or more countries.

These pilots testing of the questionnaire also served the purpose of testing it and resulted in some changes in the questionnaire itself but moreover in its filling guidelines. It was apparent in these assessments that not all institutions that collect agricultural, fisheries, aquaculture, forestry, environmental and rural statistics were consulted to fill in the questionnaire.

References

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Experiences of Initial Country Assessment in the CIS (Commonwealth of Independent States)

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Abstract

Commonwealth of Independent States (CIS) is one of the implementation regions of the Global Strategy to Improve Agricultural and Rural Statistics. Interstate Statistical Committee of the Commonwealth of Independent States (CISSTAT) is the implementing partner in the region. In summer 2012 CISSTAT, based on the draft Standard Country Assessment Questionnaire (SQ), has conducted a round of assessment of capacity of CIS countries to produce agricultural and rural statistics. The paper describes the experience of this exercise. In particular, it shows how the questionnaire was adapted and how it was administered, as well as discusses the lessons learnt. It also presents main findings of the country assessment which provided input for the Action Plan to Implement the Global Strategy in the CIS region.

Keywords: Global Strategy; country assessment; CIS.

1. Introduction

Commonwealth of Independent States (CIS)[1] is one of the 5 regions for implementation of the Global Strategy to Improve Agricultural and Rural Statistics [World Bank et al., 2011]. To contribute to the implementation of the Global Strategy in the CIS region, at its 47th meeting in April 2012, the Council of Heads of Statistical Services of the CIS Countries[2] endorsed the proposal of FAO to start developing an implementation plan of the Global Strategy in the CIS region. The Council commissioned Interstate Statistical Committee of the Commonwealth of Independent States (CISSTAT) to develop a draft Plan for implementation of the Global Strategy in the CIS region.

Country assessment is one of the important components of the Action Plan To Implement the Global Strategy [FAO et al., 2012]. Although CISSTAT was quite familiar with the state of agricultural and rural statistics in the CIS region, it was decided to apply a country assessment questionnaire to CIS countries in order to get additional material for analysis and better determine priorities for the draft Regional Plan. This also would serve as a good testing exercise for the country assessment questionnaire that was being developed by FAO.

CISSTAT developed the questionnaire "Assessment of country's agricultural statistics system". In this work CISSTAT was based on the draft versions (as of May 2012) of the "Standard Questionnaire for Country assessment" (SQ) and "Guidelines on Compiling Country Capacity Indicators to Produce Agricultural Statistics" (hereinafter referred to as Guidelines) developed by FAO.

2. The structure of the questionnaire

In designing the questionnaire, the following approach was adopted:

- The structure of the questionnaire followed the structure of the Guidelines.
- Only those questions were included in the questionnaire which were indispensable for compilation of the indicators mentioned in the Guidelines.

The advantages of this approach were subsequently taken into account during the finalization process of the SQ. In particular:

- The structure of the final version of the SQ mainly follows the structure of the Guidelines.
- The questions which are indispensable for compilation of the indicators are marked by the asterisk.

The Table below shows the structure of the questionnaire developed by CISSTAT.

3. Application of the questionnaire and summary of the results

The questionnaire was sent to National Statistical Offices. National Statistical Offices filled the questionnaires in and sent back to CISSTAT for analysis.

Summarization of the information provided by National Statistical Offices allowed to carry out, to a considerable extent, an analysis of the systems of agricultural statistics in the CIS countries. It allowed to enlarge and adjust the draft Plan for implementation of the Global Strategy, in addition to earlier formulated priority issues of development of agricultural statistics. The major summary findings of this country assessment process are as follows.

- In majority of the CIS countries there is no national statistical council which would coordinate agricultural and rural statistics.

Table 1: Structure of the Questionnaire "Assessment of country's agricultural statistics system.

No.	Sections and subsections of the Questionnaire	Number of questions
I	**Section "Institutional infrastructure"**	
1.1	Normative basis	5
1.2	Interconnection with the statistical system	7
1.3	Strategic conception and planning	11
1.4	Ways of interaction with users	12
II	**Section "Resources"**	
2.1	Financial resources	2
2.2	Human resources	5
III	**Section "Information technologies and statistical methodology"**	
3.1	Software	3
3.2	Data collection technology in agricultural censuses or sample surveys	4
3.3	IT infrastructure	5
3.4	International classifications	4
3.5	General statistical activities	8
3.6	Data availability on agricultural markets and prices	10
3.7	Agricultural censuses and surveys	17
3.8	Derived statistics and analysis	9
IV	**Section "Availability of statistical information"**	
4.1	Availability of core statistical data on agriculture, their timeliness and quality	81
4.2	Accessibility of statistical data	3
4.3	Quality awareness of statistical data	3

- In majority of the CIS countries a national strategy (plan/programme) of development of statistics has been developed which reflect agricultural statistics issues as well.
- In many of the CIS countries there is no formal forum for dialogue between agricultural data producers and users, which impedes timely reaction on emerging user needs. At the same time, in many countries there exist two-way communication channels with various user groups within the framework of informal dialogue.
- In the CIS practically all states ensure compilation of production and income generation accounts in agriculture. At the same time, only some national statistical services compile primary income distribution accounts, capital accounts and other accounts in the sphere of agricultural production.
- Countries have practically no experience in compilation of such indicators as quality of water used in animal husbandry, volume and value of aquaculture inputs, indicators characterizing financial conditions of agricultural producers and the role of government and business community in their support.
- Environmental statistics is not sufficiently developed.

4. Follow up

Once the final version of the SQ is published, it will be used by CISSTAT as a basis for developing an improved version of the questionnaire for assessing country capacity to produce agricultural and rural statistics. This questionnaire is supposed to be applied annually and to become an important tool for monitoring implementation of the Global Strategy in the CIS region.

References

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Endnotes

1 CIS consists of 11 member states: Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan (associated member), Ukraine, and Uzbekistan.

2 The Council of Heads of Statistical Services of the CIS Countries was created on 6 February 1992 by the heads of statistical services of CIS. The main duties of the Council are as follows: determining directions of collaboration in the sphere of statistics within the Commonwealth; discussion of and decision-making on important issues of interaction in the sphere of statistics; approval of work programs of its executive body – Interstate Statistical Committee of the Commonwealth of Independent States (CISSTAT) as well as its reports on implemented activities; creation of appropriate bodies and commissions for consideration of issues of statistical methodology and approval of their Terms of Reference; interaction with international organizations; consideration of other issues within the framework of its powers.

IDCB 2

Enhancing the Credibility of Survey Data through Better Quality Data

Organizers: Barbara Rater, USDA/NASS and Gero Carletto, The World Bank

Chair: Barbara Rater, USDA/NASS

Survey data, in general, and agricultural statistics in particular, notoriously suffer from poor quality and low credibility. While quantifying sampling errors in surveys is rather straightforward and based on sound statistical rules, poor data quality is more often the consequence of non-sampling errors for which proper quantification is much more complex, if ever possible. Non-sampling errors may derive from a number of sources including poor wording or inadequate understanding of the survey instruments, intentional or unintended misreporting by respondents, undocumented inclusion or exclusion of sampling units, poor capacity and weak data processing systems. Putting in place strict data quality control protocols, including proper training of interviewers, clear definition of roles in field operations, a sound outreach campaign to enhance the legitimacy of the survey purpose and appropriate data management systems, including systems of concurrent data entry and computer-assisted interviewing, can help mitigate some of the negative consequences of non-sampling errors and enhance the credibility of the information being collected. Recent advances in technology, and the rapidly decreasing costs, can also help strengthen data quality control in survey operations; experience to date clearly demonstrates the great potential of these innovations in supporting and monitoring field operations.

This session will present practical approaches to improving survey data quality, including techniques for training data interviewers, smart data entry systems, and real-time monitoring protocols. It will also provide examples of how technological advances can be used to facilitate the job of survey data producers and enhance the experience of data users.

Papers:

- Zaza Chelidze (Georgia), Barbara Rater, Michael Steiner (USA), “Improving Data Quality in Agricultural Statistics in Georgia”
- Aberash Tariku Abaye (Ethiopia), “Ethiopian Data Quality Assesement Framework (EDQAF)”
- Souleymane Diakité (Senegal), “Statistical Methods for the Detection of Falsified Data by Interviewers and Application Survey Data in Africa”
- Jonathan G. Kastelic (USA), “Improving Survey Efficacy through Data Management and Remote Supervision: experience from recent Living Standards Measurement Study surveys”
- Linda J. Young, Denise A. Abreu, Andrea C. Lamas et al. (USA), “Identifying, Reducing, and Accounting for Misclassification Errors in Farm Status”

Improving Data Quality in Agricultural Statistics in Georgia

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Abstract

The National Statistics Office of Georgia (GEOSTAT) and the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (USDA) have collaborated since 2007 on improving statistical methodology for agricultural surveys in the Republic of Georgia. The paper discusses developments in the advancements to improve data quality in Georgia's agricultural statistics. It will focus on improvements in the areas of methodological works, personnel training, study tours, technical exchanges, survey monitoring, data user and producer meetings, and technological strengthening and advancements. The main benefits for GEOSTAT include: improved capabilities of GEOSTAT staff, enumerators and supervisory coordinators; improved efficiencies and quality in field work operations; improved sampling methodology; and enhanced cooperation with stakeholders, data users and producers. The paper will also address preparations and challenges in frame development and maintenance in preparing for the next agricultural census.

Keywords: agriculture; agricultural surveys; monitoring and evaluation.

1. Importance of agriculture in Georgia

Georgia is rich in agricultural tradition. Agriculture has played an important role in the preservation of its unique identity, self-sufficiency and economic development and today agriculture and food production is lagging well behind development of other parts of the economy. Agriculture provides a potential route for helping many Georgians out of poverty and for improving livelihoods. Agriculture is important because some 50% of labor force is engaged in agriculture, with approximate 85% of them self-employed. Economic diversification away from agriculture is difficult for many rural families in the short to medium term and yet a commercial farm requires much higher capitalization that a subsistence one.

There is considerable potential for growth in agricultural production. During the Soviet period, Georgia was far more agriculturally productive than neighboring countries and on much smaller land areas, but today the country imports a significant proportion of its food. Georgia has good levels of rainfall and a wide variety of rare microclimates needed for growing high value crops, and surprisingly, has low agricultural productivity (more than three times lower than in developed EU countries), massive under-utilization of fertile agricultural land and decreasing soil fertility due to lack of crop rotations or good agricultural practices.

Georgia's agricultural collapse was severe following the end of the Soviet period and a collectivised. From 1991 - 2001 agricultural production contracted by an average of 11% per year, the most profound collapse in the region and reduced Georgian production output to around 32% of its Soviet level. Even after 2001 the Georgian agricultural sector has recovered by only a total of 6%, an average of 0.6% per year, much slower than the rest of the economy. Livestock numbers are less than 16% compared to 1990 and about one third of agricultural land is currently not cultivated, as it is shown in table below (Table 1).

2. Agricultural statistics system in Georgia

In Georgia the Law on "Official Statistics" regulates the entire Georgian statistical system of the country and sets the principles of coordination of all institutions responsible for official statistics. National Statistics Office of Georgia (Geostat) was formed as an independent agency in February 2010. Geostat is managed by a board, consisting of not only government representatives, but also of independent, private sector professionals. In the past, the Department of Statistics was a subordinated agency under the Ministry of Economy.

Although Georgia has a long history of collecting statistics, experience in doing modern statistical

Table 1: Share of Cultivated Land and Livestock Numbers 1990-2012.

Year	Sown Area (ha)	Livestock (cattle head)	Pig	Agriculture Share of GDP %
1990	701,900	1,298,300	880,200	31.6%
1995	453,100	973,600	652,600	44.4%
2000	610,800	1,177,400	443,400	21.9%
2005	539,600	1,190,300	455,300	16.7%
2006	330,200	1,080,300	343,500	12.8%
2007	297,200	1,048,500	109,900	10.7%
2008	329,300	1,045,500	86,400	9.4%
2009	289.700	1,014,700	135,200	9.4%
2010	256.700	1,049,400	110,100	8.4%
2011	262,400	1,087,600	105,100	8.8%
2012*	259,600	1,128,800	204,300	8.4%

* Preliminary data

surveys is not sufficient. During the Soviet time, everything was centrally planned and statistics was not an exception. There were no sampling practices. After the collapse of the Soviet Union, the Georgian statistical system like in other former Soviet Union countries started to develop independently, introducing the new methods of surveys. Therefore, the number of well-trained and experienced statisticians was limited. In addition, due to the limited budgets, it was always difficult to attract young, talented statisticians. The combination of all factors affected the quality of official statistics, causing low public trust and weak coordination within the statistical system.

Therefore, immediately after the collapse of the Soviet Union all statistical surveys were built on experience of advanced statistical systems and were strongly supported by international organizations or National Statistics Institutions (NSI's) of other countries.

Agricultural statistical survey dates back from 2007 and form the very beginning was supported by United States Department of Agriculture (USDA).

The National Agricultural Statistics Service (NASS) of USDA has collaborated with Geostat since 2006 to improve agricultural data in Georgia by enhancing the capacity of Geostat to collect, analyze, and disseminate agricultural statistics. NASS work with Geostat is part of the USDA Caucasus Agricultural Development Initiative (CADI), with funding from the U.S. Department of State Freedom Support Act.

Sample Surveys of Agricultural Holdings are the main information source for current agricultural statistics in Georgia. The survey completely covers the controlled territory of Georgia, not including the territories of Abkhazia and former South Ossetia. Each round of the survey covers one reference year and consists of 5 interviews.

During all five interviews, the same agricultural holdings (about 5100) are interviewed which are selected by a two-stage random sampling procedure out of about 815 000 agricultural holdings existing in Georgia (the term agricultural holding means any economic unit engaged in agricultural production, without regard to the scale of production, legal status of the unit and the tenure form of agricultural assets). Each year a new sample is selected. However, it should be noted that large agricultural holdings (which are called Extreme Operators) are sampled with complete coverage, so they are interviewed each year systematically (about 350 holdings).

- **Inception Interviews** are conducted during the last ten-day period of January of the reference year. It is conducted by means of an Inception Questionnaire. During that interview, the sampled holdings are identified and the agricultural inventory and production on the holding as of January 1st is recorded on the questionnaire.

- **Follow-on Quarterly Interviews** are conducted during the first ten-day periods of April, July and October, respectively. They are conducted by means of a Quarterly Questionnaire. The questionnaire records information about

agricultural activities at the holding during the corresponding quarter.

- **Final Quarterly Interview** is conducted during the middle ten-day period of January next to the reference year. It is conducted by means of a Final Questionnaire. It provides a summary of agricultural activities at the holding during the whole year.

Based on the survey, the following information is published via internet:

Time	Type of Data ***	Reference Period
End of February	Animal Husbandry - Preliminary	Quarter IV – Previous Year
End of April	Crops – Preliminary	Previous Year
End of May	Animal Husbandry - Preliminary	Quarter I – Current Year
End of June	Agricultural Indicators – Final *Publication "Agriculture of Georgia"* National and Regional Level Data	Previous Year
End of August	Livestock – Preliminary Sown Areas of Temporary Crops - Preliminary	Quarter II – Current Year Spring – Current Year
End of November	Animal Husbandry – Preliminary	Quarter III – Current Year

*** All Preliminary Data published at national level

The preliminary data are published at the level of the whole country while the final data at more detailed geographical level. The sample size is insufficient for obtaining reliable results for all indicators at the regional level. The indicators of those regions for which, due to insufficient sample size, it is impossible to obtain reliable results are published in the aggregated form under the heading "the remaining regions."

Final, IV quarter, interview is especially important, enabling checking and harmonization of the data of all previous inquiries. At the same time, data weighting is carried out with non-responses taken into account. After finishing the database cleaning and editing, the output tables are compiled. The obtained results are compared with corresponding results of the previous periods and other data sources. In cases of significant differences, the possible causes of those differences are identified and analyzed. Only after that are the data considered to be ready for publication.

In the remainder of this paper, improvements in data quality of agricultural statistics and its challenges will be discussed focusing on of cooperation with The United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) as well as the benefits for Geostat derived from mutual cooperation with USDA will be highlighted.

3. Improved Data Collection and Management Procedures (with emphasis on NASS collaboration)

3.1 Pre-survey, training and capacity building

Sample Design. The sampling frame for agricultural surveys contains approximately 815,000 holdings. Extreme operators (EOs) are included in the survey with certainty. NASS and the Agricultural and Environmental Statistics Division (AESD) of Geostat determined criteria for EOs, using mathematical levels from frame values of land items, crops, and livestock commodities by region. The non-EO sample was selected using a two stage sample design. The first stage is a stratified random sample of holdings within a village. Each region has its own unique village strata and holding strata criteria, based on targeted commodities of importance in each region.

Geostat staff has been trained by USDA experts. All AESD staff, as well as all field enumerators are trained at least once a year. AESD personnel, in turn, become trainers and they intensively train field staff. The following training opportunities have been provided by USDA during the mutual cooperation:

- ***Permanent Staff Training on Data Cleaning.*** A short training was conducted for the permanent staff of AESD on the data cleaning process. Experts from USDA shared their experience with the staff of the division on this issue.

AESD presented logical controls and edit parameters used for cleaning the database. USDA gave recommendations regarding how to establish these controls which were taken into consideration by the division.

- ***Training of Trainers (Permanent Staff)***. There was one-day training for the permanent staff on how to plan and conduct a successful training.
- ***Training of Enumerators on Survey Questionnaires and Interviewing Techniques.*** Training of enumerators is very important for the survey as the proficiency level of enumerators determines the quality of the data collected by the survey. In this regard, training of enumerators is one of our highest priorities. In 2011 three trainings were conducted by Geostat for enumerators. In addition to the training of enumerators on the questionnaire by the staff of AESD, experts from USDA shared their experience and delivered very useful and interesting presentations for enumerators – on the concept of sample survey, on how to deal with difficult respondents, how to gain and maintain respondent cooperation, and other important issues.
- ***Training of Coordinators on Data Entry Software.*** Starting from the 3rd quarter 2012 survey, AESD introduced a new procedure of data collection – data entry and data validation was done by the coordinators in the municipalities. Coordinators are the hired persons by Geostat, who are responsible to coordinate field work in his/her work area (municipality). This transition process was difficult and required close monitoring and supervision at all stages of the process. USDA was involved very actively in this process.
- ***Study Tours.*** One of the fruitful components of the project is assistance in study visits. Top management and staff of Geostat head office and heads of regional offices benefited from this exceptional opportunity. This was a really great contribution to staff development as well as an opportunity for Geostat management to participate at international forums and conferences. Study tours to the USA were organised and hosted by USDA. Geostat management, staff from AESD and heads of regional offices visited USDA NASS headquarters office and some field offices around the states. Additionally, Geostat management were given the opportunity to participate in the International Statistical Institute World Statistics Congress and the International Conference on Agricultural Statistics (ICAS).

Equipment. USDA helped Geostat to upgrade its physical and technical infrastructure. AESD is well equipped by personal computers, notebooks, printers and statistical software (STATA).

3.2 Outreach efforts

Dialogue with data users is the way which improves trust towards NSOs and its official statistics. USDA has been actively involved in co-organization of data users and producers meetings in Georgia. Together with Geostat management, USDA experts actively participated in discussion with different data users. Those meetings helped Geostat to identify needs of data users, especially the Ministry of Agriculture. As a result of these meetings joint working group of Geostat and the Ministry of Agriculture created and draft of memorandum of cooperation initiated.

3.3 Monitoring data quality

Survey monitoring was never done in agricultural statistical survey before 2010. USDA assistance was very important in order to evaluate performance of field staff and to identify erroneous and false cases of the field. Monitoring also gives an opportunity to field staff if needed. Every enumerator had several interviews randomly selected for quality control.

- In 2010 – Every Enumerator by one stage:
  – After the second quarter
- In 2011 – Every Enumerator by two stages:
  – 2/3 part after the second quarter
  – 1/3 part after the third quarter
- In 2012 – Every Enumerator by two stages:
  – 2/3 part - was completed after the second quarter
  – 1/3 part - to be completed after the third quarter

3.4 Survey proper

More than 200 interviewers are engaged in the survey. Face to face interviews are conducted via visiting the holdings. To each municipality a coordinator is assigned whose duties are to organize and control the work of the interviewers and to validate the completed questionnaires. From the 3rd quarter 2012 survey, coordinators duties increased – now they have also to enter the questionnaires into computer by means of a specially elaborated software application.

Before the 3rd quarter 2012 survey, completed questionnaires (paper) were gathered in Regional

Offices from which they were transported to the Central Office. The collected information was entered into computer by operators within 15 days after the questionnaires were received at the Central Office. After the 3rd quarter 2012 survey, a new procedure was implemented. The questionnaires are data entered by coordinators in the field (municipalities) and were validated by the computerized data validation program which reveals the questionnaires with inconsistencies. Data inconsistencies could then be resolved in the field in a more timely and efficient manner. After that, paper questionnaires are gathered in Regional Offices from which they are transported to the Central Office. The staff members of AESD control the data entered by the coordinators and correct inconsistencies via comparing with the questionnaires and phone checking with the interviewers and respondents. In case it is impossible to check a questionnaire by phone, it is corrected logically. At present, computerized validation is carried out based on about 200 criteria.

3.5 Post survey

Data Cleaning. USDA is also involved in the process of data cleaning. The data is analyzed and checked to identify outliers and suspicious data. Some plots and diagrams reflecting outliers and suspicious data are used by AESD. Such cases are considered and the data are rechecked by the staff of AESD. Also every special (non typical) case influencing the results is analyzed very carefully and a decision is made by mutual agreement. As the sampling frame is out of date, there are cases when holdings are assigned non typical ("wrong") weight compared to its size. Such cases influence the final results. These cases are considered individually and recommendations made by USDA are taken into account by AESD.

Data Analyses. Data analysis takes place within record and across records. After producing statistics, indicators are compared with corresponding results of the previous periods. Various statistics are analyzed to check how different indicators are logically connected to each other, for example how production, consumption and import-export indicators are connected to each other. USDA is involved in this process and recommendations are taken into account by AESD.

Estimating Reliability. After the data are cleaned and ready to calculate various statistics on agriculture, coefficients of variation are calculated by USDA which reflects the reliability of the survey indicators. Coefficients of variation of various indicators are provided to AESD which are used to decide which data are more or less reliable for publication for the data users and which are not.

Updating the Sampling Frame. The sampling frame of the sample survey of agricultural holdings is out of date; therefore it is our special concern to update it. Regarding this issue, much work is done every year. USDA is actively involved in this area as well. Recommendations made by USDA are taken into account by AESD. In 2012, data on large agricultural holdings were provided by the Ministry of Regional Development and by the Ministry of Agriculture, they collect these data from the municipalities. These large agricultural holdings were checked whether they were in the frame or not. Large agricultural holdings not on the frame were identified, a special survey was conducted (by telephone interview) to obtain the needed data on these holdings and they were added to the frame.

4. Achieved results and progress made

Due in large part to the support of USDA, Georgian agricultural statistics are developing and improving every year. In particular, the following achievements were fulfilled with assistance of USDA:

- ***Skills of the permanent staff of Agricultural and Environmental Statistics Division (AESD).*** Trainings conducted during the last three years improved skills of the permanent staff of AESD. Proficiency level of the permanent staff directly influences the quality of agricultural statistics produced by Geostat.
- ***Field operations with special IT tools.*** The field operations procedures for data collection have improved. Data entry and data validation procedures are now conducted in municipalities by the coordinators, not in the Central Office. Transition to the new procedure of data collection will improve quality of agricultural statistics and will reduce the time gap between the field operations and data dissemination.
- ***Skills of Enumerators and Coordinators.*** Trainings of enumerators and coordinators improved their skills. High proficiency level of the field staff guarantees the quality of the collected data, which is the basis for producing high quality agricultural statistics.

- ***Quality of the Sampling Frame and Agricultural Statistics.*** Quality of the frame is one of the most important issues in sample surveys. Incomplete frames cause incomplete statistics. The work that has been done and continues to be done for updating the frame improved agricultural statistics.
- ***Cooperation with Data Users****.* USDA contributed significantly to the improvement of cooperation and exchange of Geostat with data users. Staff from the Ministry of Agriculture and other stakeholders participated in the data users meetings conducted by Geostat.

5. Difficulties and challenges

Update the Sampling Frame. Updating of the frame still remains a major challenge of the Sample Survey of Agricultural Holdings. The next agricultural census will fully update the frame. Until then, we should work to update frame from other sources. The updated frame will give us more quality data and additional statistics on agriculture requested by data users.

Transition into New Procedures – Data Entry and Initial Data Cleaning in Municipalities. The second main challenge for Geostat is transitioning to the new procedures – to implement data entry and data cleaning procedures in municipalities. This will increase the quality of the agricultural statistics and reduce the time gap between the field operations and data dissemination.

2014 Agricultural Census. An Agricultural Census will be conducted in November 2014, in conjunction with a Population Census. The decision on conducting the censuses was made by the Georgian Government in spring 2013. Preparations for both censuses must be completed in a relatively short amount of time.

Demand for Additional Agricultural Statistics. The Georgian Government has made development of the agricultural sector the number one priority for Georgia. Georgia was a leading agricultural region of the USSR. The break-up of the Soviet Union sent the agricultural sector into a freefall, with the agriculture share of Georgian GDP falling from 45% to less than 9%. The Ministry of Agriculture of Georgia will implement a series of programs to increase agricultural production in Georgia, and has requested a large increase in the quantity and frequency of agricultural statistics.

6. Future plans

- Continue training efforts for enumerators to improve qualification of the field staff;
- Continue monitoring and quality control of field enumerators to improve and maintain high data quality;
- Planning the next agricultural census, scheduled for 2014;
- Develop a plan to updating the sampling frame after the census;
- Expand the agricultural surveys program to meet the demands for new agricultural statistics.

Ethiopian Data Quality Assessment Framework (EDQAF)

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Abstract

Central Statistical Agency of Ethiopia (CSA) has developed the National Strategy for the Development of Statistics (NSDS). The NSDS is a road map for the statistical activity to be conducted in the five years. The NSDS have six themes and one of the themes refer to the development of EDQAF to improve the quality of statistical data by assessing the system and the output. The design of the EDQAF involved the participation of sector ministries and their comments were incorporated. International experiences were also taken in to account in the EDQAF design.

EDQAF has four different phases. These phases are Phase 1: Initiation and Preliminary Investigation, Phase 2: Systems Assessment, Phase 3: Overall National Assessment, Phase 4: Reporting and Conclusion. EDQAF document defines the data quality dimensions in terms of output, process and Institutional Environment Quality Dimensions.

Keywords: data quality dimensions; data quality assessment phases.

1. Introduction

Good quality data is important for planning and to support decision-making. Monitoring and evaluation of Growth and Transformation Plan (GTP) and other millennium development goals requires good quality data. Assessing the quality of the data will ultimately result in improvements in the data quality.

The objectives of the Central Statistical Agency are to collect, process, analyze and disseminate the necessary socio economic and demographic statistical data through census, sample surveys, continuous registration and administrative recording system; and to provide technical guidance to government agencies and institutions in their endeavour to establish administrative recording, registration and reporting systems; and build the capacity required for providing directives and consultations in database creation and development of administrative records and registration systems. Looking at the powers and duties of CSA, one of the duties is to design and monitor the implementation of statistical recording and reporting systems to be followed by government agencies or institutions and other organizations. From this act and associated powers and duties, it can be deduced that CSA is mandated to develop and implement EDQAF.

CSA designed National Strategy for Development of Statistics (NSDS) Covering period 2009/10 – 2114/15. Six strategic themes of which two are very relevant to quality issues. The six themes are Theme 1: implementation of the statistics law, theme 2: developing data quality procedures, theme 3: enhance advocacy and use of statistics, theme 4: methodological improvements and statistical modernization, theme 5: capacity development in the NSS. Theme 6: Relationship of NSDS to the monitoring and evaluation of Growth and Transformation Plan (GTP). Strategic Theme 1: Implementation of the Statistics Law describes about Establishment of an NSS methodological and support unit in the CSA for quality assessment and NSS capacity building, Development of common standards, classifications & definitions for the NSS for consideration by the Council as legal decrees for official statistics, Introduction of memoranda of understanding between the CSA and its NSS partners, Coordination of donor relations and statistical initiatives in the NSS. Strategic Theme 2: Develop data quality procedures states about Developing a data quality assessment framework for Ethiopia, Development and support of ministry/agency statistical units in NSS partners, Strengthening of NSS quality and support unit in the CSA for quality assessment and NSS capacity building. To accomplish the duties given in the statistics act and implement the NSDS, CSA designed the EDQAF.

2. EDQAF objectives

The EDQAF is designed to meet needs of data users by Providing better quality data, Providing data of known quality - quality reports, Identifying/labelling “official statistics”. The EDQAF is also designed to meet needs of data producers by Providing

quality reports, Highlighting quality problems and proposals, Ensure quality proposals are tabled with senior managers. It is also designed to meet needs of 0ther stakeholders/ funding agencies by Providing evidence of well conducted statistical system and good quality data output.

The Target Outcome of EDQAF is more satisfied users, using better statistics to make more informed decisions. The Overall Objective is to introduce a comprehensive quality assessment program that summarises the quality of NSS data outputs for the benefit of both data producers and users, and that identifies quality problems and potential quality improvements and brings them to the attention of producers and senior managers for action. The Specific Objectives are to assess the quality of all NSS data outputs and of the systems that produce them, to identify quality problems and to highlight the major ones, to propose quality improvements, to ensure that quality problems and potential improvements are brought to the attention of senior management, to review the extent to which quality problems have been addressed in the next assessment round, to provide producers and users with a quality summaries, including quality scores by dimension, to provide quality scores enabling labelling of official statistics.

3. The EDQAF development process

The Approach to EDQAF development is that international standards and best practices are used in designing EDQAF. These standards are adapted to the Ethiopian situation. The Procedures/steps used are First draft EDQAF Developed by CSA, Second draft EDAF Distributed to NSS members for comments, Stakeholder workshop conducted, Final EDQAF prepared and adopted by the statistics council.

4. EDQAF basic assessment areas

EDQAF is designed in such a way that it assesses both the system producing the statistical data and also the final out put. Two major areas of dimensions defined. EDQAF Data Output Quality Dimensions are Relevance, Accuracy, Timeliness and Punctuality, Accuracy and Interpretability, Coherence and Comparability. EDQAF Systems Quality (Process and Institutional) Dimensions are Methodological soundness, Human resource management, Standard operations, Data management and security, Quality assurance/control, Reporting burden and performance, Mandate, Resources and Quality Management, Integrity, Provider Transparency and Confidentiality.

5. EDQAF assessment phases

EDQAF assessment involves four assessment phases. The se are Phase 1: Initiation and Preliminary Investigation, Phase 2: Systems Assessment, Phase 3: over all National out put Assessment, Phase 4: Reporting and Conclusion. Phase 1: Initiation and Preliminary Investigation involves setting up the assessment schedule and working relationships, undertaking preliminary discussions with data producer and reviewing documentation, establishing logistics of the assessment, in particular, whether or not it will include a regional systems/process phase. Phase 2: Systems Assessment involves On site assessment at each of woreda, zonal, and/ or regional levels through which the data pass, assessment of data collection, capture, processing and transmission procedures, based on discussions with production staff, and review of metadata and other documentation, at each level, verification of (samples of) data received and transmitted at each level. Phase 3: Overall National out put Assessment includes Assessment of process, institutional and output quality based on: detailed discussion with production staff at national office, review of metadata and other documentation at national level, review of results of Phase 2 assessment (if conducted). Phase 4: Reporting and Conclusion involves preparation of assessment results, comprising quality summaries and descriptions of major quality problems and potential quality improvements, distribution and discussion of results with data producer, senior managers having oversight of data production process, and key data users, formally wrapping up assessment process and provisionally scheduling next assessment.

6. Scope of EDQAF

A statistical out put data set produced by NSS is the target objects of EDQAF. NSS comprises CSA and other sector ministries producing statistical data. National level datasets produced by government agencies or institutions and that produce, or could produce government statistics are the scope of assesement. Regional, zonal, and woreda datasets

which contribute to national datasets are also in the scope. Regional, zonal or woreda organisations are free to adopt and implement the EDQAF for self assessment.

7. Questionnaire format of the EDQAF assessment

Standard questionnaire designed for each phases of the assessment. Indicator related to the dimension defined in the questionnaire. Four levels of certification are designed for each indicator. Level 4: quality statistics, Level 3: acceptable statistics, Level 2: questionable statistics, Level 1: poor statistics. Level 4: Good – the data/process/institution satisfies(s) all the quality requirements associated with the quality dimension. Level 3: Acceptable - the data/process/institution satisfies(s) many of the quality requirements. Level 2: Questionable - the data/process/institution satisfies(s) few of the quality requirements. Level 1: Poor - the data/process/institution satisfies(s) none of the quality requirements, or cannot be assessed.Dataset will be labelled as a source for official statistics if and only if it has score of at least 3 for the accuracy and sound methodology, and a score of at least 3 averaged over all quality dimensions included in Overall National (Phase 3) Assessment.

A soft ware which will help to analyse the data collected for data quality assessment is designed. This software helps to enter and store the data and also to produce outputs from the data.

8. Conclusion

There are different initiatives for developing and implementing data quality assurance frame works. The UN statistics division designed National Quality Assurance Frame work (NQAF) and also showed the mapping of the frame work with other frameworks. The European Code of practice, the Canadian quality frame work, the IMF DQAF and the South African Quality assurance framework are also initiatives towards data quality. African Union also designed African charter on Statistics to be adopted and implemented by member states.

The development of EDQAF by CSA Ethiopia is a timely decision. The frame work by itself is not the end result. Implementation of the frame work needs serious attention and requires commitment and coordination.

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Statistical Methods for the Detection of Falsified Data by Interviewers and Application Survey Data in Africa

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Abstract

Data quality has a significant impact on the results of analyzes. The concern for quality is all the more justified, if those responsible for the collection are not the professional trade. According to the director of the Institute of Statistics of Mali, 80% of people working in the field of statistics in Mali are not statisticians. In this work, we applied several methods to detect falsified data. Including law Benford, hierarchical and mixed ascending classification or discriminate analysis. Indicators used: the percentage of extreme values, the percentage of missing values, the percentage jump so the percentage of modality "Other." The results show that the classification seems to be better compared to the application of Benford's law or discriminate analysis. Also the best indicators for the detection of falsified data are ratios of extreme values and missing values. These ratios are much lower in the falsifiers.

Keywords: falsifiers; interviewers; Benford's law; classification; discriminant analysis.

1. Introduction

Data quality is one of the main concerns of users. Data quality can be affected by different ways, including, among other poor design media collections, the bad answers provided by the respondent or forgery by the interviewer it is the latter that concerns us in this study. Several authors including Schreiner, Pennie, and Newbrough (1988), Schräpler and Wagner (2003) and more recently by Sebastian Bredl, Kötschau Kerstin and Peter Winker (2012).

The work is applied several methods for detecting counterfeiters then compare the results. Thus we will apply a set of methods including Benford's law, the hierarchical classification after factor analysis, and the joint classification and discriminate analysis. These methods allow interviewers to characterize risks from some indicators defined on the characteristics of the responses (extreme responses, missing values, the number of hops, the time of filling the questionnaires, the number of completed questionnaires...).

2. Results of statistical method for detecting tampered data.

2.1 The Benford's law

Benford notes that the probability of the first non-zero number of digits can be described by the following law:
$P(d) = Log_{10}(1 + \frac{1}{d})$ for $(d = 1,2,3,4,5,6,7,8,9)$.
We have $\sum_{d=1}^{9} P(d) = 1$
This law is widely used especially in the field of detection of financial fraud. It was used by Swanson and al. (2003) to show that the distributions of the first digits of numbers in the "Consumer Expenditure Survey of the United States" followed the Benford distribution. The idea is that a significant difference in the distribution of first digits of an investigator with the i Benford indicate a risk of falsification of figures that investigator. This difference can be measured with several indicators including the chi-square distance.

$$\chi_i^2 = n_i \sum_{d=1}^{9} \frac{(X_{id} - X_{ad})^2}{X_{ad}}$$

n_i: the total number of digits in the first survey of individual i

X_{id}: the proportion of the first digit in the questionnaires individual i

X_{ad}: the proportion of first digit according to Benford's law.

A value χ_i^2 too high indicates that the interviewer i is an "investigator at risk."

The data come from a survey conducted by the National Superior School of Statistics and Economic Analysis (ENSAE) Senegal's Cyber Cafes and users. The survey was conducted by students Works Engineer Statistics (ITS) in the second and third years of training we denote respectively by T1, .., T11 and F1, ..., F22.

It turned out that some engineering students (especially those of the third year) who already had to make inquiries in the past have not been on the field to

meet users cyber cafes and generated data. The objective of the work will be to analyze the data with a view to know the risk of tampering with the interviewers. We will in the first instance, from the methodologies presented above regarding Benford's law, analyze the data quality.

The results showed that about 32 interviewers not involved the study only 10 meet the criteria for Benford's law for a risk probability of 5% corresponding to a chi-square $\chi_i^2 = 15{,}4$.

These interviewers are ten (F3, F6, F15, F16, F18, F19, F20, T3, T5, T8) represent only 31.25% of total interviewers. This low percentage allows us to say that in this context the application of Benford's law to detect fraudulent data gives rather mixed results.

Another major limitation of Benford's law is that it is only usable on quantitative variables questionnaires. Or falsification concern quantitative and qualitative variables as well.

2.2 The methods of factor analysis

Two methods of factor analysis can be used. This is the automatic classification and discriminate analysis. The latter requires a priori knowledge of forgers. The main idea is to use a number of indicators to highlight the falsifiers and make a classification as a result of a factor analysis of these indicators.

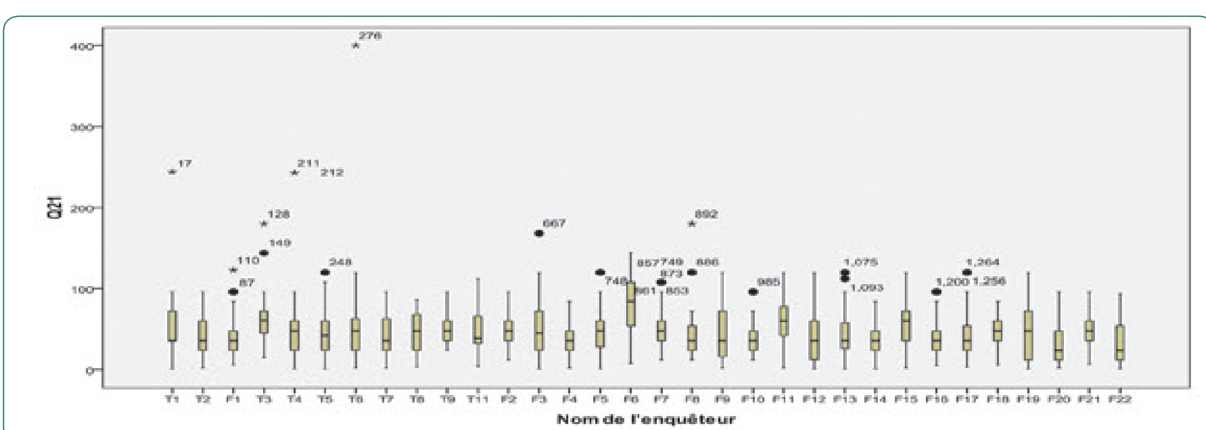
In the literature, Schafer et al. (2005) assumes that observed fewer missing values in the falsifiers. So they tend to respond to all questions. The first indicator obtained as a result of this situation is the "***partial non-response rate***", defined as the ratio of missing values on the total number of questions. In addition to Schafer et al. (2005) other authors such as English and Porras (2004) finds that the falsifiers choose less extreme answers to common questions, that is to say, the answers that seem more likely. Based on this observation, we can define a second indicator as the "ratio of extreme answers for measure questions" measured by the ratio of the number of extreme responses to total responses. Another observation is that counterfeiters tend not to choose the modality "***other specify***" for the semi-open questions, we defined a third indicator as the "***ratio other modality to specify***" in relation to all questions. This ratio should be low to the falsifiers. The fourth indicator is the fact that counterfeiters tend to choose the "no" response to the screening questions for failing to answer the questions below. We define a fourth indicator as the ***"ratio of no answers or jumps"*** to the filter questions which should be high in the falsifiers. Indeed, the choice of response not possible to perform jumps and complete the questionnaire faster.

Other indicators could be included in the analysis as the average time or the number of people interviewed per day Bushery et al. (1999). For this in our example the number of completed questionnaires is fixed in advance and we do not have the means time for interview. This place is also the number of jumps. Indeed, the greater the leaps you take less time to complete the questionnaire.

- **Ratio of extreme values for quantitative variables**

On this box mustache below, we see the presence of outliers in some interviewers. Note that outliers should be far fewer in falsifiers (F) compared to interviewers were on the ground (T). We consider the values that are beyond the first and last deciles as outliers for quantitative variables. From the box mustache, we can say that some interviewers include (F20, F21, F22, T7, T8, T9, T11 ...) pose risks falsification.

Figure 1: Box plot in time using the Internet according to interviewers.



- **Ratio of modality "others" specify for semi open-ended questions**

As noted above, forgers tend to choose the terms present in the questionnaire. Indeed the choice of modality "other" often requires precision and therefore after further reflection for the forger. On the chart below we have the ratio of other modalities. It is noted that some interviewers have hardly chosen method "Other." These interviewers as (F6 and F15). These interviewers may be suspected of having falsified the data.

- **Ratio of answers "no" followed by a jump**

On the chart below, we see the proportions of "no" answers too high for some interviewers. These proportions reach 90% in some interviewers (T7 and F5). This observation leads to a suspicion of falsification of data from the interviewers.

- **Partial non-response rate**

In the chart below, we have the proportion of missing values by interviewers. The absence of missing values for T1 interviewers, T2, F1, T3, T4, T5, T9, T11, F2, F3, F5, F6, F8, F10, F11, F12, F13, F19 and F20 causes a hint of falsification for these interviewers.

- **Results of factor analysis**

The results of the factor analysis show a number of extreme values opposition to interviewers that the choice of the other modality, while the proportion of missing values appears to be independent of the other two.

- **The hierarchical clustering**

We performed a hierarchical clustering of factors after factor analysis. We obtain a class composed of twelve individuals who can be called "class falsifiers." Indeed, as shown in the table below, it is characterized by a proportion of missing values lower (an average of 0.25 against 1.34 for the entire population) and much less extreme values (an average of 15.94 against 24.33 for the entire population).

On the individuals who composed, we find both students in the second year than the third year. Individuals who compose it are F1, F2, F10, F8, F13, F16, T1, T3, T4, T8, T9, T11.

Figure 2: The ratio modality "Other" for the semi open-ended questions.

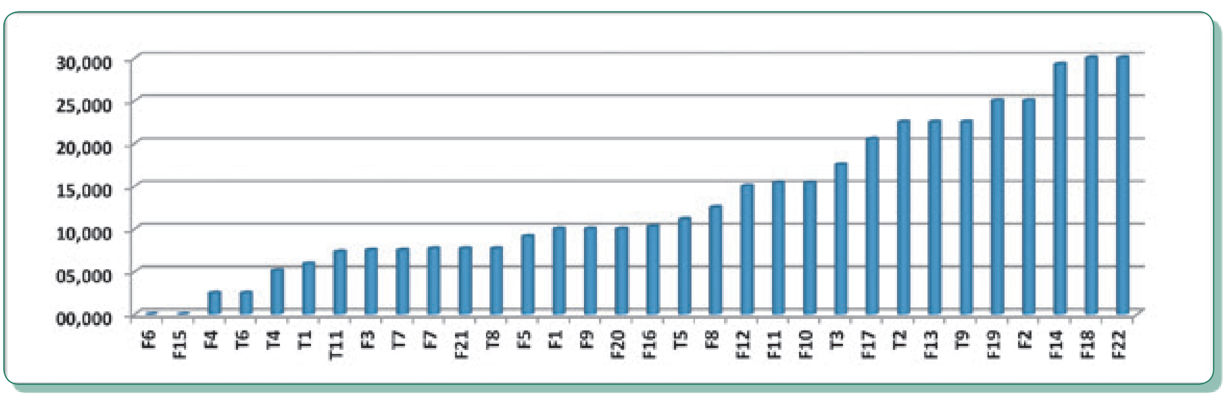


Figure 3: Proportion of answers "No" followed by jump.

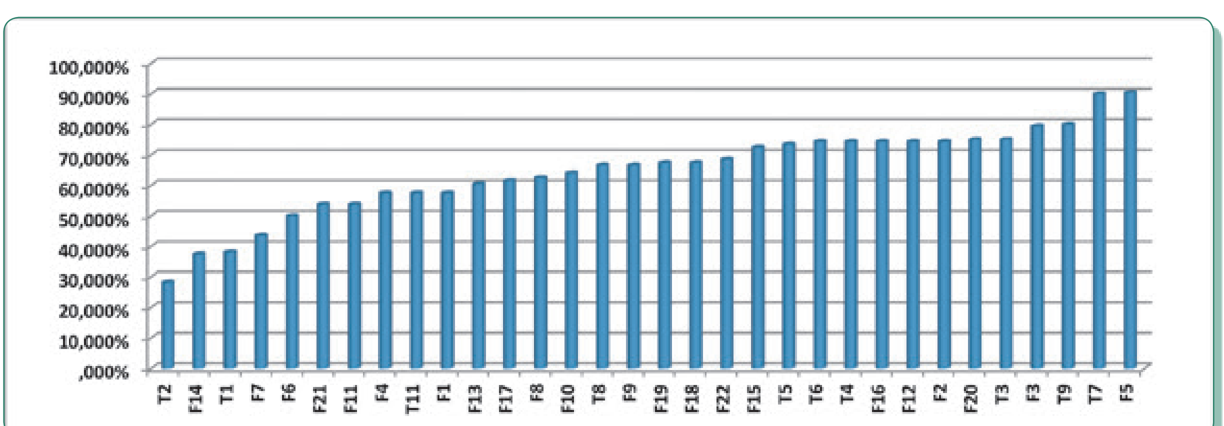


Figure 4: Proportion of missing values investigator.

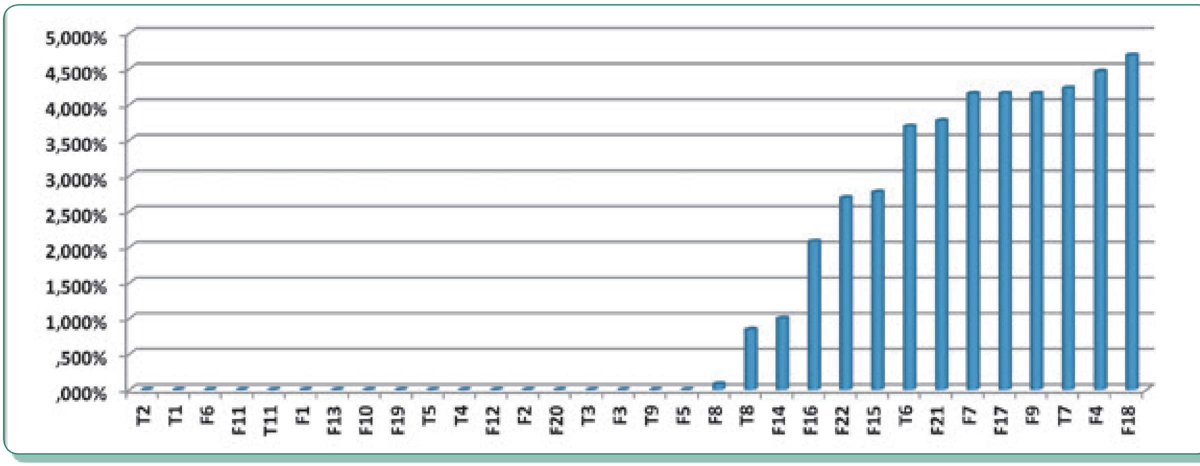


Table 1: Indicators that characterize the class of forgers.

V.TEST	PROBA	MOYENNES CLASSE	MOYENNES GENERALE	ECARTS TYPES CLASSE	ECARTS TYPES GENERAL	VARIABLES CARACTERISTIQUES NUM.LIBELLE	IDEN
		CLASSE 1 /		(POIDS =	12.00	EFFECTIF = 12)	aala
-2.61	0.005	0.25	1.34	0.60	1.79	5.Missing	C6
-2.93	0.002	15.94	24.33	6.28	12.35	2.Extreme	C3

Table 2: Individuals suspected false after the classification.

RK	DISTANCE	IDENT.	RK	DISTANCE	IDENT.	RK	DISTANCE	IDENT.
1	0.07920	F10	2	0.29510	F8	3	0.59224	T8
4	0.70576	T3	5	1.02946	F1	6	1.24404	F13
7	1.30482	T11	8	1.48205	T4	9	1.57342	F16
10	2.65791	F2	11	3.34308	T9	12	4.46437	T1

Table 3: Individuals suspected of tampering after the mixed classification.

EFFECTIF: 15

RK	DISTANCE	IDENT.	RK	DISTANCE	IDENT.	RK	DISTANCE	IDENT.
1	0.15570	F10	2	0.48675	F8	3	0.65321	F13
4	1.08539	T3	5	1.17609	T8	6	1.25466	F1
7	1.72616	T11	8	2.02974	F16	9	2.43074	F2
10	2.75543	T4	11	3.52119	T9	12	4.17213	T1
13	5.19323	F14	14	6.58308	T2	15	8.41758	F18

Table 4: Calculating the rate of misclassification after discriminant analysis.

TABLEAU DE CLASSEMENT

GROUPES D'ORIGINE	POURCENTAGES DES CLASSEMENTS BIEN CLASSES	MAL CLASSES	TOTAL
AA_1	14.00	6.00	20.00
	(70.00)	(30.00)	(100.00)
AA_2	8.00	4.00	12.00
	(66.67)	(33.33)	(100.00)
TOTAL	22.00	10.00	32.00
	(68.75)	(31.25)	(100.00)

- **Mixed Classification**

To analyze the robustness of the hierarchical clustering obtained, we took the classification using the method of mixed classification. Indeed Hierarchical Clustering has the unseemly not be a global optimum in the sense that the partition constructed at a given level depends on the score obtained in the previous step. The idea of mixed classification is to try to get as close as possible to the optimal classification if it is using the joint use of the Hierarchical Clustering and Classification of Mobile centers. The results give us a class of “falsifier” characterized by only a small proportion of extreme values (15.73% against 24.33% for the total population) in contrast to the hierarchical classification where we had a class of “falsifiers” characterized by a low proportion of missing values and outliers. The class is composed of 15 individuals from whom we have 12 individuals in the Upward classification (F1, F2, F10, F8, F13, F16, T1, T3, T4, T8, T9, T11) plus three individuals who are F14, F18, T2. Ultimately we can consider as falsifiers of 12 individuals confirmed by the Joint method CAH. Indeed, these individuals have statistically lower than those of other interviewers missing and extreme values. NB: Some of these interviewers are found to have cheated at the end of the investigation it is particularly interviewers F2, F10, F13, T9, F16.

2.3 Discriminant analysis

We will determine the variables that best characterize the two classes obtained, by simultaneously taking into account in the analysis. The class variables will be added to the data table, and play the role of variable explained in discriminant analysis from factorial components (variables) and then back to the original variables. The results show that of the 32 individuals, 22 were correctly classified is an error classification rate of 31.25%. In addition to the four variables used in the analysis, only the percentage of extreme values can be well discriminated forgers non falsifiers.

3. Conclusion

Data quality a central issue in the field of statistics because it affects the results of the empirical analysis. In this work, we applied several methods to detect falsified data. The indicators used in this study are: the percentage of extreme values, the percentage of missing values, the percentage jump so the percentage of modality “Other.” The results show that the classification seems to be better compared to the application of Benford’s law or discriminant analysis. Also the best indicators for the detection of falsified data are ratios of extreme values and missing values. These ratios are much lower in the falsifiers.

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Improving Survey Efficacy through Data Management and Remote Supervision: experience from recent Living Standards Measurement Study surveys

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Abstract

The World Bank's Development Research Group Living Standards Measurement Study (LSMS) has long been dedicated to improving the type and quality of data collected by national statistics offices in developing countries and the continual advancement of survey methodologies. In recent years the LSMS team has initiated the LSMS-Integrated Surveys on Agriculture (LSMS-ISA) project which seeks to specifically target the lack of, and growing need for, high quality household and agriculture data in Sub-Saharan Africa. Moreover, the LSMS-ISA project sets out to produce data which can be used to better understand the link between agriculture and poverty reduction. To this end, the LSMS-ISA project has partnered with country statistics offices to implement multi-topic nationally representative panel surveys while promoting the advancement of survey methodologies to meet the challenges intrinsic to the implementation of large complex surveys in Africa.

Based on lessons learned through the implementation of the LSMS-ISA surveys, this paper explores some of the common breakdowns in survey implementation and provides technical implementation solutions, with specific focus on data management techniques, that promote higher quality data.

By using field based data capture, either with Computer Assisted Field Entry (CAFE) or Computer Assisted Personal Interviews (CAPI), LSMS-ISA projects advance rapid survey quality feedback which efficiently facilitates supervision and promotes continual improvement in field staff performance.. Although the use of CAPI & CAFE in surveys may not in itself be particularly innovative, the construction of the data quality checks, reporting mechanisms and the protocols for their utilization in the LSMS-ISA projects have been hugely successful in improving the over data quality straight from the field.

The use of field based data capture and the regular transmission of data from the field to project managers has allowed for regular monitoring of project progress and the construction of aggregated performance evaluation while the survey is in the field. This availability of data at the project manager level allows for the possibility to identify weaknesses or issues in the implementation of the survey, target feedback to field staff and take concise action to address issues.

The use of these integrated feedback systems and remote supervision as in the LSMS-ISA projects proves effective in ameliorating many of the data quality problems faced in the implementation of a large complex multi-topic household surveys in Africa.

Endnotes

The full paper has not been submitted.

Identifying, Reducing, and Accounting for Misclassification Errors in Farm Status

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Abstract

The U.S. Department of Agriculture's (USDA's) National Agricultural Statistics Service (NASS) conducts the June Area Survey (JAS) every year. Among the items reported is the number of U.S. farms. The U.S. Census of Agriculture (Census) is conducted in years ending in two and seven, and the numbers of U.S. farms is also reported from the Census. In 2007, the number of U.S. farms reported by the JAS and the Census differed more than could have been attributed to sampling error alone. This led NASS to review the processes associated with each. During the 2009 Farm Numbers Research Project (FNRP), misclassification of operations during the prescreening phase was found to be substantial. As a consequence, measures were taken to reduce misclassification. Although the rate of misclassification has been reduced in the JAS, some remains. To account for the remaining misclassification, modeling is suggested.

Keywords: misclassification; record linkage; capture-recapture.

1. Introduction

Each year, the National Agricultural Statistics Service (NASS) publishes an estimate of the number of farms in the United States (U.S.) based on the June Area Survey (JAS). A farm is defined as a place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the year, and the computation includes any government agricultural payments received. An independent estimate of the number of farms is also published from the quinquennial Census of Agriculture, which is conducted in years ending in 2 and 7. At the end of each five-year period, the JAS number-of-farm estimates are adjusted based on intercensal trends. The annual estimate of the number of farms from the JAS has been declining steadily between censuses (especially between the 2002 and 2007 censuses). Furthermore, the 2007 estimate from the JAS was significantly below that from the census, and the required intercensal trend adjustment to the JAS was unexpectedly large. The discrepancy between the two estimates was larger than could be attributed to sampling error alone.

Here the steps taken to reduce misclassification are discussed. Because misclassification cannot be fully eliminated through operational changes, methods of adjusting for it are outlined. First, the two surveys are briefly reviewed.

2. June Area Survey (JAS) and NASS List Frame

The JAS has an area frame, which covers all land in the U.S., except for Alaska. An area frame is created for each state. Within the state, the land is stratified by agricultural characteristics, *e.g.*, at least 50 percent cultivated, forested, etc. Segments of approximately equal size are delineated within each stratum and designated on aerial photographs. A probability sample of segments is drawn within each stratum for the NASS annual area frame survey, known as the June Area Survey (JAS) (see Davies, 2009, for more information on the JAS design).

Sampled segments in the JAS are personally enumerated. Each operation identified within a segment boundary is known as a tract. Each tract is identified as either agricultural or non-agricultural during JAS prescreening. Non-agricultural tracts are further classified into one of the three following categories: with potential, with unknown potential, or with no potential. Each JAS agricultural tract is identified as a farm if it meets the NASS definition of a farm; otherwise it is a non-farm. The 2012 JAS consisted of 11,085 sampled segments, with 125,032 tracts, and it was supplemented with 3,692 Agricultural Coverage Evaluation Survey (ACES)

segments. ACES segments were selected to reduce the coefficient of variation (CV) for estimates of small and minority-owned farms. These additional ACES segments targeted farm demographics that typically had lower coverage rates on the list. The information from each tract (operation) within a segment is matched against operations on the Census Mailing List (CML) to determine the amount of under-coverage that exists for a wide range of farming sectors and farmer demographics. Here the full June sample, which includes both JAS and ACES segments, is referred to as the JAS sample.

A response is obtained for each record in the JAS sample. If an operator is unavailable or refuses to respond, every effort is made to estimate the responses for the JAS questionnaire using alternate sources. This could include the use of Farm Service Administration (FSA) data or an enumerator's observation of crops, livestock, land area, *etc*. on the selected tract.

Based on JAS responses, the estimate for the number of farms is $\sum_{i \in JF} \pi_o^{-1} t_i$

where π_i and π_i^{-1} are the inclusion probability and the expansion factor associated with farm i, respectively, t_i is the tract-to-farm ratio (tract acres divided by total farm acres) and JF is the set of sampled tracts determined to be farms during the JAS.

NASS maintains a list frame, which is used for some of its surveys. Maintenance of the list frame is a major, on-going NASS effort. In Census years, operations unlikely to be farms are trimmed, and the remaining operations comprise the CML, which is the list frame for the Census. The active status code on the NASS list frame is an indicator of whether an operation is likely to be a farm based on available information, which can be used in non-Census years.

3. JAS misclassification

After each census, an evaluation has been conducted to measure misclassification of farms on the CML. This evaluation involves either recontacting a sample of census respondents or overlap matching the census mail list to the JAS area frame. In the 2007 Census of Agriculture, classification errors were measured by comparing an operation's status on the Census to its status on the JAS. The 2007 evaluation of Census classification errors showed that most of the discrepancies were actually errors that occurred in the JAS, not the Census (Abreu et al, 2009). These results suggested that misclassification present in the JAS was resulting in a downward bias. Misclassification occurs when (1) an operating arrangement with qualifying agricultural activity is identified as a non-farm, or (2) a non-farm arrangement is incorrectly identified as a farm. However, the results of the study were based on a small sample of 67 respondents.

In 2009, the Farm Numbers Research Project (FNRP) was conducted to evaluate the extent of misclassification resulting from operational prescreening procedures for the JAS. Non-agricultural tracts and tracts that were estimated because of refusals or inaccessibility of operators were re-contacted. The results indicated that the estimation due to refusals or inaccessibility of operators led to a small downward bias in the JAS estimate of farm numbers. However, misclassification of agricultural tracts as non-agricultural resulted in a substantial downward bias in the JAS farm numbers.

Prior to 2007, NASS assumed that there was little or no misclassification error in the JAS, primarily because it is a survey conducted with face-to-face interviews. However, these two studies provided the first indication of an underlying cause that could help explain the discrepancy in published estimates.

4. Matching JAS and List Frame Records: 2007

In years when the Census is conducted, and as part of standard NASS procedures, matching of Census records and JAS tracts is conducted via probabilistic record linkage. In 2007, a subset of the JAS tracts (57,029) was matched to the 3.3 million CML records. The tracts matched were agricultural tracts, non-agricultural tracts with potential and non-agricultural tracts with unknown potential. The tracts that were excluded from this record linkage were non-agricultural tracts with no potential. During record linkage, records were brought together into link groups, each of which possibly represented the same operation. Routinely, link groups are classified into one of three distinct types: definite match, possible match or non-match (Broadbent, et al., 1999). All possible matches were identified for a thorough field office (FO) review. FO staff further classified the possible matches as matches and non-matches. Any JAS tract that was matched to a Census record was assigned the identifier (POID) of the Census record that it matches. This linkage resulted in 43,963 JAS tracts matching to CML records.

The record linkage also produced a Not-on-the-Mail-List (NML) domain of 13,066 records. In other words, any JAS tract that did not match a CML

record was considered possible NML (NML domain). These records were then mailed an NML Census questionnaire. NML records were "scrubbed." NML scrubbing is an in-depth follow-up process that ensures records deemed NML are not on the CML. Some of the 13,066 records on the NML domain were found to be on the CML. Based on responses to the NML Census questionnaire, others were not a farm and not examined further. The remaining 4,810 NML records were those that were not on the CML and were a farm based on their NML Census questionnaire.

In addition to using the results from the 2007 record linkage and scrubbing, supplemental record linkage was conducted on the CML and JAS/ACES non-agricultural tracts with no potential. Not all non-agricultural tracts had good quality name and address information. From the 2007 CML, 3.3 million names and addresses were prepared and standardized for matching to the 50,961 names and addresses associated with the 2007 JAS/ACES tracts classified as non-agricultural with no potential (Abreu, et al. 2010). For this supplemental linkage, no FO review was conducted in the interest of saving time and resources. Instead, only two distinct types of matches were identified: match and non-match. To maximize the quality of the final results, all possible matches were treated as non-matches. Consequently, possible matches representing farms were missed resulting in potentially fewer farms being identified.

The results of the supplemental record linkage yielded 3,410 matches between CML records and the JAS non-agricultural tracts with no potential. In other words, almost 7% of all the non-agricultural tracts with no potential matched a CML record. Furthermore, 1,978 of the 3,410 were matches to Census farms, which were included in the 2007 Census (Abreu, et al. 2012). For this work, the non-agricultural tracts without potential that did not match the CML were not "scrubbed" for possible NML. It is unknown how many, if any, additional farms would have been added to the NML if the non-agricultural tracts without potential had been added to this process.

The results of both matching procedures (standard and supplemental) and the NML scrubbing are shown in Table 1. The table presents the JAS farms and non-farms and the type of CML record they matched. Note that 47,732 JAS non-farms did not match to any CML record. There were 1,593 CML non-matches that previously matched to a JAS farm; however, the process could not be duplicated in this work. Therefore, these records were considered non-matches. The records with conflicting farm status are highlighted in the table.

5. Measures taken to reduce misclassification

When the magnitude of potential misclassification on the area frame became evident, NASS instituted a series of measures to reduce, if not eliminate, this misclassification. To decrease the number of operations misclassified as non-farms during the prescreening process, field enumerators received enhanced training, and the time allocated for screening was increased from one to two weeks.

Because JAS responses are estimated when an operator cannot be reached or refuses to respond, the quality of the response may depend on the method used for estimation. A question was added to the JAS questionnaire that identifies the source of the estimated information. The purpose is to allow later evaluation of the quality of the estimates from various sources.

In addition, a question was added to the JAS prescreening form to further categorize non-agricultural tracts. Enumerators are to choose from the following categories: residential, woods, idle open land, pasture, water (lakes, rivers, etc.), reported non-ag by respondent, vacant houses, obvious non-ag (schools, cemeteries, prisons, airports, road/highways, interstate, etc.), grassland, hunting preserve, government land, and other (explain land use). After the 2012 Census of Agriculture, the relationship between misclassification and the category of non-agricultural tract will be studied in an effort to further identify ways to reduce misclassification.

6. Matching JAS and CML 2012

During the 2012 Census, all JAS tracts, regardless of farm status, were matched to the CML. The potential for 2012 JAS misclassification remains because some records still have conflicting farm status (see Table 2).

Table 1: 2007 Census of Agriculture and JAS Records Farm Status.

	CML Non-Farm	CML Farm	NML Farm	NML Domain Non-Farm	Total
Jas Non-Farm	1,941	2,439	620	5,477	10,477
JAS Farm	2,296	32,673	4,190	1,938	41,097
Total	**4,237**	**35,112**	**4,810**	**7,415**	**51,574**

However, in 2007, 7,293 of the 51,574 (14.1%) matched records had conflicting farm status whereas in 2012, 7,689 of the 66,334 (11.6%) matched records had conflicting farm status. The reduction in the misclassification rate is one indication that earlier efforts have led to improvements. At the same time, more remains to be done.

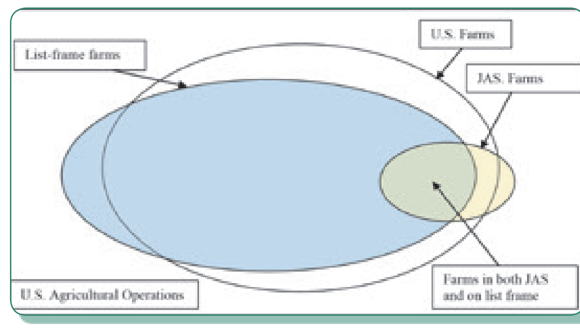
The records with conflicting farm status were sent to the regional offices for review. In each case, efforts were made to determine whether (1) the status had changed between June and December when the Census was conducted, (2) the JAS farm status was correct, (3) the Census farm status was correct, (4) the records were incorrectly matched, or (5) the farm status could not be resolved. These results will not be available until the end of July. This information will be added into the final version of the paper.

7. Adjusting for misclassification

Because misclassification has not been fully eliminated, some adjustment is needed to provide accurate farm numbers from the JAS. The NASS is exploring the use of capture-recapture methodology to adjust the JAS for misclassification. The ideas presented here draw from the work conducted by NASS for the 2012 Census of Agriculture and by the U.S. Census Bureau in preparation for the Accuracy and Coverage Evaluation of Census 2000 (U.S. Census Bureau, 2004) and for coverage measurement for Census 2010 (U.S. Census Bureau, 2008; National Research Council, 2008) as well as traditional capture-recapture methods developed for estimation of animal populations (see Chao, 2001; Seber, 2002). To implement capture-recapture methods, two independent surveys are required. In addition to the JAS, the Census (based on the CML) is used in Census years and the NASS list frame in non-Census years. Here the approach is developed using the NASS list frame although the process is the same when using the CML.

The NASS list frame provides information that can be used to model the probability that an operation on the list frame is captured by the JAS. In addition to assuming that the JAS is independent of the NASS list frame, the second basic assumption is that the proportion of list-frame farms with a given set of characteristics captured by the JAS is equal to the proportion of U.S. farms with those same characteristics captured by the JAS. Thus, the list frame records that overlap with JAS segments are matched with the JAS tracts (the JAS sample). The list frame records that match with JAS tracts represent the list sample. Note: The list sample is a subset of the NASS list-frame records and includes only those records matching a JAS tract (see Figure 1). Both agricultural and non-agricultural tracts are included in the matched dataset.

Figure 1: The Census sample is comprised of the Census records that match JAS tracts.



For a farm to be captured by the JAS, it must be in the JAS sample, respond to the JAS, and be correctly classified as a farm during the JAS. The probability that a tract is in the JAS sample is known and equal to the inclusion probability π_i.

The probability of response, given that a tract is in the JAS sample, is one because responses are recorded for every tract. The probability of misclassification is unknown and must be estimated.

Misclassification can occur in two ways. First, a JAS operation may be a farm (F) but recorded as a non-farm ($\overline{JF}$). This type of misclassification results in an undercount. A second type of misclassification occurs when an operation is recorded as a JAS farm (JF), but was not a farm ($\overline{F}$), resulting in an overcount in the number of U.S. farms. To account for both sources of misclassification, each JAS farm's weight is adjusted before summing: $\sum_{i \in F} \pi_o^{-1} t_i \frac{p_{1i}}{p_{2i}}$

where $p_1 = P(F \mid JF)$ is the probability that a JAS farm is truly a farm, $p_2 = P(JF \mid F)$ is the probability that a farm

Table 2: 2012 Census of Agriculture and JAS Records Farm Status.

	CML Non-Farm	CML Farm	NML Farm	NML Domain Non-Farm	Total
JAS Non-Farm	2,903	2,923	1,082	19,694	26,602
JAS Farm	2,233	34,028	2,020	1,451	39,732
Total	**5,136**	**36,951**	**3,102**	**21,145**	**66,334**

is a JAS far, and the set F is comprised of all farms in the matched dataset. Because p_1 tends to be greater than p_2, the effect of adjusting for misclassification leads to an increase in the estimate of the number of U.S. farms.

One of the challenges is that the probability of misclassification is not the same for all JAS records. As examples, large farms have a higher probability of being correctly classified than small farms, and commodity farms, such as those growing corn or wheat, have a higher probability of correct classification than specialty farms, such as those growing Christmas trees or nuts. Several approaches have been used to adjust for this differential probability. One approach is to partition the farms into groups so that the probability of being captured by the Census is about the same within each group (Alho 1990, 1994; Alho, et al., 1993; U.S. Census Bureau, 2004). Although the members within each of the constructed groups have similar misclassification probabilities, some variation remains. Logistic regression was chosen to model the probability of correct classification. This has been used extensively to model the capture probabilities in wildlife studies (Chao, 2001; Armstrup, et al., 2005). The NASS applied it to adjust for undercoverage, nonresponse, and misclassification in the 2012 Census and, in 2010, logistic regression was utilized in the Accuracy and Coverage Evaluation by the U.S. Census Bureau (U.S. Census Bureau, 2008). If the variables in the model of the probability of misclassification are all categorical, then groups of members with similar capture probabilities are formed, as with demographic analysis and classification trees. However, continuous variables can also be used so that each member could have its own capture probability.

8. Conclusions

Obtaining an accurate estimate of the number of farms in the U.S. is challenging. An agricultural operation must be found, and then a determination made as to whether or not the operation meets the definition of farm. By comparing the farm status based on two independent surveys, the JAS and the Census, the extent of misclassification has been found to be more extensive than originally thought. The JAS is focused on the operator, and the Census is directed toward the operation. Consequently, ensuring that the records are properly linked and resolving the farm status has been challenging. This is particularly true for certain types of operations.

As part of the 2012 Census of Agriculture, regional offices attempted to resolve the farm status for records with conflicting status on the JAS and Census. This process has provided insights into processes that could be revised so that misclassification could be further reduced. However, it is highly unlikely that misclassification in the JAS can be eliminated. Therefore, adjusting for it using models is anticipated to be a continuing NASS effort.

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IDCB 3

Carrying out In-depth Assessment of Agricultural Statistics Systems for Building Strategies for Improvement

Organizers: Mukesh Srivastava, FAO and Mark R Miller, USDA/NASS

Chair: Mark R Miller, USDA/NASS

Increasing international demand and declining availability of agriculture statistics present a challenge for many developing countries. It is recognized that in many developing countries the capacity to produce agriculture statistics has declined over a period of time, and that there is a need for global effort to build the national capacity to produce agriculture statistics. The Global Strategy to Improve Agriculture and Rural Statistics aims to build national capacities through Research, Technical Assistance and Training.

The Country Assessment of Agricultural Statistics System questionnaire provides the starting point for understanding the current level of a country's ability to produce timely and relevant agricultural statistics. From this self analysis starting point, missing or incomplete analysis items can be provided by stake holders within the country and international development partners with the additional view of moving towards the development of an agricultural statistics improvement plan.

This next step in the improvement of agricultural statistics in referred to as an in-depth assessment. As such it provides the pivot point for moving from analysis to plan of action. It brings together the agencies charged with producing agricultural statistics within the country, the internal data users, domestic funding sources with the international donor organizations and development partners. The efforts of these entities, utilizing the knowledge of the existing agricultural statistics, will identify the interventions necessary to implement the Global Strategy to Improve Agriculture and Rural Statistics.

Papers:

- Mukesh Srivastava (FAO), "Designing the In-depth Capacity Assessments to Produce Agricultural and Rural Statistics"
- Mariam ATJ Mapila, Klaus Droppelmann, Isaac Chirwa et al. (Malawi), "Landscape Analysis of the Agricultural Statistics' Sector in Malawi"
- Mwahib Elseid, Nuha Mahammed (Sudan), "Status of Agricultural Statistics in Sudan"
- Zhiquan Xu, Wei Zhou (China), "China's Capacity Assessment to Produce Agricultural and Rural Statistics"

Designing the In-depth Capacity Assessments to Produce Agricultural and Rural Statistics

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Abstract

The paper focused on the design, scope and coverage of in-depth assessment of capacities of statistical systems producing agricultural and rural statistics planned as part of the Global Strategy to Improve Agricultural and Rural Statistics. It highlighted the purpose these assessments as the basis of making country proposals for seeking technical assistance. The report of these assessments was seen as an authentic reference document for wider national and international community interested in the development of agricultural statistics. In the short run, the assessment should obviate the need of another assessment by a resource partner interested in funding development of a specific aspect of agriculture statistics system.

The assessment was expected to result in a set of indicators on various dimensions and elements of the capacity assessment framework established by FAO and partner institutions. The capacity profile will help identify specific area for priority attention. The assessment report would cover the agricultural statistics on all the related sub-sectors (fishery, forestry, crops, and livestock) in an integrated manner. Focus of the assessment was expected to be on verification of existence of means to produce the minimum the core data item identified in the Global Strategy while taking into account the data needs of the users, particularly those relating to current development priorities. It was expected to ccomprehensively cover statistical activities at all stages: from availability and use of statistical infrastructure to methodologies in use to field operation to data dissemination to its analysis and use, and evaluate existing and potential linkages between activities and agencies.

The paper also presented an outline of the assessment report.

Endnotes:

No paper related to this abstract has been submitted.

Landscape Analysis of the Agricultural Statistics' Sector in Malawi

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Abstract

A study was conducted to analyze the nature of partnerships and institutional linkages as well as interactions between agricultural statistics stakeholders in Malawi. The study also aimed to explore stakeholder perceptions pertaining to key challenges and capacity constraints that hinder efforts to improve the provision of timely, reliable and accurate national level agricultural statistics; resulting in poor quality and inaccessible statistics. Using landscape analysis the study included all major institutions that generate agricultural statistics; a sample of end users as well as organizations that provide technical support for agricultural statistics generation and dissemination in Malawi. The study therefore included insights from the public and private sectors, development partners, academia as well as local and international research institutions. Findings from the study show that primary stakeholders that generate national level agricultural statistics have a high frequency of interaction but the strength and depth of interaction is weak. This results in difficulty in harmonization and at times the generation of contradicting national level statistics. Weak harmonization, institutional rigidities as well as the nature of the prevailing smallholder farming system of the country; coupled with inadequate technical and financial capacity further constrains the provision of timely high quality reliable data for facilitating evidence based decision making. An analysis of stakeholder perceptions shows that the sector is performing slightly below capacity in the areas of data generation, processing and dissemination. Factors preventing the full utilization of potential capacity include inadequate human and financial resources; organizational slowness in adopting technological advancements; low demand for and utilization of agricultural statistics in decision making processes by policy makers; and inappropriate incentives for staff. Short term recommendations include the need for greater financial investments to modernize systems for data collection, transfer and dissemination; capacity building for improving statistical data management and analysis; and to increase the number of university trained statisticians in the public sector. In addition there is need for greater collaboration amongst primary agricultural statistics stakeholders. Long term recommendations include the development of a standardized conversation system for local weighing and measurement instruments to avoid subjective conversations. Finally lessons are drawn for other countries in the region facing similar problems from the establishment of a Malawi Agricultural Statistics Forum – the first of its kind in the region.

Keywords: Africa; Agricultural Statistics Forum; statistics harmonization.

Endnotes

The abstract refers to a report that can be found at the conference website.

Status of Agricultural Statistics in Sudan

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1. Introduction

Agriculture played and is still playing a very important role in the economy of the country as more than 70% of the populations are engaged directly or indirectly in this activity. Despite its diminishing contributions in the overall exports earnings, after the discovery and export of oil in the late 90s yet agriculture share in GDP still represents about 45%. Such an essential activity needs an efficient information system that provides decision makers, planners, researchers and data users with appropriate, accurate and timely data. The *agricultural information system must fulfill the following:*

- Identify the information required for the most important and public decisions and specify the kinds of information that deserve highest priority.
- Utilize methods and means of collecting, processing, analyzing, and presenting data that meet reasonable standards of accuracy, coverage and timeliness, while at the same time try to minimize financial and human costs.
- Have institutional structure which brings users and suppliers of information in a continuous dialogue and which is able to adapt itself to the changing demands of information and modern methodologies for generating it.

Despite the general perception and understanding of the importance of information system by decision maker politicians, planners, and most categories of data users, but still there is a wide gab between the understanding and adoption and application reality, and in fact the standard of agricultural statistics is even deteriorating in recent years.

2. Historical background of agricultural statistics in Sudan

Agricultural data collection in the agricultural sector started as early as the beginning of the 20th century, with the establishment of department of agriculture and veterinary services, followed by department of irrigation. The department of statistics evolved as a division in 1903 and developed into department in 1953 & into a central bureau of statistics in the late 80s.

The first agricultural economics and statistics section within the ministry of agriculture was established in 1958. It started with a very limited numbers of officials with economic and agricultural background.

In the early 60s, the division received a technical support in the field of agricultural statistics, and international expert was deployed to assist the division to develop and adopt objective methods of data collection, analysis and publication. Theoretical and practical training courses were conducted in area measurement and crop cutting experiments. Sudan is considered as one of the countries in Africa and the Arab world that very early applied crop cutting experiment to estimate yield of sorghum. The first specialized agricultural statistics bulletin was published 1960/1961, containing information on area, production and average yield of the main crops by centre of production, administrative setup and type of irrigation. Also rain fall data was included in this bulletin. This series of annual bulletins continued till 1969/1970. In 1970/1971, it was substituted by the agricultural your book, which was on the same line as the bulletin, but included more detailed information of the main crops, rainfall and some livestock data. In mid 80s other publications were issued such as the current agricultural statistics bulletin (CAS) and agricultural situation and outlook. These publications were meant to give supplementary information for the data included in the yearbook or to bridge the gap between two successive issues of the agricultural yearbook.

The agricultural division was upgraded to administration of agricultural economics and statistics, under the umbrella of the general administration of agricultural planning and economics. During the period 1990/1991 the administration received financial and technical support through the agricultural planning and statistics project financial by USAID. The administration benefited from the project in building capacities in form of training at all levels and a form of equipment and transport facilities. Also this period witnessed advanced trials for constructing an area sampling frame.

In 1993 the agricultural statistics got autonomies status and evolved as independent administration.

On 1996 within the new structural setup in the ministry of agriculture, a general administration of information and statistics was established comprising three administration namely agricultural statistics, computer and documentation and agricultural economics. But in 2001, due to the institutional reform undertaken by the ministry of agriculture, the agricultural statistics administration again reformed to the general directorate of planning.

After the implementation of the federal system in Sudan, data collection, analysis and publication was entrusted to the state ministries of agriculture, while the national agricultural schemes (Gezira, Rahad, New Halfa and Suki) were responsible for producing their own agricultural data. The role of agricultural statistics at the federal level was confined to training, technical support, co-ordination and publication of the agricultural data at the country level.

3. Methods of collecting current agricultural statistics

As methods of data collection may differ from agricultural sector to another it is better to have an idea about the different agricultural sectors in the country. According to type of irrigation, agriculture in Sudan can be *divided into two main sectors:*

a) The irrigated sector:

This sector includes areas irrigated from the River Nile and its tributaries by pumps, or gravity or flood even from seasonal streams other than the River Nile. Also areas irrigated by pumps from bore (mataras) are considered as apart of this sector.

b) Rain fed sector:

In this sector the source of irrigation is rains. The rain fed sector is further sub divided into mechanized rain fed sector which is categorized by using machinery land preparation and harvest whether fully or partially and also large size of holdings are parts of this sub sector, sizable portion of the mechanized sector is demarcated into schemes of regular shape of 1000 and 1500 feddans. Part of this sub sector is un-demarcated and the size of holding can range from less than 100 feddans to a few thousands (up to 5000). The other sub sector is the traditional rain fed sector. This category includes areas mainly in western and southern Sudan where no machinery is applied and traditional methods of cultivation (agricultural tools) are adopted, but besides this, small holdings (roughly up to 50 feddans) where machinery is used in land preparation and partial harvest are considered as part of the traditional sector.

4. Methods of collection agricultural data in the irrigated sector

National schemes

The national schemes follow a proper crop rotation, where each crop is planted in a separate piece of land with a number, definite size of feddans and usually includes tenancies with equal sizes. Also the layout of the canalization system facilitates the estimation of planted areas under each crop. Accordingly, the statistics of area planted are accurate and reliable. The estimation of yield is based on sample survey were crop-cutting is conducted, an example is Gazira scheme, the statistics division of the agricultural planning administration carries an annual survey to estimate yields of the main crops (sorghum, wheat, groundnuts and cotton). As the administration is interested to have information at the level of the block, all blocks are included, as the first stage of selection starts at the tenancy level. In scheme, 36 tenancies were selected from each block resulting 3.2% according to the planted area, in a sample size of 40032 tenancies. The sample design adopted is a multi-stage random sample.

In the first stage applying systematic random selection, three canals (Turaa) are selected from each block, representing the start, the middle and the tail of the major canal. In the second stage, from each selected canal three numbers are selected applying simple systematic random selection, also representing the start, the middle and the tail of each number. At the 3rd stage, 3 farmers are randomly selected from each selected number, one at the start, one at the middle and one at the tail. At the last stage, 3 plots of 2*2 meters are randomly selected at the beginning, the middle and the end of the tenancy. Then the heads are cut dried, threshed and weighted, and the weighted average is calculated to estimate the yield of crop. At the same time paroled estimation which is mainly based on weekly records of the agricultural inspectors is prepared by the agricultural administration. Both estimates are mode available to the top administration of the scheme.

To avoid duplication and some times contradiction, it is better to depend on the objective method adopted by the planning administration and to supply with more facilities and financial capabilities to improve this job.

The other national schemes (Rahad, New Halfa, Suki) are using more or less similar procedures of estimation, but Gezira scheme is more experienced in this aspect and its coverage and persistence is better.

Other irrigated agricultural schemes

The state ministries of agriculture are responsible for generating the agricultural statistics of the irrigated sector in that state. Although these schemes are having their own agricultural rotation and somewhat similar canalization like the national scheme, but they rarely follow objective method of estimation. The data of area planted and area harvested has fairly good degree of accuracy, and usually there is a plan for targeted area and a close follow up at area planted and areas to be harvested. An early stage where crops are at maturing stage yields depend on eye estimates, and then refined from acetous records of threshers or combine harvesters at harvest time as crops like sorghum, wheat, broad bean are harvested either fully or partially by combine harvesters or threshers. The accuracy of yield figures in this sub sector can be considered acceptable, as an example we will consider this as the procedure adopted for collecting agricultural data mainly for food crops in River Nile state.

According to the administrative division in the state, they are six localities, at each locality there is an agricultural inspector, assisted by new graduates of agriculture, who are located at administrative unites under the locality. Each locality has an average of about 10 basic units. Each assistant inspector is responsible to collect data from his units by interviewing farmers plus his own observations, weekly reports are submitted from each locality from the time of land preparation till the time of harvest, giving information about areas, performance of the crop yields and factors affecting the crop, rainfall, number of irrigations, application of fertilizer, number of weedings, pests, and diseases etc .... At time of harvest, the inspectors try to record the production by following the combined harvesters' threshers in the field. The agricultural planning administration with in the ministry of agriculture at River Nile state is responsible to prepare a weekly report reflecting the agricultural situation at state level.

5. Rain- fed mechanized sector

Estimation of planted area

The preliminary estimates of area depend to a large extent on the records on the annual renewal records of the schemes as the farmers are supposed to pay rent before the start of the season. Information of rain fall, prices, and information from farmers are supplemented and refined.

Usually in September a team from mechanized farms co-operation (MFC) visits all schemes one by one to estimate the planted area either by interviewing the farmers or the manager of the scheme or by eye estimation by the members of the team. In November and December, depending on the availability of funds and transportation facilities, the teams estimate the areas to be harvested and the expected yield by subjective methods (eye estimation). The federal administration of agricultural statistics of the ministry of agriculture in collaboration with state ministries of agriculture used to carry crop cutting surveys to estimate the yield of sorghum. The intensity of coverage and timeliness of these surveys depend considerably on the availability of financial resources. The coverage of the surveys in season 05/2006 was the best during the last 15 years as it covered Gedaref, Damazin, S.Kordofan, Sennar, White Nile and Renk. Gedaref being the largest area is chosen as an example to explain the sampling procedure of the crop cutting survey.

Objectives of the survey:

- To estimate the average yield per feddan and consequently estimate the total production of sorghum.
- To estimate the harvested area depending on response from the selected farmers identifying planted and harvested area.
- The same sample or a sub sample can be used to collect information on cost of production and marketing of agricultural products.

Sampling design and sample size

The survey design was a stratified two stage random sample with uniform sampling fraction (proportionate allocation). The producing centre was considered as in domain and a sampling error of 5% of the average yield was contemplated. For the specified degree of accuracy, it was decided that 1000 experiments to be conducted in Gedaref. Blocks were considered as the main strata and sections within blocks as sub strata. The first stage of sampling and number of farms (selection) is selected randomly from each section with in each block. This number is proportionate to the size area sown in that section. In the second stage of selection, two plots are randomly

selected with in each selected farm, with a size of a plot of 5*5 meters = 1/168 feddans. The selected plots were harvested, the number of heads was recorded and weighted wet and dry, \ and the grain weighted. Simple weighted averages together with variance and sample errors were computed to calculate the average yield per feddan and confidence limits for the total production expected for each section and block, and accordingly the weighted average together with the maximum and minimum yield expected at the level of the producing center (Gedaref).

6. Methods of data collection in the traditional rain-fed sector

As this sector is characterized by small size and scattered holdings, with mixed cropping and shift cultivation, the data collection is problematic and its accuracy is questionable. In the 80s regular surveys (pre-harvest and post harvest) were conducted in most part of western Sudan where traditional agriculture is very common. Technical and financial support were provided by projects receiving finance from foreign organization or countries e.g Savanah project, Jebel Marra project, Kordofan development project. Most of these projects are not largely functioning since the late 80s and early 90s, which led to irregularity in conducting these surveys, but also a drop in the coverage and accuracy is due to shortage in funds, transportation, facilities, equipment, and well trained staff. Also the late disputes and insecurity problems in Darfur hindered the activity of data collection. In most cases, either no survey is carried or only one survey either pre-harvest or post-harvest is conducted. As an example for this sector, the post-harvest survey in North Darfur in season 05/2006 is considered.

Sample design

A two stage stratified sample was adopted. The state was divided into 18 administrative units. From administrative unit (1-2) villages or town were randomly selected taking into consideration the density of population, geographic locations and the economic situation of the population. 33 localities (village or town) were selected and from each selected locality 10 farmers were randomly selected and interviewed and the information was recorded in a questionnaire designed to fulfill this objective. The questionnaire contains information about seeds, agricultural operations, area planted, area harvested, yield, etc.

This information is supplemented from key information in different areas. Due to insecurity and limitation in funds the size of the sample is small and no statistical indicators are calculated, so the results of the survey should be taken with same precautions.

Cereal balance sheet

The report of FAO/WFP crop and food supply assessment mission included a very import table which reflects the national cereal supply / demand situation.

Table 1: Area planted, area in sample, sample size, and actual area harvested.

Crop-cutting on sorghum season 2005/2006:

Area covered, sample size, and the actual area harvested.

Area in (000) feddans.

State	Area planted	Area in sample	Sample size		Actual area harvested Feddan
			Farmers	Plots	
Gedaref	4567	422	500	1000	6
Sennar	2209	104	200	400	2.4
Blue Nile	684	119	151	302	1.8
White Nile	1491	60	200	400	2.4
Renk	477	136	200	400	2.4
Northern Kordofan	970	7	521	1042	6
Southern Kordofan	2192	166	482	964	5.9
Total	**12590**	**1014**	**2254**	**4508**	**26.9**

The format of the table is as follows:

	total cereal	rice	Sorghum	Millet	wheat	maize
Availability						
Opening stock production						
Utilization						
Food						
Feed						
Seed						
Post- harvest losses						
Export						
Closing stock						
Commercial imports						

Availability

It's the sum of the opening stock and the production of the current season.

Opening stock

It's usually the closing stock from the previous season, but it may be adjusted if new information is available in agencies like strategic reserve.

Production

It's the estimated production of the different cereals.

Utilization

Comprises human consumption, live stock consumption, seeds for the next season, post harvest loses, export and closing stock.

Food

The human consumption estimation is based on the estimation of the population at mid year of the season in question (e.g 05/2006), multiplied by per capita cereal consumption. The estimation of population depends on extrapolation from the last population census taking into consideration other factors like number of returnees, refuses etc.

Due to the absence of reliable data on per capita consumption as this requires regular and firmly surveys covering all regions, FAO estimated to use per capita consumption as 146 Kg in Northern Sudan, and 85Kg in southern Sudan. These figures have been reached taking in consideration regional differences in diets, food production as availabilities historical trends, and conditions created by on going civil conflicts.

The 146Kg consists of 83Kg of sorghum 11Kg of millet 49Kg of wheat, 2Kg of rice and 1Kg of maize.

Seed requirement calculation are based on the forecast at the area of cereals for the coming season multiplied by used seed rate for each cereal crops: 5Kg of sorghum/fed, 2Kg of millet/fed, 5Kg of wheat/fed, 7Kg of maize/fed and 3Kg of rice/fed. These rates are based on MOA recommendations and farmers stated practices and are within the range of rates used in similar environments elsewhere.

Post harvest losses may differ from one season according to production, availability and cost of labor, prices of the crops, but usually these are estimated in the range of 7-15%, as no comprehensive survey has been carried.

Export

The only exportable cereal is sorghum and the quantities exported are marginal as our prices are not compatible with international prices. The quantities to be exported are estimated taking into consideration the internal production, previous trends and production, political and economic relation with the neighboring countries that consume sorghum.

Closing stock

It's calculated considering all the above mentioned items and the quantities of cereals expected to be imported.

Commercial imports

The main imported cereal is wheat which is in continuous increasing of demand due to urbanization and change in food habits. The estimation of wheat imports is based on trend from previous years and

the production of wheat in the country and to some extent the production of other cereal crops.

The ministry of agricultural economics and planning of MOA presents cereal balance sheet on the same pattern as the CFSAM balance sheet. The figures are consistent with figures in CFSAM report. The ministry relied on human consumption estimation from the consumption survey that covered all states. The field surveys look place in 2002, while the data was analyzed and published in 2005. There was no significant difference in per capita consumption of wheat, millet, rice, and maize in the two reports, but per capita consumption of sorghum registered a remarkable difference (about 45% less than the FAO estimate). We suggested that there is underestimation in the MOA estimates, as if this was true, we would not practically have any food deficit at national level and probably our storage facilities will not be enough to store the cress quantities. Some of the states in central and western Sudan used to prepare cereal balance sheet at the level of the state following the same per capita cereal consumption.

Food security and nutrition assessments methodology (WFP)

The methodology adopted by WFP for calculating food access shortfalls as the difference between expected food consumption requirement of people or household in any geographic area or population group and what they can provide for themselves without adopting distress strategies. According to the global standard the amount that households need to consume to live on active and healthy live is estimated at 2100 real/per person/day. This amount could be subjected to adjustment due to factors like temperature, activity level and health/nutrition condition, age, sex, distribution if data is available. The difference between the two above mentioned components excluding households consuming more than 2100 real/person/day provides an estimate of the percentage of people and their average food deficit for a given location and demographic profile. These estimates are further extrapolated over similar agro- ecological zones and demographic profiles give the overall scope of the food deficits for various population groups. Accordingly, the emergency food needs to be met with international assistance are calculated taking into consideration other factors like the national response capacity, changes in economic security situation, and level of external assistance provided during past similar year. WTP also considers the assistance rendered by other international or national agencies (Zahal – S.R.C) to address some of the food deficits from the own resources.

CFSAM relied to a large extent on primary or secondary food security analysis undertaken by national and international institutions within the country plus the missions' observations during the field visits, stakeholders consultations and methodological reviews. In addition to different data sources, the mission mainly relied on the findings of the multi agency food security and nutrition assessments including Darfur Emergency Food & Nutrition Survey (EFSNS), Annual Need Assessment (ANA) for the rest of the country plus other surveys on nutritional assessment of rural Kassala and Red sea state.

EFSNS target population covered what is defined by United Nations as crisis affected population (3.2 million), including internally displaced persons living in camps, out of camps, as well as residents. The sample design was a two stage cluster sample where a total of 101 clusters were selected from the whole region of Darfur, using a population proportionate to size method. Due to insecurity, 87 clusters were actually covered, and data was collected from 2090 HHs, and 1943 children were measured, 25 HHs were selected applying systematic sampling from early selected clusters where heads of H.H.s were interviewed and responses were recorded in the questionnaires designed for this purpose, and children 5 years were measured – and weighed.

A special community questionnaire was designed to supplement the information provided in HHs questionnaire where leaders, teachers, women, health workers were collectively interviewed.

Nutrition and Health data was analyzed by EP into TM version 6.04d software (version 2001). Tests for statistical significance a proportions were done using a chi-square test.

Limitations of the survey:

- The results can not be generalized to cover all Darfur regions, as it only targeted the needing populations.
- The seasonal effect in terms of food consumption, dietary diverse and frequency is not captured, as the survey is a one time exercise.
- The inaccuracy in population estimation due to lack of reliable population data may have a bearing on the accuracy of the assessment.

ANA addresses only the food security situation but it doesn't cover most of the state where food deficit is expected. Although some effort was made to introduce new methodologies of data collection, the rapid assessment methodology is prevalent.

ANA is expensive and requires considerable funds and human resources.

ANA adopts a multi agency approval that yields a considerable amount of data, part of it is neither thoroughly analyzed nor disseminated due to financial and technical constraints. Besides the effort exerted by WFP in assessing the food security and nutritional status in food deficit area, NGOs, our WN agency and the government are carrying out similar surveys, but it is necessary to unify these efforts or at least create collaboration among these agencies to avoid duplication and contradiction and to prioritize the activities.

Marketing information agricultural products

Reliable, accurate, and timely marketing information is a very essential component that assists decision makers, traders, farmers and consumers to tab the right decision and contributes to a high marketing efficiency, reduces marketing cost and increases marketing margins. In Sudan growing demand for agricultural product and food items coupled with food shortages, under lined the need for efficient marketing system. Historically, even at the beginning of the 20th centaury department of trade collects some prices since the 60s, the central bureau of statistics used to publish marketing information dealing mainly with different commodities including agricultural products in different regions in a publication known as internal statistics. Currently the bureau of statistics collects consumer prices to calculate the consumer price indices. After the years of drought in 1983-1984, there was an increasing need for marketing information, not only for the government, but also for organizations and international bodies that were involved in the relief activities. An early warning unit was established and hosted in Relief and Recovery Commissioner (RRC) with technical and financial support from aboard. In the Mid 80s, the department of agricultural economics carried a survey and published marketing information in a publication known as marketing costs and margins for selected agricultural commodities in Sudan.

The series of publication continued till the early 90s and was interrupted due to lack of finance.

Recently this activity was resumed again but its continuity will depend to a large extent on the availability of funds.

Some cereal markets like Gedarif, Obied which were at one time under the umbrella of the central cereal market corporation used to collect daily prices of the main agricultural commodities (sesame, groundnut, sorghum, millet, gum Arabic, karkade, and water melon seeds, etc.), and the quantities sold. At the project time, these cereal markets are controlled by the states and structurally they are under the ministries of finance. Gedaref and Elobied cereal market are the most developed ones and all the data is computerized and up to date.

Many other organizations whether public or international organizations (VAus united WFP) or a CGO, are collecting some marketing information. Most of agricultural planning administrations at the level of the state used to collect prices either on weekly or monthly bases. The strategic reserve authority receives daily information of prices of agricultural commodities mainly cereal from eleven different markets representing cereal production and consumption. A number of other institutions like the agricultural bank, the economic security administration are involved in price data collection of the main agricultural commodities but there is a little co-ordination or exchange of data among these different agencies.

Livestock marketing statistics

The coverage, timeliness and standard of livestock marketing statistics are even below the level of the marketing statistics of other agricultural commodities. At the time when the livestock marketing corporation was formed, the prices of livestock, quantities sold were collected, but after the corporation was dissolved, the standard of coverage of livestock statistics decrease drastically. At present very few livestock markets record prices and qualities of livestock sold, and even the registration takes place only for livestock which are exported.

China's Capacity Assessment to Produce Agricultural and Rural Statistics

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Abstract

In China most of agricultural and rural statistics including the crops output, livestock output, agricultural producer prices are produced by the National Bureau of Statistics (NBS) of China. While some other agricultural statistics related to forestry, fishery and commodities market information are conducted by the line ministry such as Ministry of Agriculture, National Forestry Administration as complementary sources to compose a relatively panoramic agricultural statistics of China. In this article, the country capacity assessment for China's agricultural and rural statistics is overall evaluated in four aspects, including: (1) Legal and institutional infrastructure, (2) Resource allocation, (3) Statistical methodology and practices, (4) Information dissemination and data accessibility. The advantages of the current statistical mechanism in China to produce agricultural and rural statistics are summarized. Meanwhile the challenges which Chinese agricultural and rural statistics encounters have also been discussed.

Keywords: statistical capacity assessment; agricultural statistics; rural statistics.

1. Introduction

As a traditionally large country in terms of agricultural production, China is currently in a transition to its industrialization and urbanization stage. In 2012, Chinese agricultural value added accounted for 9% of GDP, and the proportion of rural population in the total population was 48.7%, falling below the level of 50%. The progress of industrialization and urbanization is significant. However, as a country with large population, China's food production is always a major event in national welfare and people's livelihood, and Chinese government has always put agricultural production in an important priority. Half of China's population lives in rural areas, and a large number of migrant workers flow between urban and rural areas. Therefore, it is very important for China's agricultural and rural statistics to reflect the situation of agriculture, food production and rural development objectively.

Under the background of China's overall agricultural statistics production, learning from the statistical capacity evaluation system of "Country Assessment of Agricultural Statistics System" that is conducted for Asia-Pacific countries by FAO, and combining with the characteristics of Chinese agricultural and rural statistics, this paper attempts to build a comprehensive capacity evaluation on Chinese agriculture and rural statistical and give the results of the assessment, and finally puts forward suggestions on how to strengthen the capacity of agricultural and rural statistics in future.

2. Overall capacity assessment on China's agricultural and rural statistics

The following four dimensions can be used to build an overall indicator system for capacity assessment of China's agricultural and rural statistics. The first is the legal and institutional infrastructure for statistics, the second is the statistical resource allocation, the third is the statistical methods and practices, and the fourth is the statistical information dissemination and data accessibility.

2.1 Legal and Institutional Infrastructure of Statistics

As for the legal and institutional infrastructure of China's agricultural and rural statistics, we choose two assessment indicators including legal infrastructure and institutional infrastructure.

- Legal infrastructure. The implement of Chinese agricultural statistics has a relatively sound legal environment. Since its implementation in 1984, China's Statistics Law has been revised twice respectively in 1996 and 2009 in order to meet the situation development and the work requirements. Statistics Law is the legal guarantee for China's National Bureau of Statistics (NBS) to carry out the statistical surveys as well as agricultural census. All statistical survey projects should be

guided by the Statistics Law. Statisticians should exercise the power and functions independently concerning statistical investigation, statistics report and statistics supervision according to the law. Any organization and individuals that are under statistical investigation are obligated to provide truthful, accurate, complete data in a timely manner. After establishing the agriculture census system in 1996, China later promulgated Regulations for the Census of Agriculture in 2006, with detailed provisions including census content, census scope, organization and implementation, budget, quality of information, dissemination and so on.

- Institutional infrastructure. For a long time, China's statistical work takes a centralized administration mode. Wherein, NBS is responsible for production and dissemination of the major agricultural and rural statistical data, with the statistical data from other relevant departments as a supplement. In the production of agricultural statistical data, Rural Survey Department of NBS is responsible for statistical surveys on crop production, livestock production, producer prices of agricultural products and so on; while other relevant statistics on forestry, fisheries and agricultural market information are mainly from State Forestry Administration and Ministry of Agricultures as a supplement. In addition, Rural Survey Department of NBS is also responsible for surveys of rural society and economy, rural community development and so on. Household Surveys Department of NBS is responsible for rural household survey of income, expenditure and so on.

Agricultural and rural statistics as an important part of the national statistical system has been integrated into the overall statistical development strategy planning of NBS during the 12th Five Year Plan period. Agricultural and rural statistics is toward the standardized, open and transparent way mainly in the following there aspects. First, agricultural and rural statistics plays an important foundation role in the national statistical system, and survey results for crop and livestock production together with household income and expenditure are important statistical data. Second, methodology reform and investigative means improvement for agriculture and rural statistics are incorporated into the future national statistical development strategy. Third, NBS have established a sound data coordination and consultation mechanism with some departments of agriculture, forestry and water conservancy who are responsible for other relevant agricultural statistics.

However, it is still necessary to further strengthen the coordination mechanism among different departments on agricultural statistics at national level. During the whole process of the agricultural statistical data production and dissemination, in order to ensure the consistency and integrity of the agricultural statistical data that are provided by different ministries, it is needed to strengthen the work coordination and consultation mechanisms between NBS and relevant ministries at the national level.

2.2 Statistical resource allocation

As for China's agricultural statistical resource allocation, we choose three assessment indicators including statistics institution setup, personnel allocation and fund security.

- Organization setup. China's agricultural statistics has a better organization, depending on specialized agricultural statistical offices covering from NBS to the statistics bureau at the provincial, municipal and county levels. Moreover, in order to conduct independent surveys and independent reports, NBS also set up separate survey teams in all 31 provinces, more than 300 prefectural-level cities, and about one-third of the counties throughout the China. Governments at the town level also set up statistics positions with full-time statisticians. In addition, there are relevant functional departments undertaking agriculture-related statistics in Ministry of Agriculture, State Forestry Administration and Ministry of Water Resource.

- Personnel allocation. NBS has specialized agricultural and rural statistics personnel in statistical bureaus at the provincial, municipal, county and town levels. But the investigation teams at the grass-root level, especially at county level, are relatively lack of personnel, with larger per capita workload and relatively aging knowledge structure. At the village level, NBS also hires assistant investigators to help on-site investigations.

- Fund assurance. NBS gives adequate fund assurance on agricultural and rural statistics work. Conventional agricultural statistical surveys and agricultural census are funded by the both central

and local levels of government, seeing through the smooth implementation of various agricultural and rural investigation projects.

2.3 Statistical methods and practices

As for the agricultural statistical methods and practices, we choose the following five assessment indicators including survey methodology, international practice and scheme innovation, survey themes and core indicators, data collection means, IT infrastructure and data processing.

2.3.1 Survey methodology.

The survey methodology of Chinese agricultural and rural statistics has formed a methodological system that takes agricultural census as its foot and sampling survey as its body, supplemented by comprehensive statistics, typical investigation, major investigation, administrative records and scientific projection. For the main varieties of food crops (rice, wheat, corn, etc.), the conventional agriculture and rural statistical surveys has always been using standardized sampling method to investigate the areas and yields. For agricultural production conditions and cash crops such as cotton, oil, hemp, sugar, vegetables and other produces, the complete statistical reporting is still kept to use. For rural household and migrant workers survey, the sampling survey method is used. The fisheries and forestry statistics mainly use the investigation results from Ministry of Agriculture, State Forestry Administration and other relevant departments. Statistics on rural development and county level socio-economic status uses administrative records and relevant statistical results.

The crop production statistics carried out by NBS mainly uses sample survey for the crop and livestock varieties. Crop sample surveys covers production statistics of the main varieties of crops such as rice, wheat, corn, cotton and so on. At present sample methods need to be gradually extended to more varieties of crops including small grains, oil, hemp, vegetables, etc. In addition, as the statistical monitoring activities are conducted with respect to the large grain-producing counties and the large livestock-producing counties in the main output areas in the future, the current sampling design that takes the province as a target will be gradually expanded to the sampling design that takes the county as a target.

2.3.2 International practice and scheme innovation.

By learning from good international agricultural statistical practices, NBS implements standardized method and scheme innovation in China's agricultural statistics. For a long time, China's agricultural production sample survey mainly uses the village level materials obtained by agricultural census to compile list sample frame, and conduct surveys by sampling the villages and the land segments. In recent years, by taking use of the extracted plot data obtained from the Second National Land Enumeration, and combining with the corresponding remote sensing image data, NBS started to develop area frame and conduct crop surveys based on area fame in major crop belt. The area frame based crop surveys will gradually expand to all of the major grain-producing provinces in the future. At the same time, the area monitoring work is carried out in some producing areas using remote sensing technology and has achieved good results. In the future, it is still necessary to strengthen innovational research on agricultural and rural statistical methods and reference to good international practices.

2.3.3 Survey themes and core indicators.

The agricultural statistical surveys conducted by NBS covers a relatively large variety of topics, with the scope including the production of major grain crops, the production of major livestock and poultry, the producer prices of main agricultural products and the intermediate consumptions, the rural household investigation and some special investigations on agricultural and rural fields, and forms a series of relatively complete system of core indicators, together with the statistical results from other departments as a supplement.

With all-around attention is paid on the various sub-sectors within the agriculture as well as the rural society and ecological environment, the scope and indicators of agricultural and rural statistical surveys should be gradually spread to wider fields including agricultural economy, rural social development and ecological environment.

2.3.4 Data collection means.

The data collection in sample survey relies mainly on fieldwork and face to face interview. In recent years, the GPS-enabled PDA began to be adopted gradually when conducting field observation in agricultural surveys. The electronic accounting machine began to be promoted to use in the agricultural producer prices survey at national level. Therefore, at present China

is in a transition from traditional data collection means to modern data collection means.

2.3.5 IT infrastructure and data processing.

Relying on modern information and communication technology, China has realized network connection covering all survey organizations at national, provincial, municipal and county levels, and some surveys begin to be conducted in a manner of online reporting via network. In agricultural statistical surveys, dedicated applications are used for data processing, and thus realize the data entry, checking and editing, processing and output more effectively and meet the requirement of regular work. Overall, IT hardware infrastructure is relatively sound, and software infrastructure and applications need to be further improved.

2.4 Statistical information dissemination and data accessibility

As for the statistical information dissemination and data accessibility, we choose the following four assessment indicators including dissemination of core indicators, data quality and credibility, data timeliness, and data accessibility.

2.4.1 Dissemination of core indicators.

In accordance with the requirements of the ongoing statistical programs, the dissemination is typically in a frequency of quarter, half a year and year. The public can access to the statistical information timely by visiting the official website of NBS. Since China joined the Generalized Data Dissemination System (GDDS) of the International Monetary Fund (IMF) in 2002, data dissemination is towards being standardized and transparent in accordance with the international common practices. The dissemination of agricultural statistics information is usually the result of aggregating to a certain administrative region, while the individual information in sample data is confidential with no dissemination.

2.4.2 Data quality and credibility.

In recent years, NBS strengthened the quality control of the statistical data by taking dramatic measures to enforce statistical capacity building. With respect to the production process of agricultural statistical data, NBS has formulated the overall quality control management covering all aspects from survey design to data collection, data processing, data dissemination, and so on. That is, NBS takes measures to implement data quality control on every aspects of the whole procedure for agricultural data production. On the whole, the credibility of the data is high, and the consistency of the data is good.

However, it should be noted that on the aspect of estimation and dissemination of survey data, compared with the world developed countries, we still have not released the accuracy evaluation of sampling error such as the coefficient of variation (CV) and other relevant indicators. In addition, agricultural statistical data from other relevant departments are still lack of making a unified measures for total quality control management. All of these are to be further enhanced in the future.

2.4.3 Data timeliness.

The production and dissemination of China's agricultural statistical data is of a relatively high timeliness. NBS has developed a specific data dissemination timetable, and disseminate official data strictly according to the stipulated time.

2.4.4 Data accessibility.

There is a China macro statistics database in the official website of NBS for data users to query and use the historical and newly disseminated agriculture and rural statistical data. These data cover the regular quarterly survey data as well as the agricultural census and thematic survey data, etc. The existing database consists mainly of national and provincial statistical data. Some queries on disaggregated data are pre-customized, but for the time being free customization is unavailable.

3. Results and conclusion

Based on the above qualitative analysis for a comprehensive assessment composed of indicators in four dimensions, we selected some experts who are familiar with Chinese agricultural and rural statistics to give a score to each indicator. The score to each indicator with regard to current capacity status is designed to 5 grades of Likert scale. The score from 1 to 5 is represented as poor, underdeveloped, fair, good, excellent respectively. The summarized results for the overall assessment of China's capacity to produce agricultural and rural statistics are seen in the following table 1. The score listed for each indicator is taken the mode of individual marks given by selected experts, and the score listed for each dimension is a simple average of relevant indicators within this dimension.

Table 1: Overall assessment for China's capacity to produce agricultural and rural statistics.

Assessment Indicators	Indicator score	Overall score
1. Legal and Institutional Infrastructure of Statistics		**4.5**
Legal Infrastructure	5	
Institutional Infrastructure	4	
2. Resource Allocation		**4.33**
Organization Setup	5	
Personnel Allocation	4	
Fund Assurance	4	
3. Statistical Methods and Practices		**4**
Survey Methodology	4	
International Practice and Scheme Innovation	4	
Survey Themes and Core Indicators	4	
Data Collection Means	4	
IT Infrastructure and Data Processing	4	
4. Information Dissemination and Data Accessibility		**4.5**
Dissemination of core indicators	5	
Data quality and credibility	4	
Data timeliness	5	
Data accessibility	4	

In general, the current centralized statistical management in China has played a positive and effective role in the whole procedure of producing agricultural and rural statistics. First, China agricultural and rural statistics has established a sound foundation of legal and institutional infrastructure (4.5 score). Second, China agricultural and rural statistics has equipped with a relatively adequate statistical organizations and personnel (4.33 score). Third, China agricultural and rural statistics are taking measures to continually improve survey methodology and practice (4 score). Fourth, the output and data dissemination of agricultural and rural statistics are moving forwards to better satisfy the data needs of government and the public (4.5 score).

Meanwhile, we should also recognize that Chinese agricultural and rural statistics has shortcomings and need to strengthen the capacity building. Taking the advantages of the Regional Action Plan for Asia and the Pacific for Global Strategy to Improve Agricultural and Rural Statistics as a guideline, the National Bureau of Statistics (NBS) of China will be positive response to the regional action plan. NBS is taking measures to strengthen the capacity building of agricultural and rural statistics through research, training and technology application, for aiming at producing more relevant agricultural and rural statistics with high quality to better serve the user's need.

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IDCB 4
Administrative Data

Organizers: Jeffrey Smith, STATCAN and Marcel Ernens, EUROSTAT
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Three issues facing statistical agencies are becoming increasingly important: the reaction from respondents and others concerning statistical reporting burden resulting from survey activities; the cost of operating survey programs in the face of budgetary pressures; and the ever-growing demand for relevant, timely and detailed agriculture data on which to base important policy and operating decisions. Perhaps in no other statistical domain are these interconnected issues more acutely felt than in agriculture statistics programs. As agricultural statisticians strive to impose less burden on busy agricultural producers, keep costs in check or reduce them, and still meet government, industry and other data needs, they are exploring and implementing innovative ways to maximize data already "in the system" for the production of high-quality statistics. This session will examine uses of administrative data in the production of agricultural statistics.

Papers:

- Phiri Innocent Pangapanga, Shelton Kanyanda, George Kussein et al. (Malawi), "Economic Constraints in Agricultural Statistics: could administrative data complement agricultural surveys in Malawi National Statistical Systems?"
- Daniel G. Beckler (USA), "Administrative Data Used by the National Agricultural Statistics Service"
- A. Reale, M. Riani, M. Greco et al. (Italy), "Use of Administrative Data for Outlier Detection in the VI Italian Agriculture Census"
- Jeffrey Smith, Martin Beaulieu, Erin Smith et al. (Canada), "Recent Developments in the Use of Administrative Data in the Production of Agriculture Statistics"
- Anders Grönvall, Ann-Marie Karlsson (Sweden), "The Usefulness of Quality Frameworks when Deciding on Replacing Surveys with Administrative Registers - the case of the Swedish sheep register"

Economic Constraints in Agricultural Statistics: could administrative data complement agricultural surveys in Malawi National Statistical Systems?

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Abstract

Economic support for statistical activities is dwindling in most developing countries in millennium era despite the importance of statistics in evidence based policy making. This poses structural constraints to most Statistical Offices in undertaking agricultural surveys. Although various schools of thought have suggested of adopting an integrated household survey programme, on one hand, and administrative data, on the other hand, such approaches still demand more attention to quality and relevance of statistical products. This paper therefore attempted to assess the complementarities that exist between administrative data and agricultural surveys in Malawi. It applied a deep desktop analysis and high level stakeholder consultative approach in examining the synergy of the two through four researchable questions. Firstly, this paper asked who could be particular users and what the uses of administrative data are. Secondly, what could be the advantages and disadvantage of administrative data to Malawi and lastly it assessed how quality and relevance would be assured as statisticians strike a balance between statistics demand and economic constraints. From the results, it is found that there is an observable match between administrative data and surveys in Malawi. For instance, this is through farm records and survey sampling. Furthermore, almost similar users utilize statistics from both administrative data and surveys. However, this paper found that quality and relevance would only be assured if methodologies, concepts and definitions used in both are agreed, standardised and harmonised through stakeholder consultations.

Keywords: Malawi; administrative data; agricultural surveys; quality.

1. Introduction

Economic support for statistical activities is dwindling in most developing countries in millennium era (NSO, 2012; NSS 2008) despite the importance and increasing demand of statistics for evidence based policy making. This poses structural constraints to most National Statistical Offices in Sub Sahara Africa in undertaking agricultural surveys. Although various schools of thoughts have suggested of adopting an integrated household survey programme, such approach still demands more funding for survey planning to findings dissemination. Studies from developed countries have revealed that administrative data would be an option for statistical offices faced with financial burdens in terms of undertaking surveys (Accrombessy, 2008). Moreover, most government departments use administrative data in their daily operations and service delivery. Nevertheless, administrative data would require more exploration and would not be a total substitute for statistical surveys. They would also require harmonization of surveys' questionnaire and to share the same database for administrative data. This would ensure on the one hand the comparability and on the other hand of avoiding double data employment. Generally, the context of its implementation and utilisation must be regulated with regard to its legal and institutional aspects and it will be necessary to establish solid bridges between administrative sources and production. Through this, administrative data can lead for calibrating data and build a unique system of agricultural performance.

Most economies in sub-Sahara Africa are agricultural based. Hence, agricultural statistics are very crucial for poverty reduction and evaluation of other national development programs. However, data required for agricultural statistics are very limited due to irregularities and periodicities of statistical

surveys. In this paper we review the possibility of using administrative data in agriculture by comparing complementarities of methodologies and techniques applied in administrative data and statistical surveys in Malawi. Following the high need in the National Statistical System in Malawi, this paper specifically attempts to identify users and uses of administrative data for statistical purposes; examine advantages and disadvantages of agricultural administrative data; discuses on quality issues with regards to agricultural administrative records in generating desired statistics; and assess similarities in data, methodologies and techniques between administrative data and agricultural surveys.

2. Methodology

2.1 Theoretical and empirical frameworks

This paper casts its methodology on the very strong assumption that statistical offices aim at optimizing products from various statistical undertakings. Therefore, methodologies chosen are rational and function with a resultant of high quality derived information. Similarly, data sets in both administrative and agricultural surveys embrace almost the same assumption. In this paper, we further make another strong assumption that data set in administrative data records and agricultural surveys can be matched or not matched; matched and observed or matched and not observed or unmatched and not observed. Mathematically, this paper follows the work of Hazen (2011) and it can in its simple forms be illustrated as follows:

$$\nabla_{ij}= \gamma_0 + \gamma_i m_{ij} + \gamma_i d_{ij} + \gamma_i m_{ij} d_{ij} + \varepsilon_{ij}$$

$$\nabla_{ij}= \begin{cases} 1 & \textit{matched that is if both } m = d = 1 \\ 0 & \textit{not matched that is if } m = 1 \textit{ or } d = 0 \textit{ or otherwise} \end{cases}$$

where (∇_{ij}) is a complemented statistical product that is derived from either administrative data or survey data collections. (m_{ij}) is an parameter that can be either matched or not matched. (d_{ij}) is a parameter to the researcher where it can either be observed or not observed. (ε_{ij}) is a white noise that can be explained according to the design of the study. In this paper, another assumption is made that parameters in both administrative data and survey undertakings may not be observed at the first sight from a lay man's understanding. However, it would require a technical working group to identify a particular variable that matches and can be observed after thorough debates and brainstorming. In this case, another illustration is adopted as follows:

$$\widehat{\nabla}_{ij}= \gamma_0 + \gamma_i m_{ij} + \gamma_i d_{ij} + \gamma_i \hat{d}_{ij} + \gamma_i m_{ij} d_{ij} + \varepsilon_{ij}$$

$$\widehat{\nabla}_{ij}= \begin{cases} 1 & \textit{matched and observed} \\ 0 & \textit{matched and not observed} \\ \widehat{d}_i & \textit{otherwise} \end{cases}$$

where $\widehat{\nabla}_{ij}$ is a statistical product that can be decided after technical working groups brainstorming on a product. $(\hat{d}_{ij})$ is a dilemma parameter that can be matched and observed or unobserved and not matched after comprehensive technical observations over the statistical products from the two approaches.

The paper also makes a subsequent assumption that both types of data are collected in raw forms and later aggregated into final statistical products for policy or administrative use and this can be expressed through arrow diagrams below:

$$[\textbf{\textit{raw data}}\ (\boldsymbol{Y})] \xrightarrow{yields} [\textbf{\textit{combined data}}\ (\boldsymbol{X})] \xrightarrow{yields} [\textbf{\textit{final product}}\ (\boldsymbol{XY})]$$

2.2 Participatory approaches

A consultative process and a desktop research are also employed in this paper. Firstly, the paper conducted a detailed desk research on the level of administrative data in various data collections tools that are applied by the ministry of agriculture and national statistical office. Through such desk research, advantages and limitations of administrative data collections operations were assessed. Secondly, a semi-structured key informant questionnaire was developed to collect data on the timeliness, cost, response burden and other matched and observable variables between administrative and survey data collection instruments. Key informants were randomly sampled and interviewed in this paper. Apart from a key informant interview, a focus group discussion was also carried out with various players in agricultural sectors especially stakeholders that closely work at national statistical office and the ministry of agriculture. These focus group discussions help in cementing up responses obtained from key informants.

3. Results and discussion

3.1. Complementarity of administrative data and agricultural surveys

Malawi's economy is agro-based. Statistical data in agriculture is therefore critical in evaluating government programs on poverty reduction and wealth creation. However, statistical activities face

financial constraints (ASMP, 2013). The use of the administrative sources in agriculture is therefore key to a guarantee of continuous provision of agricultural statistics. Sources of administrative sources in agriculture also require vast exploitation with the aim of reducing the flow of statistical surveys but reaching a goal of exhaustiveness, lower cost, timeliness, reduced response burden, etc. On the contrary, agricultural surveys could not be just thrown away but a better balance between the two approaches needs to be derived for quality statistics.

From sampled statistical products in agriculture, the paper observed that there are areas where administrative data would aid. For example, most of the data on household identification such as district, traditional authorities, enumeration areas, villages and sub villages are collected by any agricultural administrative records. In addition, name and sex of household head are also collected in administrative records (Table 1). It is henceforth found that this data are also collected by agricultural surveys. In other words, response burden and cost would be reduced if the same data would be used in agricultural surveys. Since a decade ago after the introduction of farm input subsidy in Malawi, administrative records have been used to provide a sampling frame to decide on allocation, beneficiaries and distributions of agricultural inputs. A very good note is that most of the quantity of agricultural inputs that farmers have is already available in administrative records. Such records could be used to remind farmers about what they had. Hence, reducing errors that result from recall agricultural surveys and execution of other related survey data collections. Apart from household identification information, agricultural offices through officers based at village, they collect information on strategies, challenges, weather parameters of the area. In other words, this information is crucial to designing of national initiatives.

According to Accrombessy (2008), administrative sources often pose problems of quality. PFSB (2010) pointed out that the complementary components of administrative data cannot be disregarded given the dwindling economic support to agricultural surveys. Statisticians must therefore evaluate the quality of it and often proceed to reprocessing. But with the help of the qualified expertise of the NSO, and sincere debates through the NSS and the Ministry of Agriculture, the question of quality of data should be resolved. The NSS must be sufficiently flexible to adapt to itself to change in the administration providing gross data and maintain a permanent dialogue between agricultural data users, data suppliers and producers to develop sustained confidence in statistical products. According to key informants and focus group discussions, it was noted most of the data that is collected in administrative data are same as the data collected in surveys. For instance, the last survey conducted in agriculture was in 2006/07. Since then the ministry and government at large has been developing programs basing on administrative data (MG, 2012). Moreover, there are several ad hoc programs that come and require information from the ministry and that information cannot timely be supplied by surveys but rather by administrative processes.

Table 1 shows variables that are collected by both administrative data and surveys. It is officers employed by Ministry of Agriculture who collect the data (Table 1) and send it to Agricultural Planning Areas/blocks. Block offices send the data to the district office. Thereafter the district office combines all the data at district level from all blocks and send it to the Agricultural Development Division (ADD). The ADD is responsible for combining all data from Agricultural Rural Development Programmes (RDP) and sending it to the Ministry. At the ministry most of statistical final products are computed. Focus group discussions revealed that administrative data is available at the ministry request. In addition, data collection is cost effective as data is collected by officers who are on government pay roll. It should

Table 1: Similarities in data instruments of administrative data and surveys.

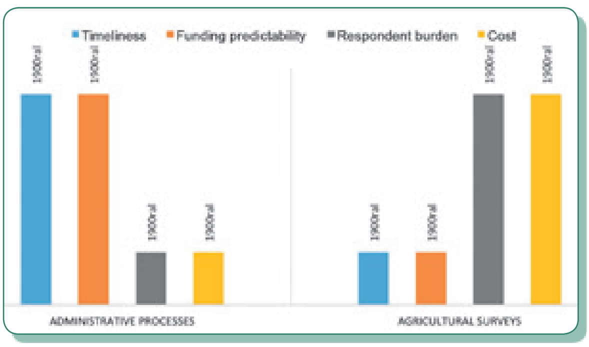
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
District	TA	Village	HH head	Sex of the HH Head	Garden # + Area	Plot # + Area	Crops planted
Information on these variables and others can be collected through administrative process							

be understood that sometimes, when resources do not allow, most agricultural surveys are based on the sampling of household listing that was also collected by officers in farm records.

3.2 Advantages of administrative data

Figure 1 presents key informants perceptions with regards to administrative data compared to agricultural surveys with scales ranging from 1 (Low) to 4(High).

Figure 1: Scales of administrative data and survey data collection.



Governments collect a large amount of data as a part of day to day administration. The administrative records and other related documents contain a wide variety of data on demographic, social, economic, cultural and environmental topics (Accrombessy, 2008). From Figure 1, it is noted that administrative data collection is less expensive and has low cost of doing the data collection as compared to agricultural surveys. Key informants reported that administrative data is low cost due to that routine officers are mostly used to conduct data collection as compared to household surveys. Respondent burden is also reduced due to that farmers are ably given space of what variables to ask. On the other hand, a time point survey instrument is supposed to be filled at the same time over all variables included in the questionnaire.

In addition, key respondents affirmed that the expensiveness of the household surveys prevents annual execution of the surveys hence they are done periodically. For instance in Malawi, the national census for agriculture and livestock (NACAL) is done every ten years. The previous one was done in 2006/07 and the next one will be in 2016/17. However, funding for the next survey may not be predictable. On the other hand, this prevents the timely need of data for statistical purposes. Administrative data on crops and livestocks would complement the national surveys on agriculture. In other words, for the years where the NACAL is not done, policy makers rely on the data that is collected using the administrative data (NSO, 2010). Resources to actually collect administrative data are predictable and usually met by administrative process itself. In brief, administrative data help government machinery for planning purposes and is available annually as it is required. As of late through the national statistical system, the NSO is promoting the use of administrative data for statistical purposes across NSS partners (NSO, 2012). However, administrative data should be aligned to survey components so that is can be used for statistical purposes. In order to make it simple, a management information system is advocated to be designed so that data are made available to the management from various sources and so that they can be used to statistically estimate some variables.

Furthermore, through use of administrative data, statistics can be prepared relatively quickly and released earlier. Since certain records in the register when aggregated together could serve as a sampling frame for surveys, they could be used to check the results obtained from other inquiries. Most often information on administrative unit records is available in registers of records that facilitate extraction of primary data and relatively error free compilation and aggregation of statistics; Since data is collected usually invoking some statutory or regulatory authority vested with the government organization the coverage and completeness of data are usually better than those derived through sample surveys; and Ministry of Agriculture with its network of regional, district and areal offices extending to the ward/ village levels would facilitate data reporting reducing response burden.

3.3 Limitations of Administrative Data

Some of the limitations of administrative data were: records reported from administrative units are often incomplete or inaccurate due to the fact that administrator(s) responsible for collecting data may not be properly trained, or methodology for recording appropriate information may be flawed; because administrative data is usually aggregated at a broader level, some information content is lost relating to individual variation and equity concerns; private individuals may be less inclined or not required to contribute data to the aggregated dataset, thereby sometimes leaving out a significant population that utilizes these services; the system as designed will not result in the records covering the desired

population or may be incomplete; The concepts and definitions used as required in terms of laws and regulations may be unsuitable for statistical purposes and also not conform to international standards; the records may contain insufficient data to provide the detailed information required to accurately classify the variables; there could be legal restrictions or confidentiality provisions that restrict access to the records; and, there are other limitations where the format of the record makes it difficult to extract statistical data, where records are kept in multiple registers. Nevertheless, PFSB (2010) argued that frankly administrative data of a country is always preferred if they possess a reasonable quality.

Since agricultural records have some disadvantages over definition, coverage and quality and these discourage the use of administrative data to generate agricultural statistics, it is therefore suggested that more work has to be done in order to reduce statistical challenges encountered when using administrative data for statistical purposes. It is also suggested that some of the challenges in using administrative records can be reduced by integrating with agricultural survey listing frame by standardizing methodologies and techniques used in either approach. Needless to mention that all National Statistical Offices (NSOs) have a duty to produce agricultural statistics with high quality with reference to relevance and completeness, timeliness, accuracy, comparability and coherence, accessibility and clarity, cost efficiency, and low response burden. NSOs must therefore strike a balance between the quality desired and the practical and economic realities of using administrative data should be much preferred if they possess a reasonable quality.

Administrative data meets purposes of statistics production in terms of direct use of register data, register estimation, combined use of survey and register data in the form of (i) additional information from registers, (ii) use as sampling frame, (iii) non-response control, (iv) imputation, (v) determining the structure of non-response. Though agricultural surveys would be the best option for statistical purposes, they poses a number of challenges such as: restricted periodicity; long time lag in producing results e.g. most of them would take a year after data collection; restrictive coverage; prone to data collection errors and loss of comparability aspects. Advantageously, administrative records are not only timely, cost effective, updated, inexpensive to acquire, computer readable and encompass large populations but also reduce response burden.

4. Conclusion

This paper has found that the agricultural surveys integrate administrative data in some of its stages. Most government departments within the ministry of agriculture use administrative data for planning, implementation and evaluation of development initiatives. In this paper, it is found that use of administrative data for statistical purposes is limited in terms of definition, coverage, quality and others. However, it can grossly be integrated in agricultural surveys only when data instruments are designed through stakeholder consultations; information need assessment is conducted; and scope, quality and data items to be collected are properly defined and agreed. In short, statisticians need to strike a balance in order to take advantage of either administrative data or survey undertakings.

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Administrative Data Used by the National Agricultural Statistics Service

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Abstract

The National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (USDA) utilizes a variety of administrative data collected by other USDA agencies to generate official agricultural estimates. These administrative data are collected by non-statistical agencies within USDA as requirements for agricultural conservation, regulation, and risk management programs. This paper discusses the various ways NASS uses these administrative data, including: (1) building and maintaining sampling frames, (2) as ground-truth for remotely sensed data, and (3) to supplement data collected on NASS's censuses and surveys. The paper also discusses various hurdles NASS has either resolved or continues to struggle with regarding the use of USDA administrative data.

Keywords: administrative data; administrative records; USDA; NASS.

1. Introduction

The National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (USDA) produces official estimates on many aspects on agriculture in the United States (US). These estimates are based mainly on censuses and sample surveys of agricultural producers. The Farm Service Agency (FSA) is another agency within USDA and is tasked with administering a variety of agricultural assistance and conservation programs that provide price-support, disaster assistance, loans, and other services to agricultural producers. The omnibus US Farm Bill, generally renewed every five years, provides authorizing legislation to FSA for the programs it administers. FSA collects an abundance of information from agricultural producers on the various application forms required to participate in the programs. Some of these data and FSA's geographical information system (GIS) data are used by NASS as administrative data (also called administrative records). NASS uses these administrative data in a variety of ways, including: (1) building and maintaining sampling frames, (2) as ground truth data for remotely sensed data, and (3) to supplement data collected on NASS's censuses and surveys.

The FSA administrative data improve the overall efficiency of generating official statistics. Such uses of administrative data are encouraged by the US Office of Management and Budget, which provides the overarching policy directives for US Government agencies (see Zients 2010, 2012a, 2012b).

This paper provides more details on how NASS utilizes FSA administrative data. It also discusses various hurdles NASS has either resolved or continues to struggle with regarding the use of FSA administrative data.

2. NASS usage of FSA administrative data

FSA administers a variety of agricultural assistance and conservation programs that provide price-support, disaster assistance, loans, and other services to US agricultural producers. In order to participate in these programs, agricultural producers must provide certain detailed information about themselves and their operations to FSA. This information is provided to FSA on a variety of forms and is used to determine program eligibility and benefits. This section explains how NASS uses some of the information FSA collects. All FSA administrative data described in this paper are confidential and may only be used within the USDA (Section 1619, Public Law 110-246).

2.1 FSA crop acreage data

One of NASS's main sources of FSA administrative data is FSA's, *Report of Acreage*. All agricultural operators who participate in the majority of FSA programs must complete a *Report of Acreage* form (FSA Form 578) annually. The *Report of Acreage* collects detailed information on the specific crops planted in a particular crop year on all acres associated with an FSA Farm (FSA 2012a). The *Report of Acreage* is usually completed by the farm operator in an FSA County Office (although FSA is working towards allowing Internet reporting). An

FSA Farm is an FSA administrative unit of land that has the same operator(s) and all of the following in common: (1) labor, (2) equipment, (3) accounting system, and (4) management (FSA 2012c). The information collected by the *Report of Acreage* is used by FSA to administer various agricultural programs and is of particular interest to NASS because it provides a reliable source for the minimum number of acres planted of each crop in the United States. The acreages are considered *minimums* because not all producers choose to participate in FSA programs. Statistics are unavailable for the number of producers who participate in various FSA programs; however, comparing official NASS year-end estimates with FSA acreage totals shows that typically 90 to 99 percent of major commodity acreages are enrolled in FSA programs.

Over the years, NASS's access mode for FSA's *Report of Acreage* data (commonly referred to as either *578 data* or *acreage data*) has changed multiple times. As of this writing, access is in a state of transition. The most reliable mode, which has been used for several years, involves receiving *Report of Acreage* data from an FSA staff member in ASCII files obtained from FSA's mainframe computer. NASS then processes the data with SAS and Hyperion software to conform to NASS metadata and program specifications. In the past, NASS was able to directly query the acreage data from an FSA-administered relational database. Unfortunately, problems with that database necessitated a change in delivery. Also as of this writing, FSA is re-establishing a relational database to hold their acreage data; NASS will again have direct query access to that database. The ability to directly query FSA data is much more efficient for NASS and FSA, since it removes the need for FSA staff intervention and it allows NASS staff more immediate access to the data.

Regardless of the access mode, NASS obtains FSA acreage data roughly weekly throughout the crop-production season (late June through late December). The data are obtained multiple times in order to ensure having the most complete (and current) data at each point in time the data are used. FSA has established due dates for when farmers are expected to complete their *Report of Acreage* forms, and these dates differ by crop and by location. Also, not all farmers meet the due dates, and processing schedules can delay the availability of data in FSA's computer systems.

The acreage data are used (operationally) for two purposes: (1) in estimating crop planted acreages, and (2) as ground truth data in the creation of the Cropland Data Layer. The second purpose is explained in Section 2.4.

Once obtained, NASS processes the FSA acreage data through a series of steps to transform the data into a usable format for NASS's systems. This process involves transforming FSA metadata into NASS metadata, as well as general reformatting. Once in a suitable format, NASS aggregates the FSA acreage data and incorporates them in its estimation process along with NASS survey data.

Based on experience, NASS uses aggregate FSA planted acreage data along with survey data (and remote sensing data) at specific times during the growing season to arrive at planted acreage estimates. The timing is based on relative completeness of reporting coverage for FSA programs. NASS first utilizes FSA data in September for cotton, rice, and peanuts, and in October for corn, soybeans, sorghum, canola, sunflowers, and dry edible beans. NASS uses these data in establishing the final end-of-season planted acreage estimates published in late September for small grains and in January for row crops, and as covariates in statistical models for county-level planted acreage estimates.

2.2 Producer name and address information

In addition to the crop acreage data reported on the annual *Report of Acreage,* FSA also associates one or more persons with each FSA Farm. Each of these persons is categorized as an *owner/operator*, *operator*, *other* name, or *owner* of the FSA Farm. Each of these terms has its definition codified in either US law or FSA policy; the details are not germane to this paper. However, it is worth noting that each person associated with an FSA Farm receives a positive percentage, called a *share*, of the governmental payments that may be generated by the agricultural assistance programs in which the FSA Farm is enrolled. The majority of FSA Farms have between one and three persons associated with them. However, a non-trivial number have more – and a small percentage may have a dozen or more. The same persons are often involved with multiple FSA Farms.

NASS utilizes the FSA names as one source in building its list of farm operations, which is used as a sampling frame for its sample surveys and as the basis for the quinquennial US Census of Agriculture mail

list. One or more persons associated with one or more FSA Farms form NASS's concept of a farm operation. Since such associations may be very complicated, FSA names are not used directly to build NASS's sampling frame. Instead, the FSA names are used as a further confirmation of agricultural activity for names NASS receives from the other sources. (This is further explained in Section 2.3.) Consistent with the definition of a farm operator in the US Census of Agriculture, NASS is interested in persons who make day-to-day decisions for agricultural operations; it is not interested in persons who only *own* agricultural land. Names received from FSA and other sources contain both day-to-day decision makers and non-decision-making landlords. By combining the lists, NASS is better able to identify the target population.

2.3 NASS versus FSA reporting unit

NASS maintains its list of farms based on the US Census of Agriculture farm definition: *A farm is any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the census year*. For each farm, NASS also maintains one or more persons who make the day-to-day decisions for the operation; one of these persons is designated as the *target operator*. For most NASS surveys, the sampling frame (population) is the collection of all target operators, while the reporting unit is all farms each sampled unit (i.e., target operator) is involved with. For a survey, each sampled target operator is requested to complete a questionnaire for each farm operation he/she is involved with. Each target operator self-identifies what constitutes a separate "farm". NASS's list frame consists of the collection of "farms" identified by the target operators.

There is no single FSA reporting unit. Instead, data are aggregated (or disaggregated) as FSA needs necessitate. As previously mentioned, most FSA data are based on the concept of an FSA *Farm*. FSA Farms are then sub-divided into one or more *Tracts*, and each Tract is sub-divided into one or more *Fields*. A *Tract* is a unit of contiguous land that is both: (1) under one ownership, and (2) operated as a farm or part of a farm. A *Field* is part of a farm which is separated from the balance of the farm by: (1) permanent boundaries, (2) permanent waterways or woodlands, (3) croplines in cases where farming practices make it probable that such croplines are not subject to change, and (4) other similar features (7 CFR 718.2, FSA 2012c). Each person involved with an FSA Farm completes a separate *Report of Acreage* form for each FSA Farm he/she is involved with. Each *Report of Acreage* form lists each Field on the FSA Farm, what crop is grown, the number of acres, and the share the person has with the Field.

Each operation on NASS's list frame may be associated with zero to many FSA persons and with zero to many FSA Farms. Furthermore, some FSA Farms may be associated with multiple NASS operations. These many-to-many associations greatly complicate record linkage between NASS and FSA operator/farm lists. A 2004-2008 research project involved explored using FSA Farms as a sampling frame instead of NASS's list of farm operations; more information is provided in Section 3.3.

2.4 FSA Common Land Units

Agricultural operators are required to delineate their individual crop fields on a paper map when they complete their annual *Report of Acreage*. FSA staff transcribes these paper maps into geographic information system (GIS) software to create FSA's Common Land Unit (CLU) data layer. Each CLU corresponds to one field. Individual CLUs are maintained as vector polygons stored in ESRI shapefile and Spatial Database Engine (SDE) formats, which are typically managed with ERSI's ArcGIS software. Attribute data for the CLUs (e.g., corresponding FSA Farm Number, number of acres within each polygon, state and county names where the CLU is located) are stored in .dbf files.

NASS currently uses CLU data in two ways. First, CLU data are used to improve data collection efficiency for NASS's June Area Survey. The June Area Survey (JAS) is a major annual survey intended to provide direct estimates of acreages as well as a measure of sampling coverage. The sample consists of approximately 11,000, roughly one-square-mile (2.6 square kilometer) land areas, called segments. NASS interviewers conduct face-to-face interviews with all farm operators located within each sampled segment; several farms typically operate within each segment. The FSA CLUs are used to identify the names and addresses of potential farm operators within the sampled segments. This is done by overlaying the FSA CLU shapefiles on JAS sample shapefiles. Data contained in the CLU attribute files allow linking the CLUs with FSA name and address information to identify individuals NASS should contact to complete the JAS. The availability of the FSA names and contact information saves

NASS interviewers time and mileage searching for individuals who farm in the sampled JAS segments.

The second way NASS uses FSA CLU data is in the creation of the Cropland Data Layer (CDL). The CDL is a comprehensive, crop-specific GIS data layer that utilizes satellite imagery to accurately locate and identify field crops (Boryan et al., 2011).

The CLU data, in conjunction with the *Report of Acreage* crop data, are used as ground truth information for the algorithms used to predict crops grown for the entire United States from the satellite imagery data. The ground truth process is used to train a computer algorithm to assign a crop (or crop category) to raw satellite imagery based on characteristics from a known sample, in this case, the CLU and *Report of Acreage* data. The details of this process is beyond the scope of this paper (for a detailed account, see Boryan et al., 2011), but the following provides an overview.

Since neither the CLUs shapefiles nor the associated attribute data contain crop information, crop acreage data from the *Report of Acreage* are linked with CLUs to provide the crops that were planted in each CLU (field). The resulting CLU data layer, now complete with crop data, is then overlaid onto satellite imagery. A decision tree is built in See5 data mining software using 70 percent of the CLU data (i.e., training data) applied to the satellite imagery; the remaining 30 percent of the CLU data are used to validate the final decision tree. The resulting decision tree is applied to satellite imagery for the United States to predict the crops grown on all land in the United States. The CDLs are published annually on NASS's interactive *CropScape* website (CropScape, 2012).

3. FSA administration data challenges

Although FSA data are a valuable resource for NASS, they also present challenges. This section discusses some such challenges NASS has encountered with FSA administrative data. Also included are applications of FSA administrative data NASS researched, but were not implemented because they did not achieve the desired results.

3.1 FSA data quality

Since NASS does not control FSA policies and procedures, it must largely rely on the FSA data as received. FSA takes some precautions to ensure data quality (such as physically measuring a small sample of producer-report field acreages to ensure accuracy). However, as with all data, there are a variety of processes – from data collection to data processing – that may introduce errors. NASS believes it is able to identify gross FSA data problems (usually traceable to FSA data entry errors); however, subtle problems are difficult, if not impossible to identify. Such was the case with NASS's October 2008 Crop Production Report.

NASS's monthly Crop Production Reports contain important acreage (planted and harvested) and production forecasts that impact worldwide commodity trading markets. In calculating crop acreage estimates for the Crop Production Reports, NASS draws upon several data sources, including farmer reported surveys, satellite imagery, and aggregate FSA acreage data. After the October 10, 2008 Crop Production report was released, FSA analysts noted a discrepancy between the acreage data contained on FSA's mainframe computer and those obtained by NASS from FSA's relational database. Using the definitive source data from FSA's mainframe, NASS repeated its acreage estimation process for dry edible beans, canola, corn, sorghum, soybeans, and sunflower. As a result, some estimates were changed and the October 2008 Crop Production Report was reissued on October 28, 2008 to reflect the corrected acreage and production estimates. That was the first (and so far only) time in NASS's 125 plus year history that a Crop Production Report was reissued.

FSA investigated why the data in their database did not match their mainframe and discovered the problem was with the extract, translate, and load (ETL) procedure that populated the database with data from the mainframe. Relatively small amounts of duplicate data were being loaded, which resulted in inflated FSA aggregate acreages.

3.2 FSA administrative data for survey item-level imputation

In conjunction with NASS's 2006 December Crops/Stocks Survey, NASS investigated the usability of FSA 578 data for item-level imputation. The experiment consisted of selecting sub-samples of positive reports in 16 states from the 2006 December Crop/Stocks Survey. The reported planted acre values were masked and NASS Field Office Staff were instructed to use the FSA Compliance Query Tool to impute for the "missing" values. The Compliance Query Tool is a Web-based application that allows users to search

FSA crop acreage data by operator name. The intent was to the compare the producer-reported data with FSA imputed data. There were two sources of potential differences. As has been stated previously, there is a many-to-many relationship between FSA records and NASS operations (i.e., operations that were sampled for the 2006 December Crops/Stocks Survey). Therefore, differences could arise from imperfections in mapping FSA data to a December Crop/Stocks Survey record. A second source of differences could arise from various measurement error issues, such as in the questionnaire design.

After the reported planted acreage values were substituted with FSA planted acreage data, the survey data were summarized and compared with the summarized values based on the reported data. The results showed a trend towards underestimation in the planted acreage totals (Swan, 2007). The results were convincing enough for NASS to abandon the practice of using FSA data for item-level imputation.

3.3 FSA data as a sampling frame research

Between 2004 and 2008 NASS extensively researched the possibility of using FSA producers as the sampling frame for its major crop-related surveys. The research goals were to improve survey results, reduce respondent burden, and contain survey costs (FSA Evaluation Report). Moving from NASS's existing sampling frame to an FSA data sampling frame required substantial changes to virtually every aspect of NASS's survey process. Questionnaires needed to be revamped; interviewer training needed to be modified; sampling methods needed revisions; all editing and summary programs needed modifications.

Ultimately, the use of FSA data as a sampling frame was abandoned as it provided no improvements to NASS's operational methods. Indeed, coefficients of variation (CV) for acreages of primary interest crops were at best similar to historical levels, and were often worse. In addition, CVs for grain stocks (also items of primary interest) were substantially worse than historical levels. Furthermore, the intended reduction in respondent burden (because respondents were asked only to respond to a single FSA Farm instead of their entire operation, as maintained on the NASS sampling frame) was never realized.

With further research, some improvements may have been possible; however, it was apparent that using FSA data as a sampling frame was fundamentally flawed and was abandoned.

3.4 Less control over administrative data

A reality with administrative data is that another organization controls their creation, maintenance, and – perhaps most importantly – their future. Although NASS and FSA have an excellent working relationship, FSA's primary reason for maintaining its data is to accomplish their own mission, not NASS's. Consequently, FSA makes changes to their data and data storage processes when their business needs necessitate. Such changes are challenges for NASS as they pose risks for becoming too dependent on the FSA administrative data. Also, changes require NASS to adjust its processing programs and rethink its methodology on how to optimally utilize the data. The impact to NASS is exacerbated when changes are made with little notice or during busy times when resources are limited to make and test processing program changes.

4. The future for the use of FSA administrative data at NASS

NASS actively pursues additional uses of administrative data. As of this writing, NASS is conducting research on the use of FSA administrative data as covariates in estimating county-level planted and harvested acres (Bellow, forthcoming). Each year NASS creates county-level planted acres, harvested acres, and production estimates for major crops. These estimates are critically important since they trigger indemnity payments for crop insurance underwritten by the USDA. In the hopes of improving its estimates, NASS is researching small-area empirical best prediction (EBP) models that utilize both NASS survey data and FSA administrative data to estimate crop acreages. Research is continuing, but preliminary corn and soybean results suggest, while the FSA data can improve the EBP model estimators, they are not improvements over NASS's current practice.

As of yet, NASS has made little use of using FSA administrative data in lieu of collecting separate survey data. This is due to several reasons. First, NASS surveys collect considerable more data than what is available at FSA. Second, the timing of the availability of FSA data is not always conducive to NASS's needs. Third, the issues discussed in Sections 2.2 and 2.3 pose challenges in pairing

FSA data with operations on NASS's sampling frame. Despite these challenges, NASS has planned research to pair FSA names with NASS operations through probabilistic record linkage. To date, NASS has limited empirical data such record linkage. The intent of the planned research is to determine the effectiveness and efficiency of this pairing then identify potential uses of record-level FSA administrative data. These uses could include using FSA data in lieu of asking for survey data (for the limited number of items available from FSA), or for item-level hot-deck imputation triggers based on the availability of FSA data.

5. Conclusion

This paper explained the various types of administrative data available from USDA's Farm Service and how NASS utilizes those data to produce products (such as the Cropland Data Layer) and gain program efficiencies. In addition, this paper explained past and present struggles NASS has regarding FSA administrative data as well as research on additional uses of the data. Although some uses of FSA data have proved unsuccessful, the availability of the data continues to be a valuable resource and further uses will continue to be sought.

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Use of Administrative Data for Outlier Detection in the VI Italian Agriculture Census

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Abstract
In order to increase census data quality, a new Editing & Imputation System (E&IS) has been developed for the VI Italian agriculture census. According to the strategy adopted, the detection and review of outliers have been performed during the data collection phase. Particularly, for detecting anomalous surfaces, a special procedure, based on the robust technique of Forward Search has been implemented. The outcome of this procedure has been a list of holdings whose values have been manually reviewed by census regional staff, according to a score function depending on the relevance of the potential error (*selective editing*).

Aiming to limit the respondent burden, the selective editing has been supported by the available information drawn from administrative sources. Particularly, this procedure has highlighted the farms whose census values are not concordant with the data of the Integrated Administration and Control Systems in Agriculture.

This method is based on the hypothesis that the differences between the two data sources are due to different classification schemes, reference time, or observation field. To detect outlier values, the holdings have been stratified on the basis of the farm size, the region and the area invested in the following main surfaces: Utilised Agricultural Area (UAA), total area, vineyards and olive plantations. The use of administrative data in this stage of editing and imputation has contributed to reducing relevant errors, thus narrowing the gap between provisional and final figures.

Keywords: agricultural census; administrative data; outliers detection.

1. Introduction
According to the guidelines adopted in planning the new Editing & Imputation (E&I) System for the 6th Italian agricultural census, the whole process of identifying and treating the non sampling errors has been divided in two main stages. The first stage has been carried out during data gathering, involving the regional census network, to correct the variables disseminated as provisional figures. In the second stage, all the remaining variables have been corrected, for achieving the final figures.

During the first stage, in order to avoid and correct fatal errors and missing values, different editing activities (micro-editing check and the outlier detection) have been carried out according to:

- the data collection method;
- the level of regional involvement in census organization;
- the entity in charge of data entry.

Data capturing has been performed by a multi-channel technique, based on the traditional face-to-face interview (paper or computer based) and on the optional release of information via web. Concerning the census network organization, while some Regions[1] have chosen the Integrative Participation (IP) model and have been mainly responsible for the field work, other Regions have adopted the High Level Participation (HLP) model and during data collection have also recorded the questionnaires by a controlled data entry system. In the first case, only a subset (about 20) of variables concerning the farm structure (*primary variables*) has been transmitted to Istat for provisional figures, and all paper forms have been recorded in outsourcing at the end of data collection. As a consequence, for the Regions with IP model, the E&I procedures launched during data gathering have affected this subset of variables only. During data recording, the Regions with the HLP model have also checked at unit level the coherence between related variables, by a micro-editing check based on a subset of 220 editing rules[2] and integrated in the data entry System.

The same constraints have been integrated in the Survey Management System (SGR, the web application for data gathering), particularly in another automatic checking procedure arranged for the electronic forms filled via web by the holdings and launched by the regional staff before sending the collected data to Istat.

For reducing missing or invalid values of the key items particularly difficult to impute, such as holding identification and location, two types of checking rules have been used:

- fatal edit rules, to force the respondent or the interviewer to correct inconsistent data;
- query edit rules, to underline supposed errors needing further investigation.

For limiting the respondent burden, these edits have been adjusted to fit the data capture technique.

2. The linkage between census and administrative data

Before the end of data collection, outlier values have been detected by a special procedure (Torti et al., 2013; Riani et al., 2012), based on the robust technique of Forward Search (Atkinson, Riani and Cerioli, 2004; Atkinson and Riani, 2000), carried out in partnership with the University of Parma and centrally managed by Istat. This procedure has highlighted the observations with anomalous values, which could have been the result of measurement errors, as well as large size holdings. These units have been prioritized according to a score function related to the relevance of the potential errors (*selective editing*) and have been manually reviewed by the census regional network. In order to improve the efficiency of additional checks, the outlier procedure has been focused on vineyards and olive plantations, for their relevance within the permanent crops and on total area and Utilised Agricultural Area (UAA), whose values correspond to the sum of the single cultivations.

For limiting the follow up of respondents, the selective editing has been performed by comparing census data with the information available in the Integrated Administration and Control System in Agriculture held by the Italian paying Agency (whose acronym is AGEA). Due to different reference time and purpose of administrative data, AGEA doesn't cover the whole census target population. Actually, administrative units correspond to the subset of farms which have applied for European benefits in a specific year, as established in the common agricultural policy. According to the result of the linkage procedure, based on the correspondence of the fiscal code of the holder in both databases, about 85% of census farms have matched with administrative units having at least one of the checked variables.

The procedure has been implemented by using the core routines from Forward Search for Data Analysis (FSDA) toolbox for Matlab[3], developed jointly by the University of Parma and the Joint Research Centre of the European Community (Riani, Perrotta and Torti, 2012). These tools have been integrated in a flexible web-based application, called "Concert", implemented to schedule and manage all E&I procedures.

3. The Methodological approach

The procedure for detecting outliers has been developed in partnership with the University of Parma and launched by Istat as soon as data have been recorded in SGR. For the treatment of a large volume of data, the robust technique of Forward Search (Atkinson and Riani, 2000; Riani et al., 2012) has been chosen, for its computational efficiency and effectiveness, to point out anomalous units.

The underlying assumption of this method is that the considered data sources should be similar, having acceptable discordances depending on different period of data collection, observation field, or classification scheme only. On this premise, data referring to the same territorial levels are supposed to be divergent only due to potential recording errors or inaccuracy during data release. In order to identify the holdings whose census values strongly deviate from administrative data, after data linkage, units have been stratified according to the farm size, the farm location and the area invested in the analyzed surfaces.

Particularly, the holdings located in the regions with high level participation model have been stratified at Inter-municipal level, while the remaining farms have been separated in provincial strata. In both cases, the analysis has been carried out for the following characteristics: UAA, total area and vineyards, while the area invested in olive plantations has been examined for the Regions with HLP model only (due to the limited set of data recorded and available for provisional figures in the other Regions).

For applying the Forward Search (FS) for regression[4], units have been divided in subsets of increasing size m, starting from m0 = p (where p is the number of explanatory variables) and ceasing when all observations not included in the subset are recognized to be outliers. In each subset, least squares are used for parameter estimation. At the beginning, the outlier-free subset is chosen according to the least median of squares criterion of Rousseeuw and Leroy (1987). Anomalous values are identified by comparing the parameters before and after increasing the number of observations in the subset. Particularly, outliers values are detected by analysing the minimum absolute deletion residual computed for the observations not in the subset, where s(m) is the square root of the estimate of the residual variance computed from the observations in the subset S(m).

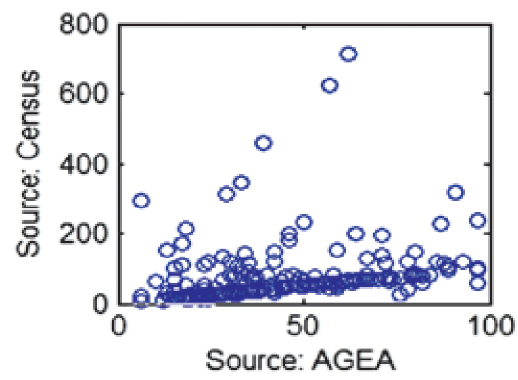
$$r_{\min}(m) = \min \frac{|e_i(m)|}{s(m)\sqrt{\left[1 + x_i^T \left\{X^T(m)X(m)\right\}^{-1} x_i\right]}} \text{ for i} \notin S(m) \quad (1)$$

If an observation belonging to the subset S(m) deviates significantly from the regression model, the modulus of its deletion residual will be greater than the maximum amongst the other units included in the subset. For the values of this parameter, a test of hypothesis has been carried out to verify the null hypothesis of absence of outliers values. The confidence interval that has been fixed is 99%, meaning that given a normally distributed population, outlier values are supposed to be found in 1% of the analyzed dataset.

Data analysis has been improved by plotting for each dataset the results of the procedure, thus providing a synthesis of model inadequacy and adjustment. For every type of area, and for every unit, represented by a point, census data are reported on y axis (Figure 1). Distant points from the main diagonal are supposed to be outlier values or potential errors that need further assessment. In our example, most of the data stands along the main diagonal and there are only nine scattered outliers (marked by the green points).

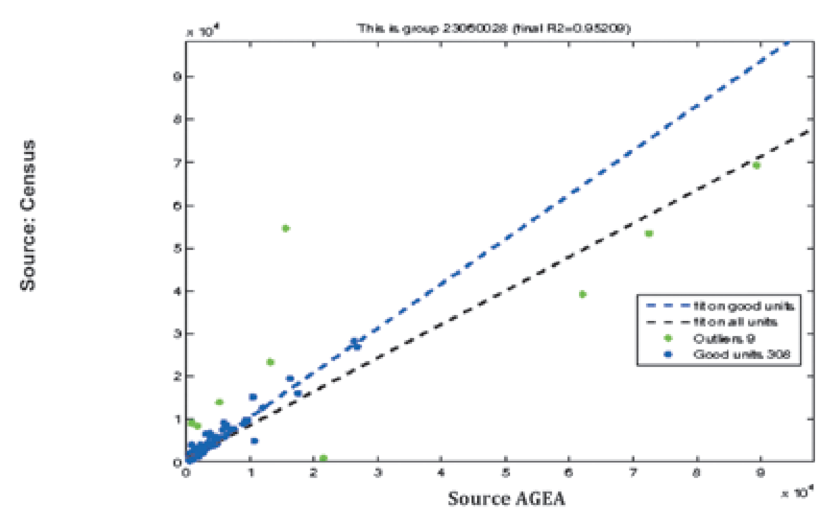
This approach has also allowed anomalous values due both to random recording problems, and to other types of errors generating a specific pattern in the outlier behaviour, to be dealt with. This may occur when in a particular area, census surfaces systematically exceed administrative values (Figure 2). In this case, starting from the area where most of units are concentrated, the FS algorithm allows identification of the scheme related to the observations far distant from the main diagonal.

Figure 2: Example of observations whose values follow a specific pattern.



In case of perfect correspondence between census and administrative values, all units would lie on the main diagonal and the regression line would have vanishing intercept and unitary slope and the variance of the errors of the regression line (σ^2) would be close to zero. In this hypothesis, small discrepancies between the two sources may produce very large residuals (after their standardization with the estimated values of σ) and very small p-values. This occurrence (known as "perfect fit" problem in the literature of robust statistics[5]) has been prevented by monitoring the coefficient of determination (R2). Particularly, when almost perfect fit was achieved (R2 was close to one), the confidence level was increased, in order to focus the analysis on relevant discrepancies. Furthermore, also the datasets with small final

Figure 1: Example of the results of the outlier detection procedure.



estimated value of R2 have been examined, to test the existence of a particular pattern, or the presence of multiple groups (e.g. Garcìa-Escudero et al., 2010).

Several t-tests, using the observations not detected as outliers only, have been performed on the estimated values of the intercept and the slope coefficient, to assess the distance from the hypothesized population values $\alpha = 0$ and $\beta = 1$.

The score function, for ranking detected outliers, has been computed according to the output of the procedure and the percent of absolute variation between administrative and census values. Only outlier units having in both sources total area or UAA greater than one ha, or area invested in vineyards or in olive plantation larger than 0.5 ha have been included in the lists sent to the regional census offices. In addition to outlier units, the Regions with High Level Participation model have received the list of units affected by relevant errors, detected by applying the whole set of editing rules to the recorded questionnaires.

4. Results of the Forward Search procedure

The analysis of the procedure outcome highlights that in most of the regions, the percentage of detected outliers is around 3% (Table 1), with the maximum value in Sardegna (7.89%) and the minimum value in Liguria (1.85%). The regions having the highest average of outlier values (last column of Table 1) among the units marked as outliers are Sicilia (1.63) and Sardegna (1.61). On the whole, these results confirm the effectiveness of the editing activities in preventing relevant errors during data collection stage.

The amount of data corrected or confirmed by comparing census and administrative data has depended on the regional degree of interaction with Istat. The percentage of census values replaced by AGEA data is lower than 7% (Table 2), for all types of area. For the revision of outlier units, other sources, including call-backs to holdings, have been used mostly. The highest rate of replacements (25%) has been computed for vineyards in the Regions which have chosen the Integrative participation model.

At the end of the manual revision, the remaining errors have been centrally treated by automated procedures managed by Istat.

5. Conclusions

Aiming at improving data quality, before the end of data collection, a special procedure has been implemented to detect outlier units. The selective editing has been performed by comparing census values with the available administrative information, thus minimizing the respondent burden.

In order to treat large amount of data, an effective and computationally efficient method has been used to detect outliers and prioritize them for further checks. The outlier detection procedure, based on the Forward Search and on a simultaneous confidence level of 99% has allowed identification of about 3% of farms, whose census data markedly deviate from the values recorded in the administrative source.

In addition to the outlier detection, the review of relevant errors highlighted by the micro-editing check launched during data gathering, has contributed to cope with timeliness constraints and to reduce the distance between provisional data and final results.

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Endnotes

1 Veneto, Toscana, Marche, Puglia.

2 As a whole, the list of checking rules contains about 1200 consistent and not redundant constraints.

3 The toolbox is freely downloadable from: http://www.riani.it/MATLAB or http://fsda.jrc.ec.europa.eu.

4 For more details on the FS, see Riani andAtkinson (2007).

5 See for example Maronna et al., 2006.

Table 1: Results of the outlier detection and relevant error detection procedures for Region.

Region	Processed holdings (x)	Units having at least one fatal error or outlier values (y)	% of units with at least one fatal error or outlier values (x/y)*100	Total number of fatal errors and outlier values (z)	Average of fatal errors per unit (z/y)	Total number of holdings having at least one outlier value (t)	% of holdings having at least one outlier value (t/y)*100	Total number of outlier values (u)	Average of outlier values per holding (u/t)
Piemonte	99,013	6,322	6.39	8,369	1.32	4,009	4.05	5,937	1.48
Valle d'Aosta	5,142	409	7.95	538	1.32	295	5.74	424	1.44
Lombardia	90,870	4,404	4.85	5,773	1.31	2,672	2.94	4,266	1.60
Veneto*	160,462	-	-	-	-	3,721	2.32	5,881	1.58
Friuli-Venezia Giulia	29,668	1,015	3.42	1,291	1.27	605	2.04	906	1.50
Liguria	34,071	1,269	3.72	1,475	1.16	632	1.85	738	1.17
Emilia-Romagna	99,132	4,019	4.05	4,726	1.18	2,775	2.8	3,421	1.23
Toscana*	104,220	-	-	-	-	4,340	4.16	5,126	1.18
Umbria	46,045	2,748	5.97	3,226	1.17	1,388	3.01	1,786	1.29
Marche*	62,691	-	-	-	-	1,604	2.56	2,301	1.43
Lazio	152,963	6,095	3.98	8,082	1.33	3,463	2.26	5,270	1.52
Abruzzo	85,844	4,106	4.78	5,588	1.36	2,441	2.84	3,698	1.51
Molise*	33,161	-	-	-	-	993	2.99	1,500	1.51
Campania	182,869	11,684	6.39	14,526	1.24	4,595	2.51	7,021	1.53
Puglia*	321,399	-	-	-	-	8,778	2.73	12,546	1.43
Basilicata	60,135	4,184	6.96	5,580	1.33	2,456	4.08	3,779	1.54
Calabria	163,518	12,273	7.51	15,890	1.29	5,602	3.43	9,028	1.61
Sicilia	272,403	13,850	5.08	19,243	1.39	8,526	3.13	13,855	1.63
Sardegna	83,092	8,538	10.28	11,580	1.36	6,554	7.89	9,416	1.44
Bolzano-Bozen	26,752	1,705	6.37	1,919	1.13	560	2.09	667	1.19
Trento	22,885	1,384	6.05	2,054	1.48	1,026	4.48	1,575	1.54
Italia	2,136,335	-	-	-	-	67,035	3.14	99,141	1.48

Table 2: Outliers distribution by type of organizational model, type of variable and outcome of the investigation: absolute and percentage values (in brackets).

Region's involvement degree	Invested area	Number of census values confirmed	Number of census values corrected according to AGEA value	Number of census values replaced with values coming from other sources	Total number of outlier units reviewed
Integrative participation model	Total area	8,452	125	2,239	10,816
		(78.14)	(1.16)	(20.70)	(100.00)
	UAA	7,840	55	1,581	9,476
		(82.74)	(0.58)	(16.68)	(100.00)
	Vineyards	5,087	200	1,775	7,062
		(72.03)	(2.83)	(25.13)	(100.00)
High level participation model	Total area	30,079	607	4,043	34,729
		(86.61)	(1.75)	(11.64)	(100.00)
	UAA	25,997	442	2,937	29,376
		(88.50)	(1.50)	(10.00)	(100.00)
	Vineyards	4,126	159	732	5,017
		(82.24)	(3.17)	(14.59)	(100.00)
	Olive plantations	2,029	175	461	2,665
		(76.14)	(6.57)	(17.30)	(100.00)

Recent Developments in the Use of Administrative Data in the Production of Agriculture Statistics

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Abstract

While the Statistics Canada Agriculture Statistics Program has made use of administrative data for many years in various ways, recent initiatives have resulted in renewed and heightened interest in expanding their use. For example, the launching of the Red Tape Reduction Commission by the Government has provided federal departments with new guidelines and has led to the development of action plans to reduce reporting burden on businesses (including agriculture producers), including making more use of data already collected for administrative purposes rather than collecting the same or similar data again. In addition, the recent strong focus on seeking efficiencies in Government operations is providing the impetus to seek potentially lower cost alternatives, such as the use of existing administrative data where possible, instead of relying on the increasingly expensive collection of data by traditional surveys or censuses.

Agriculture financial data are currently collected directly from farmers through two main vehicles, the Farm Financial Survey, which is a sponsored survey that has recently become biennial after having been conducted annually for a number of years, and the Census of Agriculture, currently conducted every 5 years. These two data collection activities are perceived as burdensome by respondents since they collect revenue and detailed expense information on the agricultural operation, which may require respondents to consult records or make calculations; the forms/interviews may be long to complete; and possibly because the same or similar data are provided to other federal or provincial government organizations. In addition, agriculture financial data have also been compiled directly from taxation records for many years. This activity makes use of data already reported to the Canada Revenue Agency for taxation purposes, and therefore introduces no new respondent burden. The experience accumulated in working with these records will be a key asset in expanding the use of such data. The paper will present the issues, methods, analysis, findings, and recommendations of a multi-year study assessing the removal of financial questions from the two major direct data collection activities and using instead the available administrative (taxation) information.

In an effort to manage response burden and program costs, the Agriculture Statistics Program has been exploring alternate ways to produce agriculture commodity and related statistics. One project studied the combined use of satellite imagery, data gathered by ground observation and administrative data held in agriculture-related databases (such as crop insurance programs). An extensive study was also conducted on the feasibility of using taxation data to replace expense questions on the Census of Agriculture. Other studies investigated and evaluated data held in a number of agriculture business risk management programs (such as AgriInvest, AgriStability) and other administrative databases (such as animal traceability) as to their suitability for replacing data now collected by surveys. The potential for other uses of these administrative sources, such as to validate or supplement survey data, for use as ground-truth data in remote sensing applications and for frame building, maintenance and improvement, was also assessed. The paper will describe the studies conducted in 2012 and 2013, and present an assessment of the feasibility and limitations (e.g., issues related to access, timeliness and quality of the administrative data) associated with the various uses of data obtained from these administrative sources. Other Statistics Canada initiatives related to increasing use of administrative data will also be described.

Keywords: administrative data; survey data replacement; taxation data; feasibility studies.

1. Introduction

The Statistics Canada Agriculture Statistics Program (ASP) has a long history of use of administrative data. The ASP releases statistics to the public on all aspects of agriculture more than 150 times per year through Statistics Canada's main dissemination vehicle, *The Daily*, and via CANSIM, the principal socio-

economic database which has been available free of charge since February 2012. The statistics are based on a suite of sub-annual and annual surveys (which for some subsectors are essentially censuses), the quinquennial Census of Agriculture, the Agriculture Tax Data program, remote sensing applications and other administrative data. In the survey and census components of the statistical program, a wide variety of administrative data are used – that is, data that were not collected by Statistics Canada (although the holder of the data may have conducted a survey, for example), and were generally speaking collected for purposes such as operating or monitoring programs, enforcing regulations, etc., rather than for the publishing of statistics. Also, some of the statistics published by the ASP are entirely based on administrative data sources. The administrative data are obtained from both federal and provincial governments, as well as non-government organizations. These sources are used in a variety of ways, including for survey and census data confrontation and validation, and for partially replacing survey taking (e.g., by eliminating the need to include some questions on surveys, or by allowing some jurisdictions to be not surveyed at all), or for complete replacement of data collection (i.e., the estimates published are entirely based on administrative data).

The Census of Agriculture, a key component of the ASP, is conducted by Statistics Canada and collects data directly from respondents every five years. The units of interest for the census are all Canadian agricultural operations[1] producing agricultural products with the intent to sell them. The respondents are agricultural operators (farmers). The most recent Census (2011) counted 205,730 farms, a decline of 10.3% from the 229,373 counted in 2006. This continued a longer term trend in the decline in the number of farms in Canada from its peak of 732,832 counted in the 1941 Census of Agriculture. The Census of Agriculture is conducted concurrently with the Census of Population and in Canada both are carried out in years ending in “1” and “6”. The most recent Census Day in Canada was May 10, 2011, and the next is scheduled for May 10, 2016. The resources required for the Census of Agriculture are not part of Statistics Canada’s main budget, but are funded through the federal Treasury Board based on submissions made for each cycle. The Census of Agriculture, like the Census of Population, is conducted on a mandatory basis under the *Statistics Act* - responding to the censuses is compulsory under the law, with provision for penalties for non-compliance and/or provision of false information.

Also part of the current program are 39 surveys conducted by Statistics Canada which collect data directly from respondents (on a sub-annual, annual or occasional basis). Funding for six of these surveys is solely from Statistics Canada’s main budget, and seven are funded from a combination of the main budget (the principal source) and some additional cost-recovery funding. The remaining 26 surveys are funded exclusively through cost-recovery clients. Thirty-five of the 39 surveys are conducted on a mandatory basis, and the remaining four are voluntary (two of which are main budget funded, and two are cost-recovery funded). Most agriculture surveys are mandatory, since like most other business surveys, the information collected is needed to feed the system of National Accounts (for GDP calculations, among other uses). In about half the surveys, the respondents are agricultural producers (farmers), but in the remaining cases, the respondents are agriculture-related businesses (such as grain elevators, processing plants, buyers of agricultural products, producers or sellers of inputs such as fertilizer manufacturers, etc.). These latter surveys are generally seeking information about quantities or prices of agricultural commodities purchased from farmers and/or inputs sold to farmers. While it would be possible to ask farmers directly about their sales to buyers and processors, and their purchases of inputs, it is much more efficient, and imposes much less reporting burden on farmers, to go to the smaller number of processors or buyers to obtain this information by asking them about their purchases from, or sales to, farmers.

It should be noted that in the case of some of the 39 surveys, only a portion of the sector is subject to surveys, with administrative data used to cover the remaining portions of the relevant universe. Two examples of this are the Maple Products Survey, where only producers in the provinces of Ontario and New Brunswick are surveyed and administrative data are used instead of conducting surveys in Québec and Nova Scotia; and the Honey Production, Value and Colonies Survey, where only producers in the provinces of Prince Edward Island and New Brunswick are surveyed, since administrative data are obtained from the other provinces.

The ASP also carries out 12 activities that produce statistics derived entirely from administrative sources and/or survey sources already collected by others (i.e.,

no direct data collection from respondents is conducted by Statistics Canada). Four of these of these are funded by cost-recovery and the remaining eight are funded from Statistics Canada's main budget.

2. Background

Currently, the Agriculture Statistics Program employs over 200 administrative datasets as part of the process of collecting, processing, analyzing and publishing its statistics. These administrative datasets are sourced from other federal government departments and agencies (for example, the Canada Revenue Agency, Agriculture and Agri-Food Canada, the Canadian Grain Commission), provincial government departments and agencies (such as ministries of agriculture, provincial statistical agencies), and the private sector (such as national and regional commodity associations, research institutes).

The majority of sources concern Canadian information, although a few international files are also obtained, where relevant - for example, where a particular commodity is traded extensively with another country. The information received from a particular source may be microdata records or aggregated statistical information, or a combination. The information obtained is used for a variety of statistical purposes, many related to assuring the quality of the ASP outputs. For example, administrative information is used to: i) ensure accurate frame coverage (e.g., lists of producers of a particular commodity); ii) to confront, validate and certify estimates from surveys or censuses (e.g., comparing estimates from administrative sources to those produced from the survey); iii) to improve survey estimates (e.g., by using administrative records in editing or imputation processes); iv) to serve as a complement or enhancement to the official survey- or census-based published estimates (e.g., the weekly crop condition information based on satellite imagery that is published concurrently with survey-based official estimates of crop area, production and yield); and, v) to reduce reporting burden (e.g., by reducing the content and/or sample size necessary in the survey operations, or by eliminating a survey altogether).

Historically, the first four uses have been the most prevalent, although numerous examples of the fifth use exist. One illustrative example is maple products. Although there are maple producers in several Canadian provinces, the Maple Products Survey is conducted by Statistics Canada in only two. For the other principal producing provinces, the required information is obtained from the provincial statistical agencies and/or ministries of agriculture from files they already hold, thereby eliminating the need to conduct the Statistics Canada survey in those provinces. Using this approach, the sample for the maple products survey is less than 30% the size it would be if all provinces were included in the survey.

One important factor driving the increased interest in the use of administrative data in the ASP is a recent federal government-wide initiative. Following up on a commitment made in the March 4, 2010 Federal Budget 2010, on January 13, 2011, the Prime Minister of Canada announced the creation of the Red Tape Reduction Commission (RTRC), stating that it would work to reduce the burden of federal regulatory requirements on Canadian enterprises, especially small and medium-sized businesses. The RTRC has a two-fold mandate: i) identify irritants to business that stem from federal regulatory requirements and review how those requirements are administered in order to reduce the compliance burden on businesses, especially small businesses. The focus was to be on irritants that have a clear detrimental effect on growth, competitiveness and innovation; and ii) recommend options that address the irritants and that will control and reduce the compliance burden on a long-term basis while ensuring that the environment and the health and safety of Canadians are not compromised in the process. The RTRC has held a series of in-person consultations and received online input through its website, and published findings and recommendations there.

Statistics Canada was included in the red tape reduction exercise, and in fact, was one of the federal organizations designated as having "significant" regulatory responsibilities, although many may not see Statistics Canada as having a role in regulating businesses in the commonly understood sense. The designation was due to its data-gathering activities, and the definition of red tape adopted by the RTRC confirmed this: "For the purposes of the Commission, the term 'red tape' means unnecessary and undue compliance burden. Compliance burden is the time and resources spent by business to demonstrate compliance with federal government regulations in terms of the following: i) planning, collecting, processing and reporting of information; ii) completing forms and retaining data required by governments; iii) inspection costs; and iv) waiting for regulatory decisions and feedback." Clearly, the first two aspects of "compliance burden" defined Statistics

Canada's survey- and census-taking activities as "red tape" and therefore subject to the RTRC's efforts.

In 2012, the RTRC published the Red Tape Reduction Action Plan. For Statistics Canada, the action plan committed to results on three strategic outcomes: i) reducing reporting burden for its business surveys; ii) reducing redundancy of data requests across government departments; and, iii) improving communication. For the ASP, the first and second commitments are the most significant and specific targets have been set. In the case of the Census of Agriculture, specific targets have been set under the Action Plan to reduce content for small and medium-sized operations in 2016 by 7% compared to 2011, and for the survey program, to reduce content for small and medium-sized operations by 5% by 2017, compared to 2012. The ASP, as part of the Statistics-Canada business survey program, will also participate in Agency-wide initiatives streamline survey taking, use more administrative data, and increase the use of electronic reporting.

It is also worth mentioning another recently-launched Statistics Canada initiative related to administrative data. To support the planned increase in activities related to the acquisition and use of administrative data, Statistics Canada created the Administrative Data Secretariat within the Statistical Infrastructure Branch in September, 2012 with a mandate to develop and implement an integrated approach to improve and increase the use of administrative data. The new Secretariat is a logical support to the commitment in Statistics Canada's 2013-14 to 2015-16 Corporate Business Plan (May 2013) that one of the organization's priorities is the "exploration and exploitation of the further potential to use public and private sector administrative data to replace or complement survey data." While the primary responsibility for integrating administrative date into statistical programs will continue to rest with the subject matter divisions, the Secretariat will facilitate collaboration with federal, provincial, territorial and municipal governments, and the private sector. The goal of the Secretariat and subject matter divisions' joint efforts will be to use administrative data where possible to maintain or improve the balance among relevance, quality, cost and respondent burden. The Secretariat's work is planned to run until March 2015 and will employ a 3-part strategy to i) develop a governance structure for the acquisition, management and use of administrative data sources, ii) review and optimize practices and procedures for handling administrative data; and iii) serve as a clearing house for the exploration of administrative data sources and innovation in their use.

3. The Agriculture Statistics Program Review and feasibility studies

As noted above, two recent significant events served to intensify the focus on the use of administrative data in statistical programs and in some respects, agriculture statistics received somewhat more of the share of the spotlight. One was launch of the Red Tape Reduction Commission in 2011 and in the initial months after that launch, consultations were conducted and the Commission heard from small business across Canada on various issues related to coping with government "red tape" challenges. While much of the feedback was aimed at the paperwork, time and apparent bureaucracy involved in meeting regulatory requirements, getting permits or licences, etc., the compliance burden for businesses to gather, hold and report information to the government was included in the definition of "red tape" and during the consultations there were mentions of the burden associated with responding to Statistics Canada surveys, with agriculture surveys being specifically cited in a few cases. This, combined with a traditional eagerness amongst some farmers to raise complaints immediately to the level of their Member of Parliament, gave agriculture surveys a certain heightened profile. The other significant event was the Government's 2010 decision to eliminate the Census of Population "long form" previously received by 20% of households and replace it with the voluntary National Household Survey containing similar questions as the old long form and received by 33% of households. While the Census of Agriculture was not directly part of this discussion (and eventually proceeded as planned), it was referred to in some debates and hearings conducted in 2010, and so the length of the questionnaire, the nature of the questions and perceived reporting burden did receive some attention. As a result, this triggered a number of investigations within the ASP, on several fronts.

3.1 The Tax Replacement Study

One project that was already underway, but nonetheless fit nicely into the context of reducing reporting burden was the Tax Replacement Study for the Census of Agriculture.

For many years, numerous Statistics Canada business statistics programs have used taxation data obtained from the Canada Revenue Agency (CRA) to supplement or replace the data collected by surveys, especially for smaller businesses. With the introduction of a value-added tax, the Goods and Services Tax, or GST in 1990 (and later, various systems of Harmonized Sales Tax, which combined the federal and provincial sales taxes), the mechanisms were in place to make this source of administrative data useful since most businesses of any consequential size had an incentive to register and obtain a business number (BN) in order to manage their GST accounts and obtain eligible rebates and credits. At the same time, the Agriculture Taxation Data Program has collected taxation data from more than 25 years, producing statistics on revenues and expenses of farms, and income of farm operators and farm families. The experience developed over the years within this program proved to be very useful to the study and eventual integration of taxation data into other statistical programs such as the Census of Agriculture.

The Census of Agriculture has traditionally contained a section which collects detailed expense data for the agricultural operation. In the 2009 Census test, as part of the 2011 development cycle, farmers were asked to provide their BN, for the purpose of accessing their tax records in order to obtain the information on business expenses they had already provided via their tax return. For the 2009 test, the detailed expense questions were still on the census form and the expense items were collected whether or not the respondents provided their BN. This allowed for the linkage of the records collected during the test to the taxation records for those who did provide a BN, and permitted subsequent comparison and evaluation of the two sets of data. About 65% of the test respondents provided a BN and of these, the majority were linkable to the corresponding record in the tax system with a high degree of confidence.

The results of the 2009 test were sufficiently encouraging that the decision was made to include a question on the actual 2011 Census of Agriculture form requesting the BN. However, since the Census test did not involve a very large number of agricultural operations (it was mailed out to about 7,300), the detailed expense questions also appeared on the 2011 form, and in this sense the 2011 Census served as a full scale test of the comparability of the tax-based and census-based sources of detailed expense information. Having both the BN plus the expenses reported on the 2011 Census of Agriculture allowed a full-scale evaluation of the linkage rates and quality, as well as a detailed study of the comparability of the two data sources, thereby permitting a decision on whether the tax data were suitable as replacement for the collected data. The results in 2011 were very positive, with most respondents providing their BN.

In using the BN to link to the tax files, more sophisticated iterative linkage methodology was employed, incorporating probabilistic methods and manual reviews where automated, deterministic links were not possible. At the end of the linking process, approximately 86% of the farms enumerated in the 2011 Census of Agriculture were successfully linked to their corresponding tax record. There was variation in linkage rates by province, ranging from about 54% to about 92%. A detailed study of the information in the tax records versus that provided on the census form showed that for almost all farms in Canada (99%) the total replacement of detailed expense information collected on the census by the data already in the tax system was feasible with a high degree of confidence. For example, based on the tax records, 2010 total operating expenses (the reference year for financial data collected on the census conducted in year t is year t-1) for all farms was estimated as $42.443 billion, while based on the data collected from the census form, the figure was $42.196, a difference of +0.6%. This difference was deemed to be tolerably small and in a logical direction since it is credible that information prepared for tax purposes might be more thorough and complete (i.e., reporting higher total expenses) compared to that reported on the census form).

On the other hand, for certain subpopulations, such as the largest and most complex farms, and for special universes (such as community pastures, institutional farms, and northern farms), the study determined that tax replacement would not yet be feasible, as the differences were larger (+5.4%, +8.6% and +20.4% for northern farms, community pastures, and institutions, respectively), or were in the opposite direction (-7.8% for large complex farms). These subpopulations are relatively small in number and in general had lower linkage rates. For these subpopulations, more research is needed before full tax replacement can be implemented. It has therefore been proposed that the detailed expense information continue to be collected on the 2016 Census of Agriculture for these subpopulations. In the case of

certain collective agricultural operations, there were relatively large differences in the expenses reported on the two sources (-13.9%), although it is thought that the linkage methodology can be improved sufficiently to allow taxation data to be used instead of direct collection by 2016.

3.2 The Agriculture Statistics Program Review

Even though the events of 2010 primarily concerned the Census of Population, it was determined in late 2010 that a thorough review of the Agriculture Statistics Program, including the Census of Agriculture, would be essential, especially in light of the expectation that the 2016 censuses would again come under scrutiny when their planning cycles began in 2012-13. The possibility that the 2016 Census of Agriculture could be cancelled under terms of the existing *Statistics Act*[2] was another reason to do some review, research and planning well in advance of key decision points. This review was conducted during 2011-12 with a report published on the Statistics Canada website August 29, 2012.

The review included consultation workshops, held in May and June 2011 in Ottawa with federal, provincial, and municipal governments, producer organizations and other industry stakeholders. A comprehensive survey was conducted with data users to gather information on their current use of data from the current statistical program and to better understand which uses are the most critical. The survey gathered detailed information on i) the organization, ii) identification of the data used, iii) details of requirements for the data used, such as which variables were used, the purposes (e.g., to fulfil legislative requirements, for policy development, for research and analysis), the level of geography, and the frequency, and iv) identification of data gaps they perceived in the current Statistics Canada suite of agriculture statistical outputs. The survey confirmed that the current outputs are widely used, but data gaps were also identified, such as a desire for more data on farm-level practices, and more farm financial data.

Reporting burden of the current program was thoroughly analysed and staff in the Agriculture Division of Statistics Canada were interviewed to harvest the accumulated knowledge of data usage and to identify potential data gaps in the current program. Other divisions within Statistics Canada were also consulted concerning their requirement for, and use of, agriculture data, in particular, divisions operating within the System of National Accounts. A review of legislative requirements for agriculture statistics was carried out as well as an extensive review of agricultural survey and census practices in more than 20 countries, with a more in-depth study of practices in Australia, England, France, Mexico, the Netherlands, New Zealand, Norway, Portugal, Sweden and the United States. These countries were selected since some have somewhat similar agriculture industries to that in Canada, some are significant trading partners, some produce certain agricultural commodities in common with Canada, have some different and interesting features in their agriculture statistics program, and as a whole represented a reasonably diverse range of approaches to producing official agriculture statistics.

In parallel with the data gathering exercises, a methodology was developed for evaluating alternative options for a redesigned ASP. This was, in essence, a point rating system with 29 factors organized into 10 categories. Based on the findings of the review, three options were initially developed and subjected to the evaluation methodology. The three options were constructed to cover a range of differences versus the status quo, and the three were evaluated using the status quo as a baseline. As it turned out, none of the three initial options scored strongly on the evaluation grid, so it was decided to develop two additional, "hybrid" options, by selecting the component parts from among the three original options that had scored most highly.

Subsequently the report was circulated and/or presented to various key stakeholders, such as the National Statistics Council, the Federal-Provincial-Territorial Committee on Agriculture Statistics, the Advisory Committee in Agriculture Statistics, to name a few. The general consensus among these audiences was that the option labelled "Hybrid B" was the most attractive option for the future state of the ASP. This option included features such as: a comprehensive Census of Agriculture in the years ending in "1" which would make full use of available and suitable administrative data, and a "minimum requirements" Census of Agriculture in the years ending in "6"; the same definition of a farm as currently used (producing agricultural outputs with the intent to sell); a survey program that employs higher sample exclusion thresholds than currently used (creating a larger take-none strata that includes more of the "smaller" operations, thus excluding them from sampling, with modelling replacing direct data collection); and, fewer annual and sub-annual

surveys as administrative data and other technologies such as remote sensing permit direct survey collection to be reliably replaced by these methods. This option was estimated to need approximately 10 years to implement (two census cycles), was rated as most attractive in terms of respondent burden (i.e., imposing the least burden among the options) and was estimated to be a "middle" option in terms of cost (with an expected total cost somewhat higher than the status quo).

3.3 The 2012-13 feasibility studies

As a result of the program review conducted in 2011-12, six feasibility studies (in addition to the Census of Agriculture tax data replacement work already described above) were proposed and approved. These were carried out in 2012-13. Five of the six were aimed at evaluating various uses of administrative data and one dealt with possible changes in the thresholds used for excluding units in the target population from being selected in survey samples.

The **remote sensing area and yield feasibility study** was designed to use Earth observation technology (satellite imagery) to develop an estimation model for crop yield and production and, in combination with provincial crop insurance data (from the program known as AgriInsurance), to produce crop area estimates. Crop estimates have traditionally been obtained using sample surveys. Crop yield models for six major crops (durum wheat, spring wheat, corn for grain, barley, soybeans, canola) were developed with the objective to produce national and provincial level estimates. Several models were investigated using i) only normalized difference vegetation index (NDVI) satellite data (1 km resolution), ii) only climactic data, including temperature, precipitation, growing degree-days, and an evapotranspiration stress index, and iii) a combination of both NDVI and climactic data. The combined model produced the highest R^2 values, ranging from 0.81 for the canola yield model to 0.87 for the wheat and corn models. Predicted yields from the combined model were compared with the yields estimated from the July, September and November 2012 Field Crop surveys, as well as those from six additional randomly chosen years (1992, 1995, 2004, 2006, 2008 and 2009). On average, over these seven years, the combined model produced estimates reasonably in line with the September and November survey-based crop estimates, as shown in Table 1, differing by about 8% to 11% at the provincial level and 6% to 8% at the national level, depending on the crop. Canola was somewhat exceptional and the model did not fare as well due to the presence of a yield depressing disease in some years that was only evident after harvest and did not show up on the crop condition measurements during the growth period.

In terms of cost, the feasibility study estimated that the cost to produce modelled yield estimates would be about one-third of the cost of collecting the data by traditional survey. For the crop area estimation portion of this study, single-date satellite imagery was used in conjunction with ground-truth data gathered from a sample of land areas in the province of Manitoba. Unfortunately, the AgriInsurance data were not accessible for this feasibility study, although the holder of this dataset appears to be open to continued negotiations for

Table 1: Percent absolute difference between modelled values and survey values.

	Provincial Level				National Level			
	Nov. absolute difference (%)		Sept. absolute difference (%)		Nov. absolute difference (%)		Sept. absolute difference (%)	
	Average	Median	Average	Median	Average	Median	Average	Median
Spring Wheat	8.1	7.4	6.0	6.0	5.8	3.6	6.2	4.5
Durum Wheat	10.9	10.6	10.2	9.7	10.0	10.0	9.0	6.3
Corn for Grain	5.9	5.5	7.5	6.9	3.6	1.6	6.7	7.4
Barley	8.9	8.2	6.0	4.7	7.8	6.2	4.5	2.4
Soybeans	10.0	11.8	7.7	7.1	8.4	7.5	3.4	3.5
Canola	20.7	15.0	19.2	13.0	14.3	14.2	12.2	9.4
Overall Deviation	**10.8**	**9.8**	**9.4**	**7.9**	**8.3**	**7.2**	**7.0**	**5.6**

future access. Overall, the area estimation results showed some promise, although the quality did not appear sufficient to consider using this method "as is" to replace the survey.

To improve the results, multi-date satellite imagery and a larger ground truth sample were suggested (in this study about 2.8% of the cropland in Manitoba was used to create the area frame, versus about 7% in similar studies in the past; by comparison, the September Crop Survey gathers information from about 6.7% of crop farms). Even with its simplified design, the cost to extend such an approach to produce crop area estimates for the entire country would exceed the current cost of the survey-based crop area estimates. However, access to geo-referenced crop insurance data (eliminating the need for expensive ground-truth data gathering) and free satellite images (allowing for 2 or 3 dates to be used) would make this approach attractive from a cost point of view.

An additional component was added to this feasibility study relating to greenhouses, to investigate the possibility of identifying, and then estimating the size of, greenhouse operations using satellite imagery and other technologies (such as Google Maps Street View). Both medium (30 metre) and high (5 metre) resolution satellite data were used. The study found that greenhouses[3] could be identified and their areas reliably identified and their areas could be estimated reasonably well, with the total greenhouse area estimated for the test area of Essex County, Ontario (64.3 million square feet) being just 3.9% less than the corresponding Census of Agriculture estimate (66.9 million square feet). This method does not provide information on area in production, or the particular greenhouse products being grown. The study also revealed some difference in location of the greenhouses when the satellite location was compared with the location listed on the frame (the Statistics Canada Business Register), which will need to be investigated.

The **Administrative data: Animal traceability** study examined the current and future potential for incorporating traceability data into the Livestock statistics program. Two provinces, Alberta and Québec, were selected based on the perceived maturity of their traceability systems. The defining elements of this administrative source are that certain aspects are mandatory and that livestock traceability program in Canada is a partnership between government and industry, but with a high level of industry involvement (control) in the program. Funding is provided by AAFC to the Canadian Food Inspection Agency (CFIA) and industry to develop the infrastructure needed to meet the traceability requirements established under the *Health of Animals Act*. Under the Act, CFIA is the regulatory agency responsible for the traceability program. As such, CFIA has access to data that may be held by the province, but CFIA does not house the data.

There are three pillars to livestock traceability in Canada: identification of the animal, identification of the premises, and animal movement information. In Quebec, all three pillars are mandatory, while in Alberta identification and movement are mandatory. At present, only the identification of the animal is mandatory at the national level, but its implementation varies by province; for example, it may be a requirement to tag an animal a certain number of days following birth in one province, but only when the animal leaves the farm in another.

Currently, the *Health of Animals Act* regulates the traceability program for cattle (including dairy cows), sheep and bison only, although an amendment to the Act to include hog traceability regulations is being considered. The Act is also under review to expand its coverage to include all three pillars of livestock traceability and to cover more species.

The study determined that given the way the traceability system is organized, pursuing opportunities with CFIA rather than individual provinces would be a logical way to ensure nationally comparable data. CFIA recommended that as the *Health of Animals Act* is currently under review, it would be more effective to implement any data sharing agreements after the revised Act came into force, which is expected in 2015. This timing is also reasonable in that the study showed given that existing traceability databases are neither comparable in terms of content and definitions, and would requiring extensive work to derive livestock statistics that meet reasonable quality standards, there would be little, if any, value in using these data today. In the meantime, Statistics Canada will prepare a business requirements document that CFIA will present during an industry forum in October 2013. Statistics Canada will also research the requirements for a Privacy Impact Assessment (PIA), which should be useful in gaining support for data sharing between the producers, the data holders, CFIA and Statistics Canada.

This study also illustrates the importance of incorporating statistical requirements early in the development of new legislation and programs to help ensure that ensuing administrative data will have high statistical value through developing long term partnerships, resolving conceptual issues and dealing with privacy concerns.

The Administrative data – AgriStability / AgriInvest study examined the current and future potential for incorporating data from these federal/provincial business risk management programs into the ASP. Two provinces were selected for study and the defining elements of this source are that the programs are voluntary and are federal-provincial partnership programs.

AgriInvest and AgriStability are two of several business risk management programs[4] in Agriculture and Agri-Food Canada's (AAFC) Growing Forward policy framework (to become Growing Forward 2 for the 2013 program year). AgriInvest and AgriStability data are housed by the Research and Analysis Directorate (RAD) at AAFC, which receives data from provincial program administrators or the Canadian Revenue Agency (CRA), depending on the province, twice per year – once in June and once in November. The timelines for receipt of the data are from one-and-a-half years to two years after the reference year end. Revised data can be received for up to three years after the reference period for AgriStability data.

While the original plan was to investigate the AgriStability and AgriInvest programs in two provinces, preliminary research and consultations with AAFC resulted in a new approach. The AgriStability and AgriInvest programs may be administered either by the province or AAFC, which receives the data no matter where the program is administered. It was therefore more effective to investigate data sharing through AAFC. Initial consultations with AAFC resulted in the sharing of metadata. The metadata provided a sound understanding of how the programs are administered and what data are available.

Given the limited time available for the feasibility study and the duration of negotiations with AAFC and the provinces, no microdata were received to conduct an assessment of the feasibility of integrating these data into the ASP. Even so, the study did show that AgriStability and AgriInvest data include information that the agricultural tax data program (ATDP) does not currently have access to, and that there is potential for these data to be used to fill data gaps in the ATDP[5]. The study also showed that although program participation (and therefore coverage) is not strong for some commodities, these administrative data sources have the potential to replace some commodity statistics for which producers have a very strong incentive to participate to the program for a number of reasons such as greater price volatility. These sources would also have great value to confront, validate and improve estimates from surveys or censuses and to improve survey estimates by using them in editing or imputation processes. On the other hand, the study also demonstrated that, since these data are typically available one-and-a-half years to two years after the reference period, these sources would be untimely for use as replacements for Statistics Canada annual or sub-annual surveys, where the data are now published several weeks to a few months after the reference period.

The Administrative data – AgriInsurance study examined the current and future potential for incorporating crop insurance data into the Crop statistics program. Three provinces were selected based on the level of maturity of this data source. The defining elements of this source are that the programs are voluntary and are administered provincially by a mix of government, arms-length and private entities. Like AgriStability and AgriInvest, AgriInsurance (also referred to as "crop insurance") is one of the tools in AAFC's Business Risk Management suite under the Growing Forward policy[6]. Producers do not have to insure all commodities that they currently have in production, so data are available only for insured producers, for those commodities that are insured. The proportion of farmers who participate in the AgriInsurance program varies by province and can vary within a province by year. Producers are more likely to insure certain commodities (e.g. those with highest risk) than others, adding an additional variation to coverage. AAFC has a database of all data at the provincial level; under Growing Forward 2, data may be available at the municipal level as well. AAFC receives multiple iterations of the data from the provinces throughout the year, but does not receive microdata. Each province is responsible for housing its own program data; microdata are therefore only available through each respective province.

Based on the preliminary research, Alberta, Quebec and Ontario were selected as their programs were considered more robust than in other provinces. Consultations to obtain metadata were held and a

soft approach was taken to negotiating access to microdata. In the case of one province, a microdata file was received, but without information needed to link it to survey data, so no assessment of its suitability could be conducted. In another province, aggregated data were received, but at a low enough level of geography to determine that for some commodities, the level of participation was high enough that the microdata, if obtainable, could be useful for survey replacement, pending evaluation of that microdata. In the third province, no data were obtained during the study period.

Data obtained at the micro level would allow more sophisticated methods to be used to increase the chance of finding a suitable way to incorporate these administrative data into the survey program. While the provincial AgriInsurance agencies approached for this study were receptive to the idea of data sharing, negotiations to obtain data had limited success. The Agriculture Division is pursuing data acquisition from all provincial AgriInsurance programs under Section 13 of the *Statistics Act*. Consultations with the provincial agencies will commence or continue, to obtain support for the data sharing. The AgriInsurance data may have potential for survey data replacement in certain cases, or for use in conjunction with Earth observation technology (as a source of ground-truth information). For the latter, one microdata file containing geographic identifiers at the field or land parcel level was obtained from one province late in the study, and work is underway to evaluate it as a source of ground truth data.

The Administrative data – Best practices/ Inventory of industry holdings study took advantage of expertise in developing administrative data-based programs that exist in different parts of Statistics Canada (e.g., the health, justice, education, which have made extensive use of administrative data for many years), by consulting with those areas to identify best practices, challenges, and any other relevant issues. It also attempted to inventory the administrative holdings of agricultural data held by industry organizations. The defining elements of these data sources are that they are diverse (voluntary, or mandatory, based on regulations) and are administered by industry organizations (based on commodity, geography or other traits). There were not expected to be any direct efficiencies from this study, however, the knowledge transfer and the resulting improved practices should facilitate the effective transition of administrative data sources into the agriculture statistics program. Consultations with administrative data users and a review of the literature identified six common categories of best practices in the use of administrative data for statistical purposes. These best practices are outlined below, in no particular order.

Legal framework - In order for a statistical agency to be able to use administrative data when compiling official statistics, there must be a firm legal basis that allows the agency to collect, and protect, the administrative data in the first place. Statistics Canada has an extensive legal framework covering the use of administrative data as well as data confidentiality, the foundation of which is the *Statistics Act*.

Common unique identifiers - Common unique identifiers allow records to be matched between the administrative agency and the statistical agency, enhancing data accuracy. Consideration should also be given to a system that would allow records to be matched between the administrative sources as well. The studies found that lack of such identifiers within the administrative programs examined was an important consideration regarding integration of these data into the agriculture statistics program for survey data replacement. Even when an administrative program is national (e.g. AgriInsurance), if they are run provincially they likely do not have common unique identifiers between the various provinces. While it is possible to link records based on other criteria (e.g. name, address, etc), the "good" link rate will likely be lower and the linkage process would require more time and resources to ensure the accuracy of the output. In addition, administrative data holders are usually very wary of sharing personal identifiers so greater consideration will be needed to negotiate access to these data.

Collaboration - Close collaboration between the statistical agency and the administrative data holders is vital, especially if sharing data will occur over a long period of time. A benefit of collaboration includes an increased opportunity for the statistical agency to be involved in the collection of the administrative data to benefit interpretability and coherence of statistical outputs. Also, over time, a statistical program may come to rely on the administrative source and therefore become vulnerable to changes within the source or discontinuation in whole or in part. Close collaboration with administrative data suppliers may help to mitigate these risks. The studies underscored

the importance of collaboration and recommended the implementation of an administrative data unit or team to engender collaboration with the administrative data holders. Statistics Canada's Administrative Data Secretariat described earlier will be a useful mechanism in fostering collaboration with potential administrative data providers.

Feedback Mechanisms - Feedback mechanisms are meant to ensure better quality data, a better working relationship between the agencies/organizations involved, and can also be used to gain support for the sharing of data. Feedback mechanisms can include regular auditing of the data and data processing and sharing of technical and subject matter expertise. The audit system could include regular, standardised data quality checks; a confirmation of data to be sent and what was received (e.g. reference year, number of variables); review and/or testing of the processing and collection systems; and a review of definitions and concepts.

Support - When integrating administrative data into a statistical program, it is important that key stakeholders, data users, the administrative data holders and those within the statistical agency all support the project. This support, or "buy-in", results in a more effective and efficient process and creates an environment where collaboration is possible.

Sound Knowledge Base - When using administrative data it is important to obtain and understand the metadata surrounding them. Metadata include why the data are collected, how they are collected and processed, and how each of the variables is defined. Knowledge of the metadata can alleviate bias, enhance data quality and improve coherence and accurate interpretability of the data by allowing these to be taken into account; this is especially relevant when combining administrative data from multiple sources. Any information regarding the metadata should be well documented and regularly updated. Alongside clear and open communication, regular documentation can alleviate the risk of the administrative data source making changes that are not clear or known to the statistical agency. Documentation maintenance will also improve historical cohesion in the statistical output.

The Agriculture Division consulted extensively with key stakeholders and data users to garner support for the use of administrative data. Data holders approached for the studies also supported the idea of data sharing; however, concerns over having the authority to share data and the support from their own respective stakeholders (including the individuals or organizations from whom they received the data) greatly limited the extent to which data were shared during the studies. The Division will continue to consult data holders, stakeholders and data users in future through forums such as the Agriculture Statistics Advisory Committee, the Federal-Provincial-Territorial Committee on Agriculture Statistics and ad-hoc discussions as required. Statistics Canada's Administrative Data Secretariat will also be a valuable resource for supporting the acquisition and integration of administrative data.

The study on **changing parameters for the surveyed population** built on work conducted on the target population in 2011-12 to examine the impact and feasibility of changing parameters for the surveyed population. This study did not use administrative data, so it is mentioned briefly only for completeness. During the recent redesign of agricultural surveys (which is done following each Census of Agriculture), a number of different options for the definition of the survey population were considered. A commodity-based 95% Royce-Maranda (R-M) threshold was established in the design in anticipation of a more restricted survey population (i.e., a larger "take-none" stratum) than is currently used. These thresholds were set so that 95% of the provincial production of major commodities (generally two or three commodities per survey) is covered in the surveyed population. Other commodities may have a survey population coverage of more or less than 95%. Since no timely administrative commodity data are currently available for the portion of the population not eligible for sampling, estimates must be produced through modelling the "missing" portion using Census of Agriculture or taxation data as model inputs.

The results of the study showed that adoption of a 95% threshold introduces a bias, regardless of the modelling method, but that modelling the population excluded from sampling using ratios derived from the Census of Agriculture minimized the bias. This study illustrated the potential loss of quality when there is a lack of complete, current administrative data to use as a replacement for data points excluded by a sampling threshold.

3.4 Continuing the feasibility work in 2013-14

Although the feasibility studies carried out in 2012-13 were useful in advancing towards the goal of

making greater use of administrative data sources, it was clear that further work needed to be done before full implementation could be achieved.

Funds were sought and obtained from the Statistics Canada Analytical Projects Initiative (API) to continue work in 2013-14 on developing alternative estimation procedures aimed at developing a robust replacement for the September Farm Survey. As noted earlier, during the 2012-13 feasibility work, six of Canada's most important crops economically were modelled (spring wheat, durum wheat, barley, canola, soybeans, and corn for grain). The preliminary crop model results from the feasibility study showed that remote sensing methods can provide viable alternatives for producing crop yield estimates, other than by interviewing farm operators. The 2012-13 results also indicated that additional work to improve accuracy, extend the models to more crops, and to further investigate costs and benefits was needed.

With the API project, Statistics Canada will continue its collaborative efforts with Agriculture and Agri-Food Canada (AAFC) and Environment Canada (EC) in order to address the data gaps within the yield modelling work. Within Statistics Canada, the Agriculture Division will work with the Business Survey Methods Division and the Centre for Special Business Projects in developing and testing of the models in order to further expand Statistics Canada's current knowledge capacity. In addition to the six crop models developed and tested as part of the 2012-13 feasibility study, this project will develop an additional 15 in order to have a full complement of crop models that could replace the September Crop Survey starting in 2014. The project will then simulate the 2013 crop yield estimates for September in parallel with the traditional survey approach. Comparison of the results will be made between the two methods and an evaluation report will be prepared on how to integrate the modelled approach within the entire Field Crops Reporting Series program.

In an effort to maintain momentum on the remote sensing work, Statistics Canada has also sought funding from the Canadian Space Agency's (CSA) government-Related Initiatives Program (GRIP), a program that is aimed at developing innovative solutions to government priorities based on information derived from Earth observation (EO). Statistics Canada has proposed a study that would evaluate the efficiency of using EO data and crop insurance data to augment, reduce, or replace traditional surveys with alternate methods, using a multi-stage approach. The work program would be as follows:

Phase 1 (July 2013 – March 2014) would involve gaining access to some provincial crop insurance data sets, invoking Section 13 of the *Statistics Act* as necessary; producing crop area estimates using the crop insurance data only; and, comparing the results with the traditional survey results produced by Statistics Canada. In addition, this phase would develop a sampling technique based on the crop insurance data; acquire multi-date EO data for the selected study sites; produce a satellite classification by crop type of the study areas using the crop insurance data as ground truth; compare the satellite classification results with the crop insurance only technique; compare the satellite based area estimation results with the traditional survey results produced by Statistics Canada.

Phase 2 (April 2014 – March 2015) would utilize the refined methodology developed in Phase 1 but expanded to the provincial level (Saskatchewan and Québec) and would serve to develop an operational procedure for future EO-CI applications as part of Statistics Canada's survey methodology.

Phase 3 (April 2015 – July 2015) will be the wind-up and implementation phase. Assuming the first two phases demonstrate that reliable estimates of sufficient quality can be produced, the new procedure will be integrated into Statistics Canada's agricultural statistics program.

On July 11, 2013 it was learned that due to a response to the CSA call for proposals that far exceeded the amount of funds they had available, the Statistics Canada proposal was not included among those projects selected to receive GRIP funding to start in 2013. Subsequent meetings have been proposed by the CSA to discuss alternate arrangements for the proposed work.

3.5 Additional feasibility and implementation work proposed for 2014-15 to 2016-17

A proposal has been made to complete the feasibility study work and implement the use of administrative data and remote sensing methods into the agriculture statistics program to the extent possible. This is a three-year proposal that would begin April 2014 and be completed by March 2017. The timing is designed to coincide with the transition of the ASP into the Integrated Business Statistics Program[7]. Five projects are included in the current proposal, and they are briefly described below.

Earth observation area and yield. Estimates for yield and total crop area have previously been modelled using satellite and climatic data. In this project, the September occasion of the Field Crop Reporting series of surveys will produced using modelled estimates for all crops (as opposed to the six that were studied during the previous feasibility study), with the aim of replacing this survey by 2014. Use of the modelled estimates for the Field Crop Reporting series will require changes to the systems used to process data, create and analyse estimates, and disseminate results. Any satellite classification for area estimates or greenhouse identification will make use of crop insurance data wherever possible. At the same time, investigation into developing specific crop area indicators for the 2016 CEAG validation will occur.

Administrative data – livestock traceability. The study will build on the business requirements document that will have been prepared for an October 2013 meeting, in which CFIA will have presented to industry the Statistics Canada request to obtain livestock traceability data. CFIA and industry support are important aspects of the integration of livestock traceability data into the program. As such, the process of negotiating access and partnerships will be further developed and refined. The first phase of the feasibility study identified a target of 2015 for integration; this study will identify and further develop the necessary elements for integration by that date.

Administrative data – AgriStability / AgriInvest. The study will investigate the use of AgriStability and AgriInvest data to fill data gaps in the Agricultural Taxation Data Program. Each province and territory will have been approached to request permission to obtain their data from the central repository held by AAFC. This study will outline the requirements to obtain the data from AAFC for use in the ATDP.

Administrative data – AgriInsurance. The study will further examine the potential for incorporating AgriInsurance data into the ASP. Initial research in the 2012-13 feasibility study met with challenges in obtaining microdata from the provinces identified for the study. As such, a full assessment of suitability for survey data replacement was not conducted; this study would continue that research. Prior to commencing the project, all provinces will be contacted to begin negotiating data access, with the use of Section 13 of the *Statistics Act* to be discussed as a possible approach.

Survey Population Definitions. Methods were developed for defining and estimating for a reduced survey population using a higher exclusion threshold for five major agriculture surveys during a feasibility study in 2012-2013. This study will continue this work on three additional agriculture surveys with the goal of defining a new survey population threshold which will reduce the burden put on small respondents while at the same time continue to provide sufficient results for the program.

4. The 2016 Census of Agriculture

Although the Census of Agriculture is conducted every five years, the cycle for funding is six years, so traditionally there is one overlapping year where the previous and next Censuses of Agriculture cycle are both funded (for their last and first years, respectively). For the 2011 and 2016 censuses, that overlapping year is 2013-14, thus planning work is well underway for 2016.

By all accounts, 2011 was a successful undertaking with a final response rate of 95.9% and very low coverage error rates[8], a significant increase in the percentage of respondents who used the internet to complete their Census of Agriculture (more than doubling to 10.8% in 2011 versus 5.0% in 2006), and the majority of the data released one year after census day, via a new, user-friendly self-serve data tool. Nonetheless, there continue to be concerns about the reporting burden imposed on farmers.

The use of taxation data to replace the asking of detailed expense questions for almost all farms in 2016 is a major advance toward the reduction of this reporting burden. Based on the 2011 questionnaire, the detailed expense section represented about 7% of the content of the Census of Agriculture in terms of number of questions, but due to the nature of the questions, represented about 12%-15% of the completion time. Further possible reductions in the content in other sections of the 2016 questionnaire will be explored and evaluated based on the availability of administrative sources, such as an annual survey that collects comparable or even more detailed data, or the presence of reliable and accessible administrative sources of appropriate quality.

Also, as in every cycle, there have been consultations on the potential content for the 2016 Census of Agriculture, and based on those and subsequent testing, there could be a few questions added or dropped based on relevance, reporting burden, availability of data from other sources, or cost.

With refinement of the internet reporting tool, it was found in 2011 that the time to complete the

Census of Agriculture questionnaire online was shorter than completing it on paper. With the use of administrative data to replace the detailed expense section and an expectation that the use of the internet for responding will increase over time, it would be reasonable to anticipate a further reduction in the average time to complete the Census of Agriculture in 2016. It is also typical in each census cycle that Statistics Canada makes proposals to the Government concerning the form, funding and content of the Census of Agriculture. These are in progress for the 2016 Census of Agriculture and it is expected that this work will be completed by mid-2015.

In the summer of 2013, consultations were held with federal and provincial government organizations, as well as with agriculture-related private sector industry organizations and groups, to attempt to determine whether those agencies hold any additional administrative data sources, beyond those already used by Statistics Canada, that would be suitable as possible replacements for questions on the Census of Agriculture. As noted in the feasibility study work to date, important considerations will be the suitability of identified new administrative data sources in terms of accessibility (to the microdata, which is necessary to be able to link the administrative data record to the record collected by the census), quality, coverage and timeliness.

5. Future directions

Statistics Canada's Agriculture Statistics Program has a long history of using administrative data to produce official statistics. It is clear that in the future, the Program will rely even more heavily on administrative data sources that it currently does. The change will represent a shift from the use of administrative data mostly as a supplement or complement to the data gathered by survey- and census-taking to the more visible role as replacement data to be used *instead of* collecting data by surveys and censuses.

Statistics Canada's commitment to the principles of red tape reduction are illustrated by its implementation of an action plan for reporting burden reduction that includes a number of measures aimed at making improvements in the Agriculture Statistics Program. Based on the studies described above, the main contributions to reporting burden reduction will be four-fold: 1) reduction in completion time for the 2016 Census of Agriculture based on the replacement of detailed expense questions by taxation data, other possible content reductions, and a greater use of the internet response channel, all combining to reduce average completion time by at least 30% compared to 2011; 2) increased use of administrative data and other already collected data to reduce (in sample size, content, or frequency) or eliminate some agriculture surveys over the next several years; 3) use of higher sample exclusion thresholds to reduce sample sizes for agriculture surveys, probably beginning in 2014; and, 4) increased reliance on estimates based on remote sensing, alone or in combination with administrative data, making these the official estimates for some programs where traditional surveys now produce the official estimates.

On another front, work is being done via the North American Tripartite Committee on Agriculture Statistics (NATCAS), which included two special topics on the agenda for its 2013 meeting in St. Louis, Missouri (USA) in August: "The Future of Agricultural Censuses in North America" and "The Future of Agriculture Statistics." In both cases, these sessions provided the statistical agencies of the three countries the opportunity to discuss common issues related to data collection and respondent reporting burden, and to begin to develop common strategies for the use of traditional methods (surveys and censuses) in combination with increasing use of administrative data and remote sensing technologies. Although at very early stages, the three countries hold similar visions where technology will play an increasingly important role in gathering data, and where the use of already-held administrative data takes on a more significant role in the production of agricultural estimates. While these trends hold out the promise of reducing reporting burden imposed on individual farmers by statistical agencies, there was a common understanding that further research and development are needed before impacts on cost and accuracy are fully known.

There is an on-going challenge to deliver a balanced agriculture statistics program that is relevant, cost effective and less burdensome for farmers. Several initiatives to reduce reporting burden were presented in this paper, with the increasing the use of administrative data at the forefront of many of these initiatives. This will require long term investment and commitment to develop partnerships with administrative data holders, and to assess the suitability of new administrative data for survey and

census data replacement. As noted earlier, a large risk to be dealt with is the fact that administrative data sources are created and controlled by others, for purposes other than statistics. This makes statistical agencies using these sources vulnerable to potential changes or discontinuance of the sources as policy or regulatory needs change.

Statistics Canada has begun to increase the level of activity and investment in Earth Observation techniques, including in conjunction with administrative data sources, and this is expected to continue in the near future. Increasing attention and efforts are also being given to the further identification and exploitation of administrative data sources, especially where these have the potential to replace data collection activities. The promise of developing methods that could dramatically reduce the reporting burden of agricultural operators (even eliminating it completely in some cases) at a cost that is lower or at least comparable to existing survey methods, while delivering similar quality estimates is very attractive.

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Endnotes

1 Commonly referred to as "census farms", although the concept of agricultural operation is intended to convey a wider coverage than the traditional notion of "farm".

2 "A census of agriculture of Canada shall be taken by Statistics Canada (a) in the year 1971 and in every tenth year thereafter; and (b) in the year 1976 and in every tenth year thereafter, **unless the Governor in Council otherwise directs in respect of any such year.**" (*Statistics Act*, R.S.C., 1985, c. S-19, paragraph 20).

3 Areas under glass, plastic or other protection, used for growing plants; not including coldframes.

4 These programs are designed to help agriculture producers manage risk while respecting international guiding principles for agriculture support measures. AgriInvest helps manage income decreases that are less than 30% of their historical reference margin. After submitting income taxes, participating producers receive an AgriInvest Deposit Notice stating the maximum amount they can deposit into their AgriInvest account, to be matched by government contributions. AgriStability is a program designed to assist producers when they experience larger decreases in their margins (greater than 30% of their historical reference margin) due to falling market prices, rising input costs or production fluctuation. Producers must submit an application and pay a fee to be eligible to receive an AgriStability payment.

5 ADTP does not receive AgriStability or AgriInvest data from incorporated farms for five provinces (Prince Edward Island, Quebec, Ontario, Saskatchewan and Alberta). Data are sent directly to these provincial program administrators.

6 AgriInsurance is a program designed to help producers recover from production and asset losses due to natural perils. AAFC splits the costs of this program with the provinces on a 60/40 basis. However, each province is responsible for administering the program through a Crown corporation or a branch of the provincial agriculture department. Coverage is available on a total-yield, dollar-value or acreage-loss basis. Producers pay premiums each year they participate in the program.

7 The IBSP is a Statistics Canada initiative that was launched several years ago to optimize the processes used to produce statistical outputs from annual and sub-annual business surveys through standardization and use of corporate services and generalized systems.

8 The estimated undercoverage of number of farms was 1.8% in 2011 versus 3.4% in 2006. For agricultural area, estimated undercoverage 0.7% in 2011 (versus 1.3% in 2006) and for gross revenue, 0.6% (versus 0.9% in 2006).

The Usefulness of Quality Frameworks when Deciding on Replacing Surveys with Administrative Registers - the case of the Swedish sheep register

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Abstract

It is a difficult and important strategic decision to decide whether or not to replace a statistical survey with data from administrative registers. The aim of this paper is to discuss the usefulness of the quality frameworks for administrative registers in the decision making process of deciding whether or not to replace a sample survey of the number of sheep with an administrative register. The quality framework of Daas et al. (2008, 2010) has been used.

The paper shows that the quality framework was useful for evaluating the quality of the administrative register in comparison with using a sample survey to count the number of sheep.

In relation to the decision making process the quality framework was most helpful in the phase of choosing between alternatives. The framework to a lesser degree provided help in the steps of defining the problem and implementing the choice. The indicators used to some extent assume using solely one register. In this case where several registers were required, the indicators needed some reconstructing to be of use. Indicators evaluating the quality of different choices in the model-building and integration phase were consequently scarcer. The greatest usefulness of the systematic approach was in evaluating the administrative registers themselves.

Regarding the case, the results when using the framework were ambiguous. Further evaluations are needed before replacing the statistical survey of the number of sheep in June with administrative registers.

Keywords: administrative registers; register-based statistics; quality frameworks.

1. Background and aim of the paper

It is a difficult and important decision whether or not to replace a statistical survey with data from administrative registers. This is especially the case for official statistics where comparability over time is an important component of quality. Therefore, when Sweden became a member of the European Union in 1995, and administrative registers in the agricultural area were created, studies were carried out to investigate the consequences of using administrative registers for statistical purposes (Selander et al. 1997; Wahlgren & Wahlgren, 1999).

The studies showed that integrating administrative registers with censuses and sample-surveys could be cost-effective ways of producing statistics with sufficient quality. The integration phase where data from several sources were integrated into a new statistical register was seen as essential for achieving sufficient quality. As a result of the studies, Swedish official statistics in the agri-cultural area has from then on been based upon extensive use of administrative data. This includes for example statistics on how agricultural land is used, the number of cattle, and the income of agricultural households. In later years work of Wahlgren & Wahlgren (2007) and Bakker (2010) has been used to increase the knowledge on how to build statistics based on administrative data.

In recent years several studies, for example Laitila et al. (2011); Daas et al. (2008, 2010) and Berka et al (2010), have discussed quality frameworks for using administrative registers for statistical purposes. This includes the quality of the register itself, the possibilities of integrating administrative registers into statistical registers and how to document the quality of the statistics produced. Holmberg (2012) concludes that there has been a theoretical improvement on how to assess the quality of administrative data. At the same time it has been pointed out, by for example, Chang (2013) that compared to the maturity of statistical research regarding the methods of sample surveys, research on methods regarding administrative registers has just started.

To use or not to use an administrative register is a strategic decision. A decision is a choice between different alternatives in order to achieve a goal. A decision can be seen as a process and thus divided in several steps (Mintzberg, 1997; Hogarth, 1981). The steps includes problem-definition, i.e., defining the difference between the situation today and a desired situation, information seeking, setting up and evaluating different alternatives, choosing between

alternatives, implementing the choice and evaluating the result.

The aim of this paper is to discuss the usefulness of the quality frameworks developed for the strategic decision on whether or not replace a sample survey of the number of sheep with an administrative register. Suggestions for areas where further theoretical development might be needed will be made.

2. Quality frameworks in relation to the case of the count of sheep

The concept of Berka et al. (2010) is focused on the Austrian census and the framework is based on measuring the quality of each variable used. The concepts of Laitila et al. (2011) and Daas et al. (2010) will therefore be studied further.

On the indicator level the concepts are to a large extent overlapping. However, there are differences in the way indicators are systemised and how quality is assessed. Daas et al. (2008) sees three dimensions: the administrative register in itself, metadata about the source and the data in the source. Indicators are developed within each dimension. Laitila et al. (2011) discusses indicators in three dimensions: output quality, input data quality and production process quality. However, they group the indicators related to the work process i.e. indicators related to information from the administrative authority, indicators related to data editing of the source, indicators related to integrating the source with the statistical register and integrating the survey with similar variables. The indicators are also grouped according to the quality declaration for official statistics in Sweden, namely relevance, accuracy, timeliness, comparability/coherence and availability.

For the purpose of this paper the indicators as systemised by Daas (2008) will be used. Even though there are advantages of following the work process as described by Laitila et al. (2008), the possibilities of getting a clear overview of each data source is seen as more important.

3. The case of the statistics on the number of sheep?

The quality framework is discussed within the context of the process of a making a decision.

3.1 What is the goal? What is the problem?

The statistics regarding sheep is used for the Swedish statistical Farm register (FR) and regulated by Swedish legislation. On national level FR has been updated yearly in June since the 1960s. It is an important part of Swedish agricultural statistics. In Swedish regulations it is therefore stipulated that every third year FR should be updated through a census in June. Variables are updated from this census and from register data (for example IACS-data[1] for crops). Information on linking-variables is collected in the census so that correct information could be gathered from different registers. In intermediate years the FR is updated through data from registers and data from different sample surveys. The register includes all farms in Sweden.

The statistics are also regulated on European Union level by (EC) no 1165/2008 and EC 1166/2008. Regulation (EC) No 1165/2008 stipulates that the sheep should be counted in December, while regulation (EC) No 1166/2008 makes it possible to choose a date between March and November for counting the sheep. In Sweden the month of June has been chosen in order to harmonise with national requirements. In the regulation it is stipulated that it is possible to use other

Figure 1: Definition of the problem regarding the statistics on the number of sheep.

	year 2010		year 2011 (and 2014)		year 2012 (and 2015)		year 2013 (and 2016)	
	Jun	Dec	Jun	Dec	Jun	Dec	Jun	Dec
Requrie-ments	Swedish FR, (EC) No 1166/2008	(EC) No 1165/2008	Swedish FR	(EG) nr 1165/2008	Swedish FR	(EG) nr 1165/2008	Swedish FR, (EC) No 1166/2008	(EG) nr 1165/2008
Todays situation	Farm cencus (whole population)	(Estimate)	Sample survey (7000 farmers)	(Estimate)	Sample survey (7000 farmers)	(Estimate)	FSS-survey, census for all husbandry	(Estimate)
Goal/ desired situation	Farm cencus (all population)	Adminstrative register/ model	Adminstrative register/ model	Adminstrative register/ model	Adminstrative register/ model	Adminstrative register/ model	FSS-survey, census for all husbandry	Adminstrative register/ model

sources than statistical surveys if the information obtained from such sources is of at least equal quality to information obtained from statistical surveys.

The problem is that the sample survey of 7 000 farms is costly for the government and also induces a total cost for respondents calculated to 30 000 euro. There is an increasing demand from Swedish farmers and the government at national- and EU-level to reduce the burden on respondents. The current estimation of the number of sheep in December has also been evaluated to be of insufficient quality and consequently needs to be replaced.

The goal is therefore to replace the survey with another source that does not invoke a burden on respondents and provides at least the same quality both for the FR and for the number of sheep in December as the current methods. The situation is summarised in Figure 1.

3.2. Setting up and evaluating alternatives

The alternatives to evaluate are to continue with the surveys, or use information from one or several administrative registers to reach the goal. Found registers concerning the number of sheep were the administrative sheep register, the administrative slaughtering register, registers from the certifying bodies regarding organic production of sheep and membership registers in breeding associations. The slaughtering register, which can give information on the number of slaughtered sheep is seen as an auxiliary register to help modelling and is evaluated as such.

3.2.1. The hyper-dimensions of source and of metadata – Quality of Daas (2008, 2010)

The indicators in the hyper-dimensions described in the text are summarised in table 1. The Swedish Board of Agriculture is the *supplier* of the data sources of the sheep register and the slaughtering register. The board is also the responsible NSO for agricultural statistics. The *suppliers* of the other registers are the certifying organic bodies and the breeding associations. About 20% of the sheep is held with organic production methods and the number of holders in the breeding associations does cover about 50 % of the total production. These two registers will therefore not be evaluated further in the text, but summarised in Table 1.

Regarding the dimension of *relevance,* in December every year the animal holder should count the number of sheep on the holding and report the result to the sheep register. There is no distinction between ewes, rams and lambs in the register. The number of sheep in June is not reported. The response burden for farmers of the sheep register is calculated to 45 000 euro. The slaughtering register is a register based on the slaughter houses reporting the number of animals that have been slaughtered each day and from what holding number (PPN_id) the animals has been transported. This register does not take into account the number of animals slaughtered on the farm.

Privacy and security issues are regulated by law. The aim of the sheep register is to give a possibility to trace animals from one production place to another in case of an outbreak of a contagious animal disease. The place of production is assigned a unique holding number. Each animal keeper could have several holding numbers but the number could never be moved from the place. The basic principle is that a holding number refers to a building for animals mainly staying indoors, or a plant if there are a number of closely spaced buildings that clearly form a unit.

The basis for the sheep register is regulation (EC) no 21/2004. The base for the slaughtering register is (EC) 2006:815 and SJVFS 1998:127. In Swedish regulation it is stipulated that administrative registers might be used for official statistics. SFS (2001:99). Confidentiality is ensured by regulation SFS (2009:400).

Regarding dimension of *delivery,* there is no cost to use the data source, except the few hours spent extracting the information. There are routines for transferring data between the statistics division and other divisions at the Swedish Board of Agriculture. The delivery can be made on demand and a request might take 1-2 weeks to expedite. In the sheep register data should be registered no later than 15 of January. Data is available in the middle of February. The data are delivered in Excel format or in text format. Delivery of data from the slaughtering register follows the same routines and data are available a couple of months after the slaughtering has taken place.

Regarding *procedures,* there are at the Swedish Board of Agriculture routines for sharing information about registers. If data are not delivered on short notice either the statistics will be delayed or the figures will be estimated based on the latest known figure.

Regarding the dimension of *clarity,* the population of the register is all holdings that have sheep at any point during the year. Those holdings should report the number of sheep in December. The one variable reported is clear and simple, the number of sheep at the production place. The comparability with the definitions in the statistics is good for the number

Table 1: Evaluation of registers according to the hyper dimensions of Daas et al. (2010, 2011).

	Sheep register	Slaughtering register auxiliary source	Register from certifying organic bodies	Registers from breeding associations
Source dimensions				
1. Supplier	+++++	+++++	+++	++
2. Relevance	++++	++	+	+
3. Privacy & security	+++++	+++++	++++	+
4. Delivery	+++++	+++++	+	++
5. Procedures	+++++	+++++	+++	+
Metadata dimensions				
1. Clarity	+++++	+++++	++	+
2. Comparability	++++	+++	++	+
3. Unique keys	++++	+++	+	+
4. Data treatment	+++++	+++++	++	+

Note: The evaluation is made on scale from 1 to 5, where 5 is the best.

of sheep. However in the FR the sheep should be divided into lambs and adult sheep (rams and ewes). In December the number should be divided between ewes and other sheep, i.e., rams and lambs.

Comparability is important. When comparing the sheep register with the statistical census or the survey, there is a large difference between the number of sheep in December and the number of sheep in June. Most lambs are born in the beginning of the year and slaughtered in the second half of the year, so the total number of sheep is far less in December than in June. The sheep register takes into account all animal holdings regardless of the size of the farm, while a threshold exists in FR and other statistics that excludes the smallest farms. The slaughtering register offers possibilities for bridging the gap between the number of sheep in June and December by deducting those slaughtered. On the individual level, however, this presents the problem that sheep can be sold between holders during the period before they are slaughtered. I.e. subtracting the slaughtered sheep of one holder from their number of sheep in June will not necessarily yield the correct number of sheep of the holder in December. Home slaughtering and sheep that for example die as a result of predators or accidents are also not included.

Even though one holding in FR can have several production places, one production place cannot have several holdings at a specific moment in time. There are *unique keys* (identifiers) between the slaughtering register, the sheep register and FR.

Regarding *data treatment,* the data is checked by the Board. However, if the sheep register is not correct there are no sanctions for the farmers. This indicates that the quality is lower than for those registers where the farmers can be sanctioned financially if they do not report correctly. There are routines at the Board for sharing information about changes in the register.

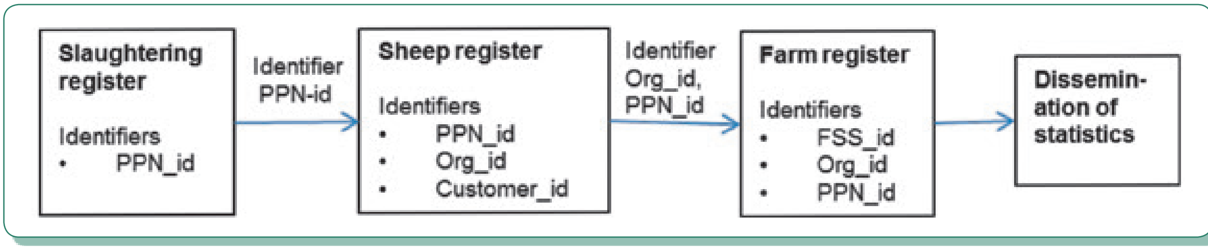
3.2.2 The hyper-dimensions of the quality of the data source

The third hyper-dimension introduced by Daas (2010) is the data dimension that focuses on the quality aspect of the data in the source. Most of the aspects in this hyper-dimension contain accuracy related quality aspects. To use this part of the quality framework to evaluate the possibilities to use the sheep register as a base for making statistics for sheep, we have to present our approach of using the registers together with modelling to achieve the statistics. I.e the quality is assessed on the full approach, not only the registers themselves.

Information from the sheep register and the slaughtering register is linked to FR. The linking of the registers is made through different steps. Data from the slaughtering register is first linked to the sheep register using the holding numbers (PPN) as identifier. Data from the slaughtering register includes in addition to the PPN also the number of slaughtered adult sheep and lambs each month. The data in the sheep register is data on the total number of sheep at a certain date in December, even though the number is in practice counted at another date in the year in a lot of cases.

The link between the slaughtering register and the sheep register is good as it is made up from the same source of holding numbers and the reporting

Figure 2: Linking between registers.



to the slaughtering register from slaughter houses is obligatory. The reason to use the data from the slaughtering register is to use the data as auxiliary information and as a base for modelling of data.

There is some missing data from the register and some data that could not be used (data corresponding to other dates than December. There is also a small number of holdings that could not be linked, which is why we are not able to use the register data as it is. I.e it is not possible to use the number of sheep directly from the register. The method used is one suggested by Wallgren & Wallgren (2007). It entails adjusting for missing values in the sheep register using straight expansion in different strata based on the number of sheep in June at a first stage. Then we use the number of sheep in June and the slaughtering statistics as auxiliary information to calibrate the weighting factors.

The table below with fictitious data shows how the linked data is organised. The fields in the grey area are identification variables that exist in several of the registers and identify the units in the farm register. The blue area variables are those from the census conducted in June 2010 and show the number of animals June 10 2010. The green areas are those variables that we collect from the sheep register. It is the total number of sheep counted at a specific date. The white fields are from the slaughtering register and are the number of slaughtered animals between June and December 2010. In the intermediate years the table is basically the same, except the blue figures are based on a sample survey and have weighting factors. As the aim is to be able to replace the sample survey in June in the intermediate years, these data are not used for calibration of weights intermediate years.

In practice we also want to distinguish between the number of ewes and other sheep in December, which cannot be achieved using merely data from the sheep register where all animals are counted as a single category. Therefore we use the information from the slaughtering register on an aggregated level

Table 2: Example of data after linking between sources.

Identifier				June 2010 census			Sheep register		Slaughtering register	
IDNR	PPN	ORGID	Kundnr	Ewes	Rams	Lambs	Sheeps in reg	Date for counting	Slaugth Adult	Slaught Lambs
100	222	Xxxx	234-2	48	0	65	Missing	Missing	12	40
101	321	Xyxx		36	0	102	58	13 dec	12	58
102	422	Xxyy	722-0	91	2	222	69	14 dec	30	136
103		Yyxx	651-0							
104	601	Yxyx		42	1	6	Missing	Missing		
105	702	Xxzy	632-8	16	3	48	36	4 dec	0	85
106	622	Zxxy	655-2	3	0	52				
107		Zzxx								
108	368	Yxzz	555-8	65	0	102	Missing	Missing	9	100
109	446	Yyzx	432-4	0	0	0	3	10 feb	0	1
110	582	Zxzy		32	4	66	70	31 dec	45	65
111		yxzy	448-2							

together with other information on for example home slaughtering etc. to estimate these figures.

In the framework introduced by Daas (2010) we have 10 dimensions that are used to evaluate the quality of the data. In the model we shall try to evaluate the sheep register using these 10 dimensions to the extent that it is possible. The results are summarised in Table 3.

Regarding *technical checks* in the framework there are readability and metadata compliance as quality indicators. The data in the sheep register is of very good technical quality and all data can be accessed. The metadata definition is the total number of sheep in December. However, in practice the number reported often concerns other dates.

Regarding *coverage* there is an over-coverage of about 20 %, which means that 20% of the holdings or animal holders are too small to be included in the farm register and accounted as farmers. There are thresholds to distinguish which holdings should be included in the FR. In a few cases there could be holding numbers that are not in use anymore. As the register is very well updated and there is a strict law stipulating the animal holders' obligation to report, we believe that there is no under-coverage. All holdings that have sheep are registered in the sheep register.

Regarding *linkability* about 7.5% of the holding numbers from the sheep register are not possible to link to the farm register. 1.2% has data on the actual variable (number of sheep in December). The remaining 6.3% have either not reported to the register at the latest animal count or have reported the number of animals on a date after 31 of December. Out of the total number of holdings there is a link of 72.5%. This corresponds to 90.5 % of the holdings when the over-coverage is removed.

There is a *unit non-response.* As the data from the register actually only consists of two variables (the number of sheep and the date of counting them) that are closely linked, the unit non-response and the item non-response give the same answer. 23.8% of the holdings have missing or incorrect data (e.g. data not corresponding to December). Out of these, 17.5 % was linkable data while 6.3% was not possible to link. Since there is only one item, the item and unit non-response is the same.

Regarding *measurement*, when making the calculation we used an expansion method to create weights for each responding unit in the frame. At the first step we made a straight expansion using only the number of missing data from the register. In the next step we also used auxiliary information from the FR and slaughtering register to calibrate the weights.

There is quite a large difference between the results from the sample survey in June and the register based survey for 2011. There are some doubts regarding the figures from the sample survey, which are suspected to be overestimated.

In processing of data we do not make any adjustments or imputations of data from registers. However, there may be some data from registers that are linked to an incorrect holding in the FR.

Regarding *precision* the standard error of the estimate of the number of sheep in December is about 2.4%. Regarding sensitivity there is about 9.5% of empty or incorrect cells in the data. Furthermore, there are 7.5% of the data from the sheep register that do not link to the FR. The dimensions described of Daas et al. (2010) are summarised in Table 3.

3.3. Choosing between alternatives

The choice should then be made whether the sheep register can be considered a reliable source and if the model gives the same quality as the survey did and if the figures from December could replace the existing model.

The results from the model are ambiguous. The sheep register as well as the slaughtering register are registers that presumably will remain of the same or better quality

Table 3: Evaluation of registers according to the hyper-dimensions of Daas et al. (2008, 2010).

Number of sheep in June 2010 (census):	564 922
Number of sheep in June 2010 (register):	566 208 (before calibration)
Number of sheep in December 2010 (register):	379 958
Number of sheep in June 2011 (sample survey):	622 711 (MSE=1, 6%)
Number of sheep in June 2011 (register):	597 706
Number of sheep in December 2011 (register):	401 567
Number of sheep in June 2012 (sample survey):	610 534 (MSE=0, 9%)
Number of sheep in June 2012 (register):	612 840
Number of sheep in December 2012 (register):	415 066

for the foreseeable future. In 2011 the quality of the model is not good enough for replacing the register. In 2012 it is. In relation to the goal it can be concluded that further testing is required before using administrative registers instead of the June survey. However, the register could be used to report the number of sheep in December.

3.4. Implementing the decisions and evaluating the results

In the census year of 2013 the administrative register needs to be evaluated further. A decision of implementation should be taken for the year 2014 after the studies of the results from 2013, where census data are available.

4. Discussion

In relation to the decision making process the quality framework is mostly used in the phase of choosing between alternatives. However, the first phase, defining the problem and clarifying the goal, should not be forgotten. Quality in a broader sense as for example discussed by Eurostat (2010) includes requirements of user needs, institutional preconditions at the organisation producing the statistics as well as the production process itself. Furthermore, evaluation of options might differ if the main goal is to reduce response burden as opposed to if the main goal is to reduce costs. It is important to have a phase in the decision making process that is open-minded and also explores other alternatives, for example solely modelling or discussing with the users if they might be willing to change their use of the statistics.

In the evaluation phase the indicators used to some extent assume using solely a register. In this case modelling was required and in that perspective the indicators needed some reconstructing to be used. I.e. research on the effect on quality on for example modelling, linking registers in several steps would be useful. Also guidelines on how to make choices or how to overcome the problems of quality in the implementation phase are scarce. In the case of the sheep, the agricultural census can be used as a quality check in the future. However, it might be difficult to check the quality when the survey has been abandoned. Therefore a long term plan to evaluate quality as well as an exit-plan might also need to be adapted.

When using the framework for the case of the sheep register some repetitions in the indicators were detected. However, it becomes obvious that the quality frameworks can be used in the part of the process where a choice is made of whether or not to use the administrative register. The greatest usefulness of the systematic approach was in evaluating the administrative registers themselves.

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Endnotes

1 IACS - Integrated Administration and Control System is the most important system for the management and control of payments to farmers made by the EU Member States in application of the Common Agricultural Policy.

IDCB 5

Agriculture Structure - Development of a Harmonized Farm Typology for Policy Analysis

Organizer and chair: Mary Ahearn, USDA/ERS

Farm survey and census data contribute to a multitude of end uses. One type of use is for guiding policy decisions. Those decisions are often focused on distributional issues, e.g., how proposed policies might affect economic performance for certain subpopulations, as well as the aggregate population. Responses to policies will vary by farm and farm household characteristics and the subpopulation of focus will vary depending on the issue. Moreover, when considering agriculture in an international context, consistency in a framework, or typology, is essential for developing an accurate comparative analysis.

One of the most common typologies refers to the size of the farm business, for example, ranges of total area or sales. Another approach in some countries concerns the distinction between subsistence and commercial farming. As the organizational characteristics of farms evolve to more complex business forms and a more integrated international marketplace, typologies will likely evolve. In practical terms, different statistical institutes employ different typologies in disseminating agriculture results, usually combining different criteria. Worldwide small family farms dominate the landscape and account for a large share of the farm population. At the same time, however, agricultural production is increasingly concentrated on a small share of farms.

The ICAS is the ideal venue to address these challenges and move forward with solutions for the 21st Century. This session will consider alternative typologies that allow international comparisons of important issues in agriculture. Questions to be addressed could include: How should agricultural country-specific data be organized and presented so as to provide domestic users distributional information about the well-being of the people engaged in agriculture as well as the agricultural productive capacity of a country? What are solutions for harmonizing typologies across countries? What is the most appropriate definition of a farm? What is the most efficient approach for collecting economic information so as to minimize respondent burden and the public cost of data collection in an increasingly complex structure of agriculture?

Papers:

- Mukesh K Srivastava, Giorgi Kvinikadze, Adriana Neciu (FAO), "Developing Farm Typologies: for whom and how?"
- Eloi Ouedraogo (FAO), Ankouvi Mawoudoudji Nayo (Ivory Coast), "Agricultural Holdings Typology Construction Using Agricultural Census Data: what typology and what variables to be selected for robust typology?"
- Wagner Soares (Brazil), Steven Helfand (USA), "Typology of Farmers in the Context of the Preparation of the National Sample Surveys of Establishments Agricultural (PNAG)"
- Katrin Nagelschmitz (Canada), Hugo Hernandez Ramos (Mexico), Mary Ahearn (USA) et al., "Farm Classification Systems for North American Agriculture"

Developing Farm Typologies: for whom and how?

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Abstract

The macro-economic farm policies like differential credit rate or tax structure affect all types of agricultural farms in the same way, though the net impact of these policies in different categories of farms is different. Large farms usually mop up a large chunk of farm subsidies which are given on the basis of the quantity of land or livestock held. In order to ensure sustainability of all farms and for maintenance of a stable farm structure which supports the food security of the country, a differentiated approach to different categories of farms is needed. Politicians and policy makers thus tend to target polices to specific groups of farms in specific agro-climatic zones (desert, mountain, coastal etc.). The information from farm surveys thus needs to be disseminated in a way that it lends itself to use by a variety of users. An aggregate classification of farms based on the scale of operation does not serve the purpose: the food security implications of 2 ha of land are different for the families having land in dry-land or wet land.

Some types of farm typologies are used in Europe, India, UK, and some other countries. A few of these typologies are used for both publication of data and policy making. However, the approaches to building farm typologies are usually guided by specific policy requirements. There is a need to develop a "standard international classification of farm typologies" which could serve as a basis for stratification in survey designing as well as for policy making. It is expected that the data tabulated as per lower denomination categories of the classification will facilitate preparation of data for customized groupings of farms for any part of the population which is focus of policy attention. Adoption of classification will ease re-tabulation of data for farm groups, such as nomads, family farms, small farms, large farms and subsistence farms which are often loosely defined. The classification will promote a common understanding of these farm typologies within a country and globally.

The paper will seek to review current practices in building farm typologies and verify the potential for building a universal classification of farms which the international agencies could advocate, in particular through the FAO World Programme of Census of Agriculture.

Endnotes

The full paper has not been submitted.

Agricultural Holdings Typology Construction Using Agricultural Census Data: what typology and what variables to be selected for robust typology?

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Abstract

The FAO World Program for Census of Agriculture 2010 (WCA 2010) recommends a modular approach to census and survey planning with a core module based on a complete enumeration of limited set of key items and sample based complementary and thematic surveys. The aim of the core module is to provide structural data, data needed at lowest administrative unit and data for sampling design. Another issue is the use of these data for construction of agricultural holding typology and grouping for a better targeting of agricultural and rural development policies.

Using agricultural census and survey data from Mali and data mining and multivariate analysis, the paper aims at identifying the better typology of agricultural holdings and the main common variables from the agricultural censuses appropriate to build robust agricultural holdings typology. The result of the analysis is to come up with a set of variables, the appropriate types of variables to be considered. Recommendations on supplementary variables to be added to censuses and surveys for agricultural holdings typology building will be discussed.

Keywords: agricultural census; agricultural holding; typology.

1. Introduction

Agriculture is one of the sectors of the economy which faced many uncertainties (epidemic problem, climate risk, land, scarcity of resources...). The collection of data in this area addresses the need to control some of these uncertainties and in the best of cases, provides appropriate solutions. One of the most important sources of data in the agricultural sector remains the general census of Agriculture (GCA). The process of implementation of the GCA has undergone improvements, or even failures and experiences made over the years.

Initiated by the International Institute of Agriculture (IIA) in 1924, the first world agricultural census program became effective in 1930 in about 60 countries. The Food and Agricultural Organization of the United Nations (FAO), which has succeeded the IIA, supervised and harmonized the implementation of the General Census of Agriculture (GCA) through a ten-year program for the World programme for Census of Agriculture for the 1950s, 1960, 1970, 1980, 1900 and 2000.

One of the major changes in the 2010 round of agricultural censuses, FAO recommended to combine both population and housing, and agricultural, censuses. The main question in this approach is: "which criteria can be used to identify the core module containing structural informations". In other words how to identify and choose the most robust structural variables to integrate into the population census?

The paper aims at identifying the main common variables from the agricultural censuses appropriate to build robust agricultural holdings typology. It is particularly interested in the analysis of the period of change in these variables. It will be an analysis based on variables that describe the structure of agriculture rather than performance and not change during time.

2. Evolution of agricultural censuses

This section is a synthesis of theoretical and empirical reflections on methodological changes in the Census of Agriculture from 1950 to 2010.

2.1 Methodological evolution of agricultural censuses

The agricultural census is an operation that covers the entire national territory and provides a snapshot of agriculture in a country during a year. The methodologies used for this type of operation

changed between 1950 and 2010. Initiated by the International Institute of Agriculture (IIA) in 1924, the first program of world agricultural census became effective in 1930 in about 60 countries. FAO, which succeeded IIA, supervised and harmonized implementation of the General Census of Agriculture (GCA) through a ten-year program for the World Census of Agriculture for the years 1950, 1960, 1970, 1980, 1900 and 2000.

Programs in 1930 and 1940 focused on the collection of comprehensive and detailed agricultural statistics, notably on production. These programs have been undertaken when the available informations on agriculture were very insufficient and the collection of data necessary for the establishment of agricultural statistics was poorly organized, even in developed countries.

The methodology used in the 1950's program for the conduct of the census was focused on operational and methodological issues in order to better adapt to local conditions. "The 1950's program had a smaller content, focused on the structural aspects of agriculture, such as holding's size, land use and livestock numbers. "A system of integrated agricultural censuses and surveys: Volume 1, World Programme for the Census of Agriculture 2010 (FAO, 2007)." Naturally, subsequent programs have kept in mind the structural variables while gradually expanding the content of the census to important issues of the moment.

A decade later, new and important methodological changes have been reflected in the World 1960's program of FAO. It came from the use of sampling techniques. The use of survey methods initially allowed increasing countries' participation in agricultural censuses. This is especially countries with very limited resources and where the conduct of such operations is very expensive due to a number of constraints (PM 1980, P.6).

The 1970's program of the FAO recommends combining the complete enumeration and survey techniques for certain sub-populations of holdings.

From 100 countries which took part in the censuses of 1986-95, twenty countries (including ten (10) in Africa, six (6) Asia...) used the survey approach.

In 1980, FAO has placed particular emphasis on the training of field workers. This interest in training is shown by the organization of national demonstration centers.

In 1990, the Global Program of FAO recommends that the Census of Agriculture focuses on two fundamental objectives (MP 1990: 2.1), which are:

- Collect data on the structural aspects of agriculture;
- Build from the GCA a base (list of holdings) to other types of investigations related to the sector.

These recommendations are the result of failures seen in previous censuses which tended to include broader goals (MP 1990: P 2.5). Moreover, this approach has been highly recommended to countries that do not meet a certain level of autonomy in the collection of statistical data (availability of skills, statistical information system developed...: 1990 2.10 PM). Regarding the frequency and period of counting, the 1990's program suggests that countries conduct censuses at more frequent intervals than 10 years and also arrange that at least one of them coincide with those other countries for the purpose of comparability. The 2000 program, which covered agricultural censuses during the period 1996-2005, gave prominence to aquaculture, employment and the environment. The obligation to undertake censuses in all countries in the same year was also relaxed.

In the past, the Census of Agriculture has sought to provide data on the structure of agricultural holdings and some structural features, but also provide reference data to improve the current statistics on crops and livestock and to form frames for agricultural surveys.

The methodology previously used in the censuses of agriculture focused on the activities of agricultural production units (households or other units operating land or raising animals). Therefore, these surveys were not considered censuses of rural households. On the other hand in the census, many countries have implemented minimum size criteria to include small units (holdings of small size) in the census, and most often excluded certain areas, such as urban centers.

FAO has recommended the coordination between the censuses of agriculture and population particularly in the implementation of the census of agricultural households (Report on 1990 WCA, international comparison and primary result by country (1986-1995), FAO, 1997).

For the global program of the FAO in 2010, it was recommended a single methodology for all censuses in different countries in order to ensure comparability of data collected. The 2010 program recommended for this purpose a modular approach which consists in a base module and additional modules.

The basic module is used for the constitution of the survey base for the implementation of additional

modules. Moreover because of the expensive nature of complete enumeration, it was recommended to pair it with RGPH to capitalize on national resources.

Add-ons that are based on a census survey are to collect more detailed data and address specific topics (land, livestock, and use of pesticides...). Countries may choose to conduct one or more additional modules according to their needs, based on the list of topics proposed by the 2010 program.

2.2 Holders typology

This study will emphasize the holdings characteristics in regard to variables relative to their activities and their patrimony. It is about defining a holders' typology by a group of variables contained in the agricultural censuses.

In order to take the decision, typology definition is a pure economic logic: How can we group holdings and characterize them by a set of variables in sight of doing an identical action for them?

According to Benedict (1944), typology allows to determine a small number of simple classes with significant differences at benefits, characteristics and holdings working level. For this author, typology aim is to know and understand problems in each class.

Deselaers (1973) suggested a classification of holdings based on homogeneities criteria. Moreover, according Lenco (1973), "a classification must be a tool of economic popularization and a presentation of statistical results as well as a useful instrument for projections and forecasts. It must be used by researchers, economists, business managers and government officials as an analytical tool for supply and behaviors in agriculture, and must allow to study the impact of measures decided or planned, both at the global level that that of a region or of a 'holdings category.

Thus, we see that typology of holders relies on following keywords: consistency, simplicity and efficiency. In the literature, there are several methods for reaching holdings.

For some authors, the representation of holdings of a given zone is principally based on two approaches. The first one consists in admitting to every peasant its human specificity; in other words, it would return to consider every holding to be a unique case. This step remains however not much used, because it is not very operational in terms of analysis, of perfecting strategies of development, or of intervention. Indeed it would be necessary to be able to have a lot of means, and to be able to spend a lot of time with every holder. On the other hand, the second is based on some characteristics (structural variables) to establish a typology of agricultural holders. The first typologies established according to this last approach are those carried out in the anthropological field, with the study of Wechniakoff (1897).

Since, this approach was used in many sectors, especially in agricultural domain, starting in the 1960s with works of Ina-PG (Capillon, Sebillote and Thierry, 1975; Capillon and Manichon, 1978) and of Inra (Small Brushmaker and, 1977). In Europe, a Community typology of holdings was established in 1996. In Africa, after a research stage rather centered on the agrarian systems, this tool was quickly used to apprehend diversity within the rural communities (Jouve, 1986). Methodology employed in order to establish a typology of holders indicates to:

- specify the nature of the objects to be classified;
- identify the limits of each object;
- select discriminating criteria of classification (in order to differentiate the different holdings);
- select criteria that have a meaning in relation to what you want to do (and therefore clarify the objectives that we set to this typology);
- simplify the reality; "model" it, i.e. to caricature it to emphasize some of the most important aspects in order to obtain possible representations of reality.

Not being the reality itself, there is thus no single possible typology of holdings in a given zone. Depending on the objectives and the implemented means, different typologies will be developed. The most usually seen in the literature are:

- simple typologies, concerning certain components of the agricultural holding (surfaces, equipment, etc.);
- Descriptive typologies, of holdings structure, based on a set of quantitative variables, and / or qualitative;
- Analytical typologies, based on the current operation of holdings (objectives, practices and strategies);
- Analytical and historical typologies, based on the current operation of holdings and their past performance, their trajectory and their archetype (old type), etc.

The analyses typologies are presented in two big families, namely the structural and functional typologies. They depend on the desired objectives and discriminating indicators selected.

1. Structure typology

Their essential objective is the characterization of the diversity of the encountered situations. They provide a framework for the analysis on homogenous holders groups.

These methods are based on available means of production in the exploitation and allow getting a snapshot of these exploitations at a given date.

In segmentation method, discriminating factors are chosen gradually one by one from the most discriminative one until we get types which are homogenous enough. The disadvantage with this method is that it is only available for a small number of discriminating factors. On the other hand, multidimensional analysis is available in the case of many more discriminating factors. There exists factor analysis (FA), components analysis (CA) and ascendant hierarchical classification (AHC). CFA and PCA are used to characterize exploitations in relation to the variables used, and AHC is in use for grouping exploitations according to the importance of the variables. However, two exploitations with the same structure don't have necessarily the same working.

2. Functioning typologies

They are more operational and are analysis tools for the definition and execution of research activities and development.

The operation of a holding is defined as the sequence of decisions of the holder and his family in a set of constraints and strengths in order to achieve the objectives that govern the production process and the can be characterized by various flows in operating a hand between her and the other outside (INRA-SAD, 1988).

The types of operations are then interested in the analysis of production processes and decision-making on holdings. The Implementation of typologies of operation is reasoned and requires the existence of a synthetic model that directs and guides the procedure to be adopted to observe and reflect the diversity of holdings. This is to adopt a scheme that tries to apply to all holdings, differences in the relationship between the components of the scheme used to define the types, so patterns of functioning (Capillon, 1993).

Variants of the types of operation most frequently encountered are:

- focus on the projects and the situation of the holder, that is to say: what are its objectives and strategies?
- based on "practical systems" of holders, that is to say, what the peasant is looking for? What are the results? what to do? How does he do to achieve these results?
- related to the evolutionary trajectories of operations, that is to say, how the holder got where he is? What major events have marked its history? How was it translated?
- according to experts, this method has not been implemented in the Prasac case.

These types of families were applied by Emmanuel MBETID-Bessane et al. (2003) in the activities of the Regional Centre for Applied Research in the development of Central African savannahs (Prasac) to analyze the diversity of holdings. They first made typologies to identify the variability of the means of production and to build consistent samples for studies of the operation of holdings and the work of thematic research (monitoring plots, animals, etc.).

In both Cameroon and Chad, the segmentation method was used based on two criteria, namely: sex of the manager and access to animal traction are considered discriminatory by the management board to holdings (Djonnéwa et al., 2000. Djondang and Leroy, 2001), but also for research on animal traction (Vall et al., 200). In Central Africa, it is the multivariate analysis method, including PCA, which was used from several criteria structures (Mbétid-Bessane, 2002).

3. Methodology

The methodology used in this study combine two approaches. The first consists in defining a typology of holdings based on the more pertinent variables and the second analyzes the stability of the typology through the analysis of the Markov Chains.

The multivariate approach will be privileged to define the typology. This approach allows constituting homogeneous groups of producers taking into consideration their agricultural practices, the characteristics and the performance of their holdings according to the studied variables. In the presence of the multitude of variables collected during surveys and censuses, the interest of such an approach is to apprehend in only one analysis a

matrix (table) of complex data. It allows identifying essentially the variables which characterize at best the difference between the holdings.

This approach, based on the same principle for grouping the holdings that are similar to a certain point of view, allows the determination of a typology of holdings. The constitution of a typology responds to an economic and rational logic which consists to identify the types or groups of holdings characterized by a set of attributes, of an environment, of behaviors or equipment with an aim of leading to their regard an identical action (strategy, policy, action plan, project…).

The analysis of dynamics of the structural variables will be made from the implementation of techniques of factor analysis and classification, and the use of the Markov chains.

3.1 Data description

The Data which will be used for our analysis are from the National Census of Agriculture of Mali from 2004.

The information contained in the NCA (National Census of Agriculture) relate on the holdings which are economic units of agricultural production and individual variables on each one of them.

The variables concern particularly the localization of the holding, the demographic characteristics of the holding, its means of production (land, the animals, and the equipment),access to water (irrigation), the use of inputs, practiced cultures and the species of animals bred. It highlights precisely the following information:

- The number of holdings and their geographical distribution on the national territory;
- The size of holdings and the crop system practiced (agriculture and breeding, normal breeding, sedentary breeding, nomadic breeding, agriculture and forestry, etc.);
- The available means for holding practice and technological level (land, equipment, livestock, labour, use of input modern inputs, etc.);
- Available Services for holders: (funding, technical support, information etc.).

Otherwise, in this analysis, the structural variables are:

- the type of holdings (traditional, modern, etc.);
- land use and their size;
- crop type (seasonal or perennial);
- agricultural equipment;
- type of used inputs (seeds, fertilizers, etc.);
- access and the land's mode of development;
- demographic characteristics of agricultural household members;
- agricultural labor;
- agricultural products transformation;
- type and size of the livestock;
- the environment (access to credit, to vulgarization services, to veterinary services, to information);
- other income-generating activities (aquaculture and fishing, trade, etc.).

3.2 Factor analysis method

This study aims to characterize the holdings based on the variables contained in the agricultural censuses.

According to the needs of the analysis and the variables type, the methods such as the component analysis (APC), the Factor Analysis of correspondence (FAC) or the Multiple Correspondence Analysis (MCA) or the Multiple Factor Analysis (MFA) will be used. The use of these techniques aims the definition of a typology of holdings through an ascending hierarchical classification

In the present case, the MFA will be used to realize the factor analysis which will then lead to the classification. This choice is justified by the fact that the used data include qualitative variables (alphabetic or nominal) as well as quantitative variables. The use of MFA, contrary to the MCA, does not require that the quantitative variables are made nominal by creating value classes. In addition, the construction of the typology depends on the constituted classes. The advantage of using the MFA is that it makes it possible to preserve in the analysis all the wealth of information without affecting it by subjective and fallacious regroupings.

3.3 Markov chains

Markov chains, concept proposed since 1907, appears and is successfully used in so various domains as physics, biology, social sciences, computer science or economy. The theory of the Markov chains has, as objective, to make optimum decisions in an uncertain world. The Markov chains study, from probabilities, the evolution process of a group of states evolving in the space, temporal domain or of frequency. The

parameters of exit of Markov's models are therefore transition probabilities between two states which can be statistically analyzed from a sampling of data.

The first use of this technology by the economists intervened for the analyses of distribution of incomes and wages and in studies of distribution of the size of firms in steel industry. As for agricultural domain, it was used for the study of the dimensions of pigsties and holdings in Illinois and for the wheat output in Montana [by Bostwick (on 1962)].

These studies constituted a first step towards projections with the use of the Markov chains. Krenz Ronald D. (1965) presents a projection method of the number of holdings of the North-Dakota with the aid of Markov chains from the census data. This new stage represents enrichment in the sense that, such projections are useful in economic studies of adjustment and regional development. The author considers a process defining different groups or "states" in which any population of firms or individuals can be classified. Considering the movement of firms or individuals between states, in the course of time, to be a stochastic process, he estimates probabilities ($P_{i,j}$) for firms or individuals to pass from a state (S_i) to state (S_j).

Markov chains were often used as a tool, adapted to describe the movement of economic variables in time (Lee and al. on 1977). They served as a basis for the modeling in various studies such as that of Bernard Guesnier. With the aid of Markov chains, he describes the process which drives to a distribution according to the size of the firms of a sector in order to analyze and forecast their demography. In the basic model, Lt indicates distribution by size of total number of firms. This distribution is a markovian process, described in the following way:

$L_{t+\Delta t} = L_t * P(t, \Delta t)$, where P (t, Δt) is the matrix of transition probabilities.

So, Markov chains allow to differentiate the growth rate according to the size of firms and to raise the very limitative hypotheses of the law of proportional effect: the law of proportional effect implies an identical growth rate for all sizes.

Agriculture is a domain which knew applications of Markov chains. In this domain, agricultural structural changes are complex and dynamic processes. They depend on several factors notably the initial state of holdings, their independence, as well as social, economic and technical environments. So, to analyze the dynamics of agricultural change, Nejla Ben Arfa (2006), in his thesis of Master of Science, uses a non-stationary Markov method. The application of this method is based on the estimation of instrumental variables, developed by Karantininis (2002) which, in its turn, is founded on the approach of entropy. This method allowed the estimation of a non-stationary matrix of transition probabilities for the holdings of large-scale holdinging in the region of Midi-Pyrénées. The author considers only transitions of seven (7) categories of holdings sizes, during period from 1988 to 2000. Through this technique, he calculates the effect of some explicative variables on transition probability, and on the number of holdings in every category. He manages to calculate, in form of elasticity, the effect of some explanatory variables on transition probabilities and on the number of holdings in every category. The author assumes that holdings are divided according to their size into J categories and he notes the number of holdings in the category of size j at instant t. Then the non-stationary Markov chain can be spelt (Jongeneel, on 2002):

$x_{i,t+1} = \sum_{i=1}^{I} p_{ijt} x_{it}$; j=1... J and I⊂ J.

Where p_{ijt} is the matrix of transition of a holding of size i at instant t in size j at instant t+1. The total number of existent holdings in time t, X_t, is equal to the sum of the number of holdings in each category.

$(X_t = \sum_{i=1}^{I} x_{it})$

The equation with matrix notation can be expressed by: $x'(t+1) = P'x(t) + u(t)$

Where $x(t) = (x_{1t}, \dots, x_{St})'$ is a vector of proportions of dimension K×1, that means, the K^{th} element of x(t) represents the proportion of the holdings of large-scale farming being in the K^{th} state of Markov at instant t. Where x(t+1) is +1 k vector of proportions corresponding at instant t+1 and P the transition matrix.

Another application, well-known of Markov chains in economy, is due to Hamilton (1989). It is "Markov Switching Models". These models are based on Markov chains to describe short-term cycles. GUILLAUME RABAULT, in his article «*an application of the model of Hamilton in the estimation of business cycles*», examines the capacity of these models to redraw the business cycles of six big countries, as well as those of the whole OECD. This model allowed also testing the asymmetry of cycles.

The model of Hamilton in its original form is:

$$y_t = \alpha_0 + \alpha_1 S_t + z_t$$

$$\varphi(L) z_t = \varepsilon_t$$

With is a Markov chain describing the state of economy in date t.

4. Typology of holdings

The implementation of a Hierarchical Ascending Classification (HAC)[1] allowed defining a typology of holdings. This HAC is implemented following a Multiple Correspondence Analysis (MCA).

Various variables were considered for the realization of this typology. The adopted typology below proves to be the most stable and the most homogeneous of typologies. Moreover, one of the criteria used for the exclusion of some variables is the overrepresentation of a modality. These variables are not left therefore; they will be positioned as additional elements. Indeed, any variable which one of the modalities is taken by more than 75% individuals will not participate in an active way in the analysis. This approach allowed therefore to be freed (artificially) from variables which can have disruptive effects on the analysis. By taking into account these variables drives most often to the formation of a sub-cloud, very concentrated on itself but far from all other points and therefore in the definition of an unstable and not very informative typology. The auditing aims at making more robust the analysis.

This typology, so defined, was analyzed by considering the nature of holding (animal production or culture), the area of sowed lands by a big group of cultures (cereals, leguminous plants, industrial cultures, and tuber), the size of livestock, the access to credit and to supervision and agricultural practice (usage of improved seeds, usage fertilizing, of chemical treatment, etc.).

The typology is composed of four classes of holdings[2]. The list of variables and results are recorded in annex 2[3].

4.1 Class of holdings of weak areas and pence equipped (Class 1)

This class is constituted of a little more than a half (48%) of holdings. These last occupy only 25,4% of sowed areas. These are principally small holdings stretching over lower areas on average in two (2) hectares (with an interval of confidence of [1,8; 1,88]). These holdings are characterized by a preponderance of the culture of cereals.

It is principally about subsistence agriculture with still traditional techniques of production. Indeed, the majority of these holders (at least 70%) do not use improved seeds, do not have harnessing, apply no chemical treatment, do not benefit from supervision and did not have access to credit (campaign, equipment). Barely a third uses some organic fertilization. Besides, about two thirds of them (65%) do not dispose any agricultural equipment (no plough, no multicultural, no feature animals). Besides, animal husbandry is practiced on a modest scale. Indeed, the size of the livestock whatever the species (bovine, goat, ovine) (bovine, goat, ovine) does not exceed five (5) heads of animals in every case.

Moreover, the used permanent workforce is on average three (3) persons by working ([2, 57; 2, 97]) while the temporary workforce is estimated at ten (10) on average ([9,41; 10,21]).

4.2 Holders practicing extensive cereal agriculture (Class 2)

The second class is composed of 17,3% holdings and they occupy a little more than a third (35,8% of areas) of sowed areas. Contrary to the first class, this one is composed of holdings stretching on average over eight (7) hectares.

Moreover, the used permanent workforce is on average three (3) persons per holding ([2,31; 3,0]) while the temporary workforce is estimated at eleven (11) on average ([10,39; 12,23]).

In this class, lands are principally used for the production of cereals (millet and sorghum) and of leguminous plants (peanut and niébé) which occupy respectively 78,5% and 20,3% of sowed areas. Industrial crops are there practically nonexistent (0,5% of sowed areas).

Animal husbandry is also practiced in these holdings. The livestock cattle count on average eight (8) heads of animals for each of kinds (bovine, ovine and goat) and the poultry-yard counts 13 poultry on average ([13,03; 14,48]).

As for equipment, these holdings have at least a cart and a plough and 62% have complete harnessing. Moreover, the majority of them (at least 70%) do not use improved seeds, apply no chemical treatment, do not benefit from supervision and did not have access to credit (campaign, of equipment).

4.3 Holders practicing mainly animal husbandry (Class 3)

The third group is composed of holdings orientated to the animal husbandry of herds of small ruminants and of bovine. It represents 17% of holdings. This class is mainly characterized by the practice of animal husbandry of bovine, of sheep and goat. The size of the livestock in these holdings is on average 17 heads of goat, 13 heads of sheep and 6 heads of bovine (with respectively

an interval of confidence of [18,3; 19,6], [13,5; 14,7] and [7,06; 8,1]). Moreover only a quarter of them have a piece of land for the practice of their activities.

Although culture is little practiced in these holdings, those who make it use the good practices such as the chemical treatments, the use of weed killer...

A little more than three quarter of them did not have credit during reference period and benefited from no supervision. Moreover, this type of holdings asks for a low mobilization of the workforce: on average two (2) persons are used in such holdings.

4.4 Holdings producing industrial crops (cotton), combining with cereal crops and well enough equipped (Class 4)

This class is constituted by 17.5% of holdings and practice modern agriculture principally. They occupy 37% of exploited areas.

Indeed, 97% of them use improved seeds and practice the protection of cultures (chemical, fungicidal, herbicidal, insecticidal treatment). About a third uses at the same time some organic and chemical fertilization. About eight (8) holdings on ten in this group benefit from supervision and 83% had access to credit (campaign, equipment). These holdings, due to the importance of practiced activity, have complete harnessing.

Exploited areas in these holdings extend (on average) over seven (7) hectares. Moreover, industrial crops occupy an area on average of 2.7 hectares.

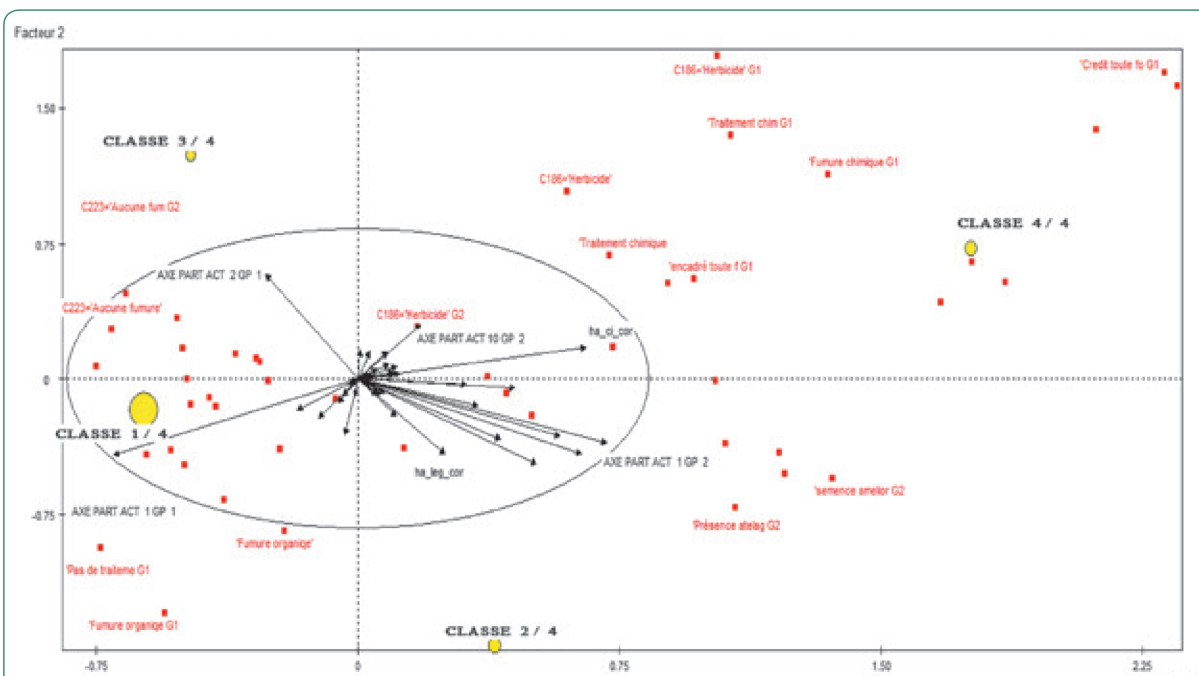
Although this class is characterized by the practice of the industrial crop, the cereal cultures (4ha on average) and leguminous plant (0.5 ha on average) are strongly practiced compared to other classes.

In addition, the breeding of the cattle is also practiced there with a size of livestock estimated (on average) at eight (8) heads of animals per holding.

5. Analysis of the classes stability

The analysis of the holdings stability in the classes is made by combining two approaches. The first approach consists in realizing an orderly regression on the variables which characterize the holding in order to estimate the probability, for a given holding, to belong to a class according to the observable characteristics. The second approach is based on the analysis of the Markov chains and tries to analyse the stability of membership in the class through conditional probability. Indeed, the question is to estimate the probability, for a given holding to pass to a class knowing that previously it belonged to another class. Thus, this approach will permit to detect groups of stable variables and their power of grouping together through their transition probability.

Figure 1: Cloud of variables and of classes of partition (axis 1 and 2).



Source: GCA data, Mali 2004, our calculations, HAC

Table 1: Estimation of orderly model: coefficients and odd ratio.

Variable	Class 1		Class 2		Class 3	
	Coefficient	Odd	Coefficient	Odd	Coefficient	Odd
Sown area with leguminous plant	2.75***	15,7	-1.20***	0,3	-1.63*	0,2
	(0.21)		(0.31)		(0.73)	
Sown area with cereal	-0.18	0,8	-2.97***	0,1	0.13	1,1
	(0.68)		(0.67)		(0.59)	
Farmyard size	0.09***	1,1	-0.03*	1	0.05	1,1
	(0.01)		(0.01)		(0.03)	
Exploited area	2.61***	13,6	-1.75***	0,2	1.80***	6
	(0.14)		(0.21)		(0.45)	
Laden harness	4.39***	80,6	-6.67***	0	8.39***	4412,6
	(0.35)		(0.86)		(2.43)	
Use of chemical operation	0.65*	1,9	7.46***	1736,3	-5.14*	0
	(0.29)		(0.82)		(2.44)	
Sown with tuber area	-4.31	0	-11.06	0	3.12	22,6
	(2.91)		(6.87)		(5.17)	
Size of the cattle livestock	0.18***	1,2	0.03	1	0.07	1,1
	(0.02)		(0.03)		(0.08)	
Size of the ovine livestock	0.17***	1,2	0.09**	1,1	-0.35***	0,7
	(0.02)		(0.03)		(0.10)	
Size of the goat livestock	0.09***	1,1	0.09***	1,1	-0.15	0,9
	(0.01)		(0.02)		(0.09)	
Use of improved seed	-0.48	0,6	1.88*	6,5	10.57***	39132,3
	(0.59)		(0.85)		(2.55)	
Benefits of staff	-1.11***	0,3	-0.65	0,5	6.42***	615,7
	(0.27)		(0.61)		(1.29)	
Pluviometry upper than 800 mm	-0.67*	0,5	5.29***	198,3	2.99	19,8
	(0.27)		(0.63)		(1.55)	
Benefits of campaign credit	-0.59	0,6	-1.25	0,3	-11.99***	0
	(0.50)		(0.90)		(2.45)	
Use of chemical manure	-6.55***	0	4.19***	65,9	9.41***	12174,4
	(0.78)		(0.90)		(2.38)	
Use of organic and chemical manure	-0.15	0,9	4.18***	65,1	10.65***	42266
	(0.37)		(0.66)		(2.04)	
No manure	-4.34***	0	8.29***	3987,8	1.55	4,7
	(0.37)		(1.02)		(1.09)	
Farming and Breeding	0.23	1,3	-0.42	0,7	5.75***	313,7
	(0.55)		(0.66)		(1.34)	
Only Breeding	-8.91	0	13.63***	829456,7	3.06	21,4
	(0.00)		(1.31)		(1.97)	
Constant	-17.11***		-1.46		-4.74	
	(1.42)		(2.12)		(3.52)	

Significance level * for p<5%, ** for p<1%, and *** for p<0.1%
Source: GCA Data, Mali 2004, our calculations, orderly logit modeling.

5.1 Estimation of transition probabilities

The transition probabilities are estimated from a generalized orderly logistic modeling, having tested the hypothesis of proportional odd ratio (or of parallelism). The results of the estimation are presented in the table below. Although the previous analysis allowed obtaining a typology in 4 classes, in the regression below, the class 4 was considered as reference class.

The results analysis permits to notice that certain classes of the typology can remain stable whatever the consideration of certain variables. Indeed, variables relative to the size of the holding (Sown area with cereal and a tuber), to the use of input for the amendment of the ground (manure) and of improved seeds, as well as the access to credit have no effect on the class 1. This situation is simply understandable by the fact that the character of survival (subsistence farming) of this agriculture does not allow an easy and immediate transfer even when they have access to certain inputs (inputs, financial means).

As for the holdings practicing breeding mainly (class 3), the access to the ground promotes a change in the class to the subsistence farming. Moreover, factors which could contribute to make it move to the superior classes are: the pluviometry, the use of inputs.

The more the exploited surfaces increase, the more the holding has chances to be classified in the superior classes. This result is valid for the classes 1 and 3. In this case, the class 1 will have a non-null propensity to mutate to the class 3 and that of the class 3 to the class 4. The ownership of ground for the holdings in class 2 tends to make them mutate to the class 1.

5.2 Estimation of the transition matrix

The main results obtained from the estimation of the orderly logistic model are the transition probability of the Markov chain with an initial distribution: λ_0 = (48.1%; 17.3%; 17.1%; 17.5%), and M the transition matrix below.

Table 2 : Transition matrix for the Markov chain state 1.

	Class 1	Class 2	Class 3	Class 4
Class 1	96.80%	1.30%	0.40%	1.60%
Class 2	3.70%	88.80%	0.50%	7.10%
Class 3	16.80%	0.90%	82.20%	0.00%
Class 4	5.70%	0.60%	0.20%	93.50%

Source: GCA Data, Mali 2004, our calculations.

This chain is irreducible because all the states communicate. Although the probability that a holding of class 3 moves to class 4 in a single stage is null, it is advisable to notice that these two classes commute. In fact, there exists certain n>1 such as $P(X_n = 4 | X_0 = 3) > 0$.

For n=2 we have the transition matrix M^2 below. So, $P(X_2 = 4 | X_0 = 3) = 0{,}003$.

Moreover, the robustness of the typology is studied by means of the matrix M. The main assumption which guides the analysis of the classes' stability is: "One class j is considered stable until the stage n if $P(X_n = j | X_0 = j) \geq 0{,}5$ and $P(X_n = j | X_0 = j) < 0{,}5$ ».

The analysis of the n^{th} power of the matrix according to this assumption allows keeping back the two following values of n: n= 4 or 7.

Table 3 : Transition matrix for the Markov chain state 2.

	Class 1	Class 2	Class 3	Class 4
Class 1	93.9%	2.4%	0.7%	3.1%
Class 2	7.4%	78.9%	0.9%	13.0%
Class 3	30.1%	1.8%	67.6%	0.3%
Class 4	10.9%	1.2%	0.4%	87.6%

Source: GCA Data, Mali 2004, our calculations, HAC.

For n=4 the matrix has the structure below and it brings out that:
$P(X_3 = 3| X_0 = 3) = 55,7\%$ et $P(X_4 = 3| X_0 = 3) < 46\%$.

The analysis of the matrix allows noticing that from the fourth stage, the holdings practicing breeding mainly (class 3) have a higher propensity

Table 4 : Transition matrix for the Markov chain state 4.

	Class 1	Class 2	Class 3	Class 4
Class 1	88.9%	4.2%	1.2%	6.0%
Class 2	14.4%	62.7%	1.4%	21.9%
Class 3	48.8%	3.3%	46.0%	1.7%
Class 4	20.0%	2.2%	0.7%	77.2%

Source: GCA Data, Mali 2004, our calculations, HAC.

(48.8%) to mutate to the class of the holdings of subsistence (Class 1) than to remain stable (remain in the same class, 46%).

Moreover, in the stage 4, although holdings of the class 2 have a probability of stability ($P(X_n = j| X_0 = j) = 62.7\%$) superior to the fixed threshold, they have a non-insignificant and increasing propensity to move to the holdings of class 4:
$P(X_1 = 2| X_0 = 2) = 7.1\%$;
$P(X_2 = 2| X_0 = 2) = 13\%$;
$P(X_4 = 2| X_0 = 2) = 21.9\%$.

For n=7 the matrix M possesses the structure below. It brings out that less than a half of holdings of class 2 have a tendency to remain in the same class. The other half having known transfers to class 4 mainly (29.9%), followed by class 1 (24%) and a very small proportion to class 3.

Besides whatever the value of n ≤ 12 is, classes 1 and 4 of the typology remain rather stable. More than a half of the holdings of these two groups are still in their origin group after the 12th stage of the transfer.

This analysis, based on the Markov chains, allowed identifying in the previously defined typology, the long-term, medium-term and short-term stable classes. It also permits to identify the variables of the agricultural census according to their power of stability.

Moreover, supposing that a transfer, however tiny, cannot take place over an infra-annual period, the duration of a stage is considered upper than an agricultural campaign (12 months). So, it is suitable to keep in mind that a stage can last more than a year (two or three years for example).

Table 5 : Transition matrix for the Markov chain state 7.

	Class 1	Class 2	Class 3	Class 4
Class 1	83.1%	6.1%	1.6%	9.8%
Class 2	24.0%	45.0%	1.8%	29.9%
Class 3	63.8%	5.2%	26.2%	4.6%
Class 4	30.8%	3.6%	1.0%	64.7%

Source: GCA Data, Mali 2004, our calculations, HAC.

Table 6 : Transition matrix for the Markov chain state 12.

	Class 1	Class 2	Class 3	Class 4
Class 1	76.4%	7.9%	1.9%	14.8%
Class 2	36.9%	27.2%	1.9%	34.8%
Class 3	71.9%	7.3%	10.9%	10.1%
Class 4	43.4%	5.3%	1.4%	50.2%

Source: GCA Data, Mali 2004, our calculations, HAC.

5.3 Discussion

Variables used in the framework of this typology are the ones which allow detecting homogeneous groups of holdings. These variables are relative and concern:

- The holdings size
  - Available surface
  - Exploited surfaces
  - Surface by type of culture (cereal, leguminous, industrial)
- The type of activity
  - Farm
  - Breeding
- The size of the livestock or the farmyard
  - Size of the herd of small ruminant
  - Size of the herd of bovine
  - Size of the farmyard
- The workforce
  - Permanent Workforce
  - Temporary Workforce
- The access to supervision
- The access to credit
- The type of plant equipment used (improved inputs, input for amendment of the ground)
- The practice of the protection of the cultures
- The equipment endowment

Classes' stability has been studied by means of the Markov chain. The most unstable class of this typology is the class 3, characterized by variables relative to the size of the herd of small ruminants and cattle. Furthermore, these are holdings which only practice breeding. But some of them possess plots of land with a rather small surface. That justifies that they tend to migrate rather quickly to a subsistence, traditional farming, maybe when the conditions are not very in favor to the breeding. In this group, the transfers are observed at least after 3 years. If the stage is equivalent to two years, then the transfer will be observable only after six years.

As for the class 2, the transfers are observed at the end of 7 years at least. This class is characterized by variables relative to the food-producing production (cereal, one thousand) on enough spread surfaces, the practice of the short-term breeding and the absence of industrial crops. At the end of 7 stages, these holdings have a tendency to pass to the holdings of class 4. These transfers are possible when this kind of holdings benefit from a supervision (training in best practice, advice support, etc.) and of financial means. They are inclined to move to a more modern agriculture, for most of them, because they have to their disposal initial endowments required (lands, small equipment, etc.).

Classes which resist to the transfers are the classes 1 and 4. The class 1 is characterized by subsistence farming, practiced on very low surfaces with traditional techniques. These holdings, because of their lack of endowment (ground, supervision, financial mean), are little sensitive to the change. Their production is essentially intended for the auto-consumption. Class 4 is naturally opposed to class 1 because of its characteristics but possess the same properties of stability. Class 4 is characterized by a modern farming, with best practice. The holdings of this class are specialized in industrial crop. Moreover, because of the size of the holdings they have, food crop is also well enough practiced there.

Variables or groups of variables or modality are grouped in the table below according to the power of their stability.

Table 7: Variables classification according to their stability and their transfer time.

Category	Transfer time	Variables or Modality
Variables or Modality with low stability	From 3 stages	-Exclusive Breeding practice
		-Size of herd of small ruminants
		-Size of herd of cattle
Variables or Modality with medium stability	From 7 stages	-Practice of cereal crops
		-Short term breeding practice (poultry breeding)
		- medium and high size holding (surface of more than two hectares)
Variables or Modality with strong stability	Beyond 12 stages	-Traditional agricultural practice (no manure, no treatment)
		-No equipment
		-Low workforce
		-small size holding (very low exploited surfaces)
		-practice of industrial crops
		-equipment endowment
		-modern farming (inputs, improved seed)

6. Conclusion

The FAO World Program for Census of Agriculture 2010 (WCA 2010) recommends a modular approach to census and survey planning with a core module based on a complete enumeration of limited set of key items and sample based complementary and thematic surveys. In this context, the paper aims at identifying the main common variables from the agricultural censuses appropriate to build robust agricultural holdings typology. It is particularly interested in the analysis of the period of change in these variables. It will be an analysis based on variables that describe the structure of agriculture rather than performance and not change during time.

The techniques of factor analysis, logistic modeling and analysis of Markov chains have been useful to achieve the results.

Using agricultural census and survey data from Mali and data mining and multivariate analysis, the paper aims at identifying the better typology of agricultural holdings and the main common variables from the agricultural censuses appropriate to build robust agricultural holdings typology.

On the basis of a typology to four classes three large groups of variables have been created. The least stable groups are those whose changes were observed at the end of three years. For moderately stable variables, mutations are observed at the end of seven years while for the most stable variables, changes were observed over twelve year. These conclusions are valid assuming a State of the markov chain is equivalent to a crop year.

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Endnotes

1 It is about a hierarchic ascending classification consolidated by the mobile centers.

2 Choosing the number of class was made following the analysis of the histogram level indices.

3 The Annexes have been removed due to space restrictions. The complete paper can be found at the conference website.

Typology of Farmers in the Context of the Preparation of the National Sample Surveys of Establishments Agricultural (PNAG)

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Abstract

A study on the typology of farmers is an excellent subsidy to planning policies and land development and, therefore, the statistical information, a basic tool for understanding this reality, it becomes an extremely valuable element for public policy makers. In recent decades the Brazilian countryside has undergone a series of transformations and "picture" can no longer be represented as a single lens. The traditional portraits of agricultural producers based on statistical information disaggregated by area classes and revenues are no longer sufficient to support the various policies targeted to this population, specially differentiating actions welfare of rural poverty alleviation those focused on agricultural development, grounded in fostering production.

Today, the changes in the countryside mainly altered the characteristics of the subgroup composed of "small farmers", which largely replaced by access to credit, technology and contracts, previously only available to wealthier producers. Another element that is also related to social relations, production arrangements and family as well as their reproduction, have changed significantly, and this installment of "small farmers" can no longer be seen only as a representation of the logic of production and its economic profitability, but with elements that portray its social diversity. And it is in this context that the term family farm, in an attempt to rescue these social relations, enabling the evaluation of the needs and goals of the family as owners and workers, whose management of the business and work become factors that are closely related, in a kind identity between ownership-work-family. According Roffmann (2010) this division polarized, the type family farming and non-familiar, though settled by law, does not represent the particularities of the many "agriculture" that we have in Brazil, being object of less efficient measures from the point of view of public policy (Carneiro, 1999; Abramovay & Veiga, 1998).

Then there comes the need to better target the group of farmers, and this work will undoubtedly pass by Statistics, responsible for much of the information the country's farm. The present paper aims to give the "tip foot" initial study typology of farmers under the Brazilian Institute of Geography and Statistics (IBGE), in order to support the formulation of the National System of Sample Surveys of Agricultural (SNPA). The strategy outlined here seeks to bring first as "background" brief contextualization of the agricultural environment in the country, highlighting the main changes in recent decades, and they have been objects of other studies and deeper. In a second step, we will stick to revise some typologies employed in the literature, and bringing some experiments currently underway by the statistical offices of developed countries. This analysis is based on the variables used in these studies and their possible use for the Brazilian case, thus allowing obtaining the knowledge closer to the Brazilian reality.

1. Transformations of Brazilian rural environment

In recent decades we highlight two major transformations in the Brazilian countryside: i) productivity gains for small farmers by bringing together producers, cooperation and collective learning (spillovers) as well as access to integration contracts, ii) the importance of non-agricultural activities in rural areas. These two great movements relate primarily to the group we call family farms, whose dynamics involves family participation not only as a unit of consumption, but also as a production unit, where management of both production and consumption, is in charge of its members. We will see that the two movements are closely associated and reveal a new family dynamics in rural areas.

The first movement, which regards to productivity, has its the genesis the increasing of crops that require little manpower and introduction, as well as spreading of labor-saving technologies, such as tillage, for example, adding further the advance of

mechanization of planting and harvesting. Today, heterogeneous establishments (family, business, large, small) participate in the same chain, competing against each other (Graziano, 2010) and integration with industry facilitates and encourages access to new technology and productive ways. Moreover, collective learning from greater interaction between neighboring farmers, cooperatives and much has helped democratize knowledge production techniques able to enter the small farmer to the capitalist market, adding to the health requirements, which in some so forcing a standardization of products and production methods.

However, not all are able to be incorporated or to be incorporated into the process of technological innovation necessary to ensure the viability of reproductive and productive units. Even with the democratization of the access to technology and most dynamic family production, there is still a range of producers also taken as a family with a high concentration of unpaid family members (consumption), and low productivity in processes that do not allow the accumulation of capital. An example are the work processes of family farmers in the Northeast of the country, since there is an increase in self-consumption, coupled with a decrease in rural gainful occupation, while there is a rise in this same population in other regions of the country (Buinain & Dedeca, 2010).

Another element to this impulse of agriculture was the National Program for Strengthening of Family Farming (PRONAF), which enabled and facilitated the modernization by such producers and on the other hand, the political ally of income transfers such as family allowance, increased the resistance of poorer producers to the historical processes of impoverishment and marginalization, contributing to the maintenance of the family in their establishments. According Buaniain & Dedeca (2011), this was a move that greatly helped to increase the participation of self-consumption in income, especially in the most unproductive establishments, which somehow would be expelled from agriculture.

A complementary analysis is that policies transfers, retirements and pensions far served as a kind of agricultural insurance, guaranteeing a minimum income to the family farmer, even if its production is not realized, taking into account the inherent uncertainties of agricultural activity. Additionally, the reduction of insecurity in the country was reflected not only in the rural producer, but also as its own offer of temporary work and his family, to put oneself in the job market as harvester or diarist (Buaniain & Dedeca, 2011). And that also is related to the second movement we spoke.

The second movement, namely, the largest share of non-farm work in family dynamics, had its consolidation with the work entitled "New Brazilian countryside" (Graziano, 1997) which found a higher rate of labor force growth of rural PEA in the 80's compared the agricultural PEA, which would be largely a reflection of the growth occupations in the services category due to an improvement and urbanization of the countryside. The survey also revealed that there was an increase in the labor force of those who work less than 15 hours, confirming the importance of the part-time worker in the production process recently.

On the other hand, the small supply of essential services in the countryside was a contribution for producers to glimpse the possibility of establishing homes in more distant rural and ever closer to the cities. Additionally, urban space also expands the boundaries rural, with sites, leisure farms, deconstructing the notion of differences, a phenomenon called rurbanization (Graziano da Silva; Del Grossi & Campanhola, 2002). There is still a movement for increasing part-time producers of urban origin, whose agricultural activity is secondary. This, unlike the familiar part-time pluriactive producer, does not face agriculture as a maintenance activity and social reproduction, and in this case the family does not hold bonds of work and management with this activity (Carneiro, 1999).

2. Typologies

In an attempt to cope with this multi facet of family producer, some countries recognize the farm household as the unit of analysis. In this context of different inserts professionals in rural areas and the difficulty of defining spatially such territory the characterization of agriculture household gains strength, to enable the look for these combinations of agricultural and non-agricultural activities in the same family unit or establishment. While these are good reasons to work with the universe of household farming, the principal, is the fact that in some rural areas the production and consuption decisions often cannot be made separately and in sequence, namely, the families are not only households (households in Household Surveys) nor the farms are only

establishments (Census of Agriculture), are a mix of the two, or rather, are what you can call "agriculture household" (Singh et al., 1986).

In general, the combination of these universes in order to set the home farm accepts conceptual variations, although there is a concept defined for the case of OECD countries. In these countries, the concept takes into account the household in order: i) wide - includes all household that derives some income from agriculture, even though this is the smallest portion of the proceeds or the allocation of working time, ii) restricted - only includes households that are primarily dependent on agricultural activities for their livelihoods, defined as those that the main part of their total income comes from the activity of self-employed in agriculture; iii) marginal - when the main source of income comes from non-agricultural sources obtained by subtracting the universe of households covered by the concept that restricted understood by the broad concept (i - ii).

In the USA, the Economic Research Service (ERS) has developed a classification that seems to be more focused to the needs of policy makers (ERS, 2001). The farmer who is not familiar to registration of legal entity, cooperatives or those responsible for the management of production is the administrator or a group of producers. Based on the combination of the main activity of occupation and sales classes, the ERS has identified five groups of small family farms (sales less than $ 250,000): The resource limited, retirees, those of rural lifestyle (life-stile) whose agricultural activity is secondary, the low income and high income. Additionally, we have also defined two other subsets of farmers, those with sales greater than $ 250,000, classified as "large" and "very large" family farmers. This typology, which defines all the 8 categories of producers, is also used by Statistics Canada.

Italy also follows a typology of producers like the U.S., but the main difference is that instead of assuming a cutoff point for each variable used in the algorithm, using the first quartile of the distribution of the variables. Sets agriculture unfamiliar likewise the ERS and 6 types of family farms: limited resources, retired operator (secondary agricultural activity), small, medium and large family farms (Napoletano at al, 2001). Germany publishes results of household income by farm size (area and yield), if full-time (divided by size), part-time and spare time (spare time).

A study conducted in Brazil by agreement between FAO and INCRA, using data from the agricultural census of 95/96 defined a quite disaggregating typology for Brazilian agricultural establishments. Altogether there are 9 categories distributed in agricultural employer (type 1, 2, 3), Institution of Public Utility, Government and family farming (type A, B, C and D). The main variables are defined from the definition of the direction of the establishment, the total number of workers hired and family, area and income generated in the establishment (Granziroli et.al., 1999).

One other type, which should also include in this study, is the ability to meet institutional sectors used for the formulation of national accounts. Recently, the manual SNA/ONU admits that for agriculture, beyond traditional institutional sectors "families" and "business", the national accounts should include family-owned businesses, which would be an intermediate category between family and the business sector.

In general, it is observed that these types use different conditions to determine various categories and they do not use the area as a variable for classification, except for the study of the FAO / INCRA and the Family Farm Law. Altogether there are about 13 variables that include the different types discussed above, as observed in Table 1. A reading of the table helps us to choose what those variables would be more appropriate in a typology for the Brazilian case.

2.1 Establishment directions, legal condition of the producer and articles of incorporation

It is observed that all studies use the variable that runs the agricultural establishment, which determines whether its management is hired or private. You must make it clear that the relevant studies now combine legal condition of the producer, CNPJ and even make a balance between the number of employees hired versus family in an attempt to discriminate the familiar production systems not familiar, and sometimes even defining what would be an agricultural company, as in the case of national accounts.

For rural enterprise, a relevant point to be discussed in the Brazilian case is that legally (article 970 of the Civil Code) is provided to rural businessman have record in the commercial registry or articles of incorporation (CNPJ), which differs from the companies classified in non-agricultural

Table 1: Variables used in studies of typology of farmer.

Variables	Typologies					
	Brazil/National Accounts	**Brazil/Family Farm Law**	**Brazil/FAO/ INCRA**	**OCDE/Agriculture Household**	**USA/ERS and Canada**	**Italy**
Establishment directions	√	√	√	√	√	√
Legal condition of the producer		√		√	√	√
CNPJ	√					
Off-farm income		√		√	√	√
Farm income		√		√	√	√
Hired work X family work	√	√	√			
Permanent employees	√		√			
Retirement					√	√
Assets					√	√
Family income					√	√
Sales					√	√
GVP			√			
Area		√	√			

activities. The same happens with the use of legal nature in the company enrollment, because some of the 2/3 companies registered its legal nature "natural person", or rather, individual contributor, what it is possible to conclude the difficulty of defining a rural company based on these criteria to the Brazilian case. In this way, the characterization of rural enterprise in Brazil does not depend on their formalization, which involves the so-called "formally constituted companies" and, therefore, non-formally constituted ones. In other words, agricultural census variables as the articles of incorporation and Legal Condition of the producer are not good criteria to define or not the agricultural entrepreneur in Brazil.

On the other hand, one should recognize the importance of the type of business management to in order to break down the producers, because in last instance it represents the degree of dedication, bond or best producer working with the agricultural establishment. The type of management employed maintains a close relationship with what we call mixed income, which comes to be a striking feature in the process of modernization of the Brazilian countryside, due to the incorporation of technology by small and medium-sized producers. Mixed income is the one coming from the producer's own work and on the basis of ownership of capital, whether physical, natural and human.

We would say that the producer with his own management or family management, once devoted more to business would have more income from his work when compared with the income from the capital. Unlike the rural entrepreneur, that could be characterized by not prevailing work incomes in their incomes as farm producers. So, hiring an administrator in the business management can be a good proxy for assessing the dedication of producer work, or on final appeal, to assess the composition of their income, that is, which one prevails the most, capital incomes or labour incomes.

We would say that there is no clear border between capital and labour income that we can simply discriminate two distinct groups of producers relying only on that feature, as is the case of the establishment managing. In fact, there is a border, a mixed area, tenue where there are both producers with contracted management work incomes in agricultural activity as there are others with family management where much of their income if it is of ownership of capital.

However, as the first discriminant the type of management seems to be a good start, considering that usually a contracted management possibly will

make use of the capital and much of its manpower will also be hired. Already an establishment whose management comes to be familiar, that Yes, would need a better distinction, since the capital job is increasingly demanding in commercial agriculture and there are family establishments operating in various scales of production, requiring even greater part of their labor as contracted. On the other hand, family producers that operate on a small scale are unlikely to have an administrator conducting the management of work, except when there are hiring foremen, for example, in places of recreation and other units where the purpose of production is not the market.

2.2 Off-farm income X farm income

The analysis of these sources of income should not be alone elements to a total discrimination between groups of producers, or better, discriminating agricultural producers of agricultural or even less discriminate against family farming or not familiar, as if it was Law 11,326.

An example of using this variable only for sorting into groups of producers was the construction of the categorization of family agriculture in accordance with the criteria of the law that defines whether an establishment produces in a familiar agricultural scheme or not. In the derived subgroup unfamiliar establishments include both the employer and enterprise segment of agriculture, as many small establishments with activities including family-based. These recent establishments were not covered by the law of family agriculture for the simple fact of not meet the criterion of agricultural income as the main source of family income, and therefore most of its earnings from non-agricultural activities. In the case of small shops to satisfy other requirements of the law, operating in productive range that requires little area and contracted labor, yet the pluriactive family had other sources of revenue whose sum at the time of the survey were more significant that the agricultural income generated in the agricultural establishment.

In this case, and that there are few in Brazil, is just the opposite, that is income that allows playback of this production system and work for some family members, namely, the non-agricultural income helps to reveal the ability of survival and maintenance of agricultural activity.

In short, an evaluation between composition of family income sources, if more farm or off-farm, should not be seen as a criterion to define a typology of producers on the basis of the determination of how the agricultural producer. You can see this analysis as an offshoot, as an additional tab, and not a criterion to define a typology of producers, helping to understand the importance of a non-agricultural income both for reproduction and maintenance of legacy left in the family system as for reproduction and leverage capital in agriculture.

2.3 Work and family work, permanent employees

The composition of the workforce of an agricultural establishment is a rather interesting variable to discriminate the dynamics of production of an agricultural establishment, determining whether much of the business's operating result comes as a function of work of employed family members or from the hiring of employees by means of the accumulation of capital. In General, the larger the largest production scale is the additional work effort, which ultimately requires the hiring of labour in addition to the family, often demanding a better level of qualification and specialization, as hiring agricultural engineer, zoo technicians, machine operators and agricultural implements, among other workers.

In this context, a characterization of the composition of the workforce using more of the family labor contractor's or more is a good measure of its scale of production. In national accounts, for example one of the criteria to define if a business undertaking, whether or not it is an agricultural one, it is found in the Institutional Sector, and if hired labor units (whether temporary or permanent) are greater than the family labor units, the happens to the Law of family farming.

An important use of this expedient questioning as a criterion in a typology of agricultural producers is that it is increasingly common to hiring employees or temporary crop producers. In some cases by more workers family members who are involved in agricultural production hiring temporary workers will impact greatly on the classification of the establishment according to this criterion of typology. A fact even worse is that many services are outsourced and the manpower employed in the work is not computed as being the establishment, that is, or is permanent and not temporary is. In large agricultural enterprises, hiring third-party services are the main source of labor in the establishment, which perhaps would disqualify according to some criterion of quota-based typology of contract

workers versus the family. Perhaps it is for this reason that the international studies that we do not incorporate such variables in the construction of algorithms of typology, since much of the agricultural workforce in these countries is done through the contracting of services by third parties.

2.4 Assets, family income and retirement

You can see these three components associated enough when we want to distinguish in a typology the target audience of specific public policies, such as the actions for poverty alleviation of those that foster productive activities. Although the assets are a good measure of scale and size of production, and reflect well the idea of capital income X income for work already discussed earlier, your measurement is difficult and is a big problem of incorporate it as a criterion in a typology. A valuation of assets that has market price (and equipment), such as land and machinery, is already difficult, let alone of assets where there is no market (intangibles), as the natural capital, for example.

Probably in countries such as the example of typology of table 1 (USA, Canada, Italy) action errors associated with this asset valuation can be a little lower depending on the accounting control for future depreciation of capital goods. In Brazil, as the overwhelming majorities (over 4 million) are not business establishments, that is to say, there is some accounting requirement; the asset valuation tends to be less accurate.

However, as much as that variable is used to define production scales, it is understood that the use of the "active" variable in these studies can better discriminate against the poor of the non-poor, or rather, the producer lacking a policy to combat poverty from that one who lacks policies to encourage agricultural activity. In fact the "active" variable in the poor agricultural categorization is more useful than that, it helps in the assessment of who is the transitional poor and who is the structural poor.

If we take as an example all categories of types used by both the ERS and by Canada, the variable "active" is used only to define the producers classified as "limited resources" and that poverty thresholds are considering an income criterion. However, if the individual that year not report revenue above this poverty threshold, but if you have for example, let's say that person is not a structural, but rather poor. For this reason we believe that these types consider individuals with "limited resources" those whose family income, agricultural income and assets are all below a pre-set limit.

Another point is that the "Land" might want to distinguish structural and transient poverty for the Brazilian case. The rural module to some extent brings a little idea, considering that considers a minimum area able to guarantee at least the subsistence of a family, taking the municipal standards of productivity, climate, biome, etc. Maybe the rural module can be used in a first look of the establishment that would be the target of his shares of, poverty relief, identifying each if it is just temporary or not. However, there is some difficulty in using it since constantly working it should be changed, representing the technological changes and the increments of productivity for now occurring in some areas of the country.

As for the retirement, it is difficult to understand the need to discriminate against an individual retired from the others when we look at the case. In the American producer typology be retired to be classified in a specific group of establishment. In the Brazilian case, the Constitution of 1988 elected rural those retirees with more than 60 years of age, regardless of contribution to social security contribution. Therefore, there is a wide range of producers and family members who receive retirement, but that the vast majority is a minimum wage. On the other hand, this retirement income comes if showing important to poverty policies in the field, with a view to guaranteeing a minimum income for many families, and in some cases shown just as an income supplement, but do not allow them to stop work or produce.

In this case it is difficult to understand in Brazil a unique category of typology for this criterion of retirement. It would be easier to conduct a post tab typology of how many or who are producers whose part of income comes from pensions and retirement.

2.5 Gross Value of Production (GVP), area, sales and agricultural income (GVP-expenses)

It is expected a good correlation between Gross Value of Production and area because both variables can be used as a criterion for scale in a study of typology, although they bring somewhat different information. The former is more focused on the issue of agricultural exploitation and result can be more unstable in the short term, while the latter, although it varies less in the short term can represent the potential of production scale, but not the actual

production. There is the case of producers with considerable area and unproductive, but also the other way around, from small producers with high productivity and they employ a lot of technology.

Although the correlation is high among these variables is convenient a confrontation of their distributions in order to assess whether both really say similar things, and then a typology study use of one or the other for a scale criteria, for example. A joint analysis of the distributions may also can help elect cut-off points that best discriminate establishments in accordance with one of the two chosen scale criteria.

We take as an example the Agriculture census data of 2006, with the variable area distributed in the categories of less than 1 ha, 1-10, 10-30, 30-100 and more than 100 ha, while GVP distributed based on an approximation of their respective quartiles, taking into consideration also the tenth and 90th percentile, as follows: 0 of GVP (10%); 0.1-R $ 318 (1Q); $ 319-R1740 (2Q); R $ 1740-r $ 8848 (3Q); R $ 8848-$ 3200 (90%); >$ 3200.

The Chi-square test between rows and columns of the table 5 x 6 rejected the hypothesis of independence between variables, indicating a strong correlation between the two variables. The adjusted residuals those crosses between categories in which there is a greater difference between the expected and observed frequency, enabling thus distinguish those cells where there are strong indications of associations (values greater than 1.96).

An analysis looking at the extremes of the joint distributions observed establishments that had zero GVP associations with those with up to 1 hectare of area, up to 10 acres and up to 30 hectares. This means that it is still common establishments with up to 30 hectares of the area does not produce agricultural products, at least in the year 2006. Not surprisingly, with a great potential of production, more than 30 hectares, have no statistics with zero production association, showing that the opportunity cost of not producing anything is too high for those who are above 30 hectares area. As for the other end of the distribution of GVP, it is noted that among the 10 largest GVP establishments no statistical association with up to 10 hectares, but from that limit. This means that there is still a considerable contingent of establishments with between 10 and 30 acres that are among the 10 that produce more productive in the country, which are certainly those many productive establishments and average that make use of technology.

Another analysis of this table is to observe those categories more statistically associated. It is observed that the biggest adjusted residuals 7.9 and 9.8, respectively, are establishments with up to 1 ha in area and Gross Value of Production between 0-R$318 and R$318-R$1740. This means that it is still very common to observe establishments with

Table 2: Contingency table 6X5 – Gross Value of Production (GVP) X Area – Brazil 2006.

	AREA (ha)					
GVP (R$)	**Up to 1**	**1 – 10**	**10.1 – 30**	**30.1 – 100**	**> 100**	**Total**
Zero	109,334 (2.11)	172,910 (3.34)	120,659 (2.33)	95,802 (1.85)	51,346 (0.99)	550,051
0 – 318	412,965 (7.98)	199,137 (3.85)	73,845 (1.43)	42,966 (0.83)	15,602 (0.30)	744,515
319 – 1,740	509,255 (9.84)	447,576 (8.65)	189,249 (3.66)	112,835 (2.18)	34,785 (0,67)	1,293,700
1,741 – 8,848	202,185 (3.91)	466,578 (9.01)	335,560 (6.48)	215,251 (4.16)	73,923 (1.43)	1,293,497
8,849 – 32,000	50,187 (0.97)	205,428 (3.97)	260,886 (5.04)	170,178 (3.29)	90,613 (1.75)	777,292
>32,000	19,930 (0.39)	72,673 (1.40)	202,185 (3.91)	135,961 (2.63)	169,701 (3.28)	516,581
Total	**1,098,515**	**1,564,302**	**1,303,856**	**435,970**	**772,993**	**5,175,636**

Note: Adjusted residuals.
Chi-Square test: 1468049, df. 20 (p-limit <0,0001)

less than 1 hectare of area producing up to R$1740, although it is also common to observe establishment with this profile of area producing up to R$ 8,848. This, therefore, would be a kind of limit in which an establishment with this area would produce, since from this point it is not possible to statistically observe establishments with this profile.

Other strong associations are 1-10 ha of area and GVPs with R$318-R$1740 and R$ 1.740-R$ 8,848 annually, 10-30 ha with GVPs of R$ 1.740-R$ 8.848 and R$ 8,848 -32,000; and more than 100 ha with 10% of establishments with higher values of GVP. This shows exactly that as we walk along the area stratum correlations will be showing up in GVP strata, also showing a positive relationship between the two variables.

In summary, let's say that it is difficult to choose between these two variables to determine which one to use to represent production scales in a study of typology. We would say that the choice will be quite the goal in aim, or rather, to assess whether the best reading is a categorization of establishments based on their productive potential (area), with a more structural look of Brazilian agriculture, or a more effective production-oriented, with a cyclical feature. In this case, for an annual survey, as the PNAG for example, maybe this last choice was the most interesting.

Once opted by a look that mostly determines effective production, as is the case of GVP, there are still choices quite similar, and suggest the same analysis, as in the case of sales amount suggested by ERS/USA and even agricultural income (GVP-expenses). In the case of Brazil the GVP seems to still take some advantage over others because they consider also those products intended for human and animal consumption in the establishment. Consumption is very important in Brazil, especially among the family producers, who are the vast majority in the country. Another advantage is that the 2006 Census showed that there is a contingent of 32% loss-making establishments in the country, which spreads between small, medium and large establishments. No doubt this is an important issue when evaluating a variable for measuring scale, revealing that the farming income alone would not be appropriate.

In Brazil, this deficit of 32% result possibly may have been an error of measurement in information capture, since the informants tend to reveal more your expenses than revenue. Maybe for the Brazilian case, a typology should be a combination of both variables and not only of the net operating result (GVP-expenses).

3. Final remarks

The analysis of the variables used in the study of typology of specific literature reveals that we should have enough care to use them in a possible Brazilian proposal, in view of the particularities of the country, from its legal aspects until the collection procedures of the information they see in the field. You must also take into account the transformations that have occurred in rural areas, accelerated through the process of agricultural development in recent decades.

What you can see with this study is that for Brazil can take approximate concepts international trends, such as the relevance of the category "life-style", which would be a kind of pluriactivity, where the income outside the agricultural establishment becomes important object. The difference is that the cut-off points should be extremely different, as well as the use of some variables to represent production scales, as for example the area, VBP, sales, etc. On the other hand, other categories such as "retirees" should be viewed with caution for the Brazilian case, in view of the huge swath of people who are beneficiaries from social security in rural areas.

On discrimination of large groups of producers, it is concluded that the variable "which runs the establishment" is a good measure for Brazil, considering the legal aspects in the definition of an agricultural company in the country, which involves the use of articles of incorporation and legal condition of the producer as variables, what no longer happens in types of ERS and Canada. Another aspect is that in Brazil, as we saw in the second section of this manuscript, many small and medium-sized producers are increasingly placed on the market, but there is still a large contingent of producers whose production purpose is the reproduction of the peasant family heritage and maintain their livelihood (non-market logic). Thus, the variable "direction of establishment" combined with "purpose" would help distinguish more clearly those hired or family-run establishments from their productive logic (commercial or not), helping to distinguish those who hire a Manager or foreman in leisure sites or production units that operate on a small scale and producers who operate on a large scale but the management is typically familiar or private.

However, in the context of the IBGE, this is only the first test of a study that requires investigation and discussions much more pronounced and that will be object within the SNPA deployment process. In a close offshoot of this work to proceed empirically in the issues raised above, evaluating both the choices of variables that best discriminate against groups, as well as the cut-off points closer to the reality of the country. We still have much work ahead to get consensus on the topic, and then establish a tabular plan which takes into account this diversity of agricultural establishments, conducting a public policy more focused and cost-efficient for the Brazilian case.

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Farm Classification Systems for North American Agriculture

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Abstract

As international agricultural markets become increasingly more integrated, internationally harmonized farm classification systems could become more useful for international comparisons of agricultural industries, as a tool for summarizing and analyzing micro-level data. Canada, Mexico, and the United States currently do not have a common farm classification system beyond the harmonized North American Industrial Classification System (NAICS), which the three countries developed and adopted shortly after the implementation of the North American Free Trade Agreement (NAFTA). While common policy themes exist among the three countries, such as competitiveness, innovation and sustainability, they have yet to be reflected in a comprehensive farm classification system.

This paper compares farm structures in North America, using the NAICS and farm size. Additional classifications that are used in North America are summarized. Additional farm characteristics that could enhance the comprehensiveness of farm classification systems are discussed. Finally, data constraints which limit the ability to develop a harmonized classification system in the three jurisdictions are discussed.

Keywords: farm structure; farm classification; micro-level data; farm typology.

1. Introduction

Farm classifications[1] are helpful when analyzing farm-level data within an agricultural policy context. Classifications serve as a framework for organizing heterogeneous farm businesses into relatively homogenous groups, according to specific criteria, for economic and policy research and analysis, such as analysis of the distribution of impacts of programs and policies.

Most commonly, farms are classified using a single indicator. For example, farm type or commodity specialization classifications are used to analyze the distribution of impact of a particular program or policy across different types of production, i. e. livestock producers versus crop producers, or mixed farming operations versus specialized farms. While these approaches provides a method for grouping farms into relatively homogeneous groups, classifications using multiple indictors may provide a more comprehensive grouping of farms.

There are several arguments for creating a classification system based on an integrated set of indicators. This type of classification offers a tool to synthesize and assess farm indicators as an integrated set, thus highlighting linkages among the various indicators of interest, as well as evaluating and designing more differentiated farm-level policies taking into account the wide range of differences (Andersen et al., 2007).

The farm characteristics selected for classification are typically based on key indicators identified as relevant to policy discussion (Andersen et al., 2007). Farm classifications have largely focused on the size and type of the farm. The most commonly used measurements of size include the land area of the farm, gross sales or gross expenses (Hanson, Stanton, and Ahearn, 1989).

Since 1998, Canada, Mexico and the U.S. use the common North American Industry Classification System (NAICS) to collect industry statistics in the respective countries. While the classification was not designed specifically for agriculture, this classification offers standardized categories where farms are assigned a NAICS code based on their most important production activity. Currently, this is North America's only harmonized classification system for agriculture. While NAICS is useful from a production standpoint, it does not contribute to discussion of any of the

emerging issues in agriculture. Today the objectives of the agricultural policies have been broadened and increasingly focus on additional indicators.

Research suggests that additional indicators outside of the size and type of farm could help capture the complexity and diversity of farm behaviour and performance, such as for instance income of farm operator families, degree of production specialization and production intensity of land use, (Briggeman et al., 2007; Galbraith et al., 2013, Andersen et al., 2007). A classification system can only be developed based on available data or, ex ante, it could guide data collection.

This message resonates in the Global Strategy to Improve Agricultural and Rural Statistics (FAO, 2010), which was jointly developed based on input from a large number of stakeholders, including national statistical institutes, ministries of agriculture, and regional and international organizations. The framework recognizes the linkages between rural households, agricultural holdings and the land and other natural resources that they use and impact.

A more comprehensive harmonized classification system could help facilitate cross-country comparisons, allow regions to learn for one another, help identify best practices, and help recognize cross country similarities (and differences) that may not be obvious at first glance.

The paper first provides background on the agricultural industries and agricultural policies of Canada, Mexico and the U.S, to give context to the discussion of farm classifications. The paper then shows the farm structure in the three countries based on NAICS classifications and farm size. This is followed by a discussion of additional indicators that have been used to classify farms for policy discussions, as well as a discussion of the benefit of multi-dimensional farm classification systems, and related data requirements.

2. Background

Canadian, American and Mexican agriculture operate in different economic environments (see Annex 1[2]), including structure of their industries. This impacts the type of farm classification system that could be relevant to policy analysis.

The population of Mexico and Canada are respectively about one third and one tenth that of the U.S. In all three countries around one fifth of the population is rural. The size of the Canadian and Mexican economies are each about one-tenth of that of the U.S., measured in Gross Domestic Product (GDP). GDP per capita, however, is very similar in Canadian and U.S. economies, $47,283 and $46,215, respectively, while the Mexican GDP per capita is $9,566 (2010, FAO).

Agricultural value-added contributes 1.6% of GDP in Canada, 4.3% in Mexico, and 1.2% in the U.S. Value-added per agricultural worker was highest in the U.S., with Canadian value-added per agricultural worker 90% of the U.S. and Mexico 7% of the U.S. (2009, FAO). Agricultural Total Factor Productivity grew the most between 1992 and 2009 in Mexico and least in the U.S. (Fuglie, 2012).

Total trade among the three North American countries has steadily increased since the North American Free Trade Agreement (NAFTA) between Canada, the United States, and Mexico became effective January 1, 1994[3].

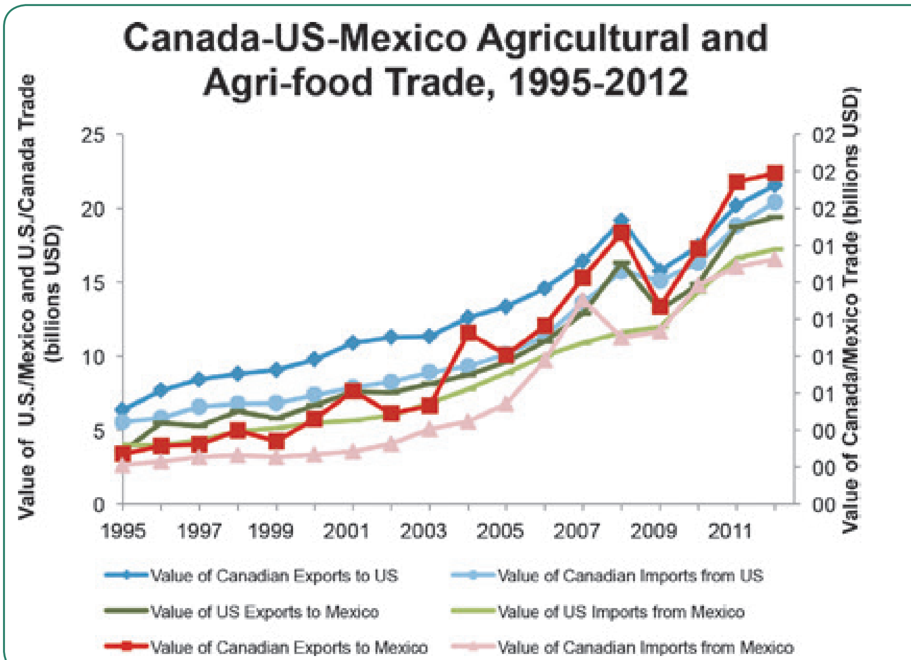
The U.S. is the most important trading partner for both Canada and Mexico. Canada is the second most important destination for Mexican vegetables, and Canada follows the U.S.as the second most important source for wheat, beef and pork to Mexico. The most important destination for U.S. exports is currently China, but Canada and Mexico rank second and third, respectively (ASTI, 2011).

According to OECD data, the total value of agricultural production, at the farm gate, in the three countries was $467.4 billion in 2011, with 10% produced in Canada and Mexico, each, and 80% produced in the U.S.

Public investment in agricultural research and development (R&D) in absolute dollars is significantly greater in the U.S. than in Canada and Mexico, which are approximately 20% and 5% of those in the U.S., respectively. Total support to farmers as a share of agricultural production at the farm gate was higher in Canada than Mexico while the U.S. had the lowest share[4], according to the OECD (2011).

The agricultural land base encompasses 64.8M ha in Canada and 91.5M ha in Mexico, compared to 365M ha in the U.S. At the same time, Canada has just under one-tenth of the number of farms as the U.S., while Mexico has over twice as many farms as the U.S. (Table 1). The definition of a farm differs somewhat across countries, see Box 1). Between 1991 and the most recent census, the number of farms declined in Canada by 26%; however, both Mexico and the United States saw an increase between those two years in the number of farms, of 10% and 14%, respectively (Table 1). For the U.S., this increase is a recent reversal of a long-time trend of declining farm numbers.

Figure 1



Source: Foreign Agricultural Trade of the United States (FATSU)
Notes: The left axis refers to the value of import/exports between Mexico and US and Canada and US reported in billions USD.

The right axis refers to the value of import/exports for Canada and Mexico, reported in millions USD.

The share of farms operated by women is 27% and 30% respectively, in Canada and the U.S., where up to three farm operators can be reported per farm. In Mexico, the share of women operators is 16%, with only one operator per farm reported. In the U.S. the share of women among "principal" farm operators is 14% (see Annex 1). Note: The Annex has been removed due to space restrictions. The complete paper can be found at the conference website.

These basic indicators set the context in which the farm classifications based on micro-data demonstrate the diversity within each country's agricultural sector.

2.1 Current policies for the agricultural sectors

In order for farm classifications to be effective tools for policy analysis, they need to be aligned with the policy issues at hand. Although policies differ between Canada, Mexico and the US, some common themes exist, such as competitiveness, productivity and innovation.

2.1.1. Canada

In Canada, a new five-year agricultural policy framework, Growing Forward 2 (GF2), came into effect April 1, 2013. GF2 represents C$3 billion ($2.96 billion) of government funding over the following five years, which includes significant resources allocated toward programming related to innovation, competitiveness and market development. This programming supports private sector R&D, the commercialization and adoption of innovations; industry-led efforts to expand domestic and export markets and to respond to emerging food trends; as well as the development of Canadian national assurance systems and attribute standards[5]. In addition to these program activities, GF2 includes a suite of Business Risk Management programs that

Table 1: Change in number of farms.

Canada	1991	2011	Change
Number of farms [thousands]	280	205.7	- 26.5%
Mexico	**1991**	**2007**	**Change**
Number of farms [thousands]	4,407.9	4,848.3	10.0%
U.S.	**1991**	**2007**	**Change**
Number of farms [thousands]	2,116.7	2,204.9	4.0%

Source: Canada: 2011 Census of Agriculture, Mexico: VIII Agriculture, Livestock and Forestry Census 2007, US: Farms, Land in Farms, and Livestock Operations 2011 Summary.

help farmers in managing risk due to severe market volatility and disaster situations.

2.1.2. Mexico

In Mexico, the objectives, strategies and priorities for development are assessed at the beginning of each federal administration, and they are established in the National Development Plan, as well as through regulations as per the Planning Law. The objective, as outlined in National Development Plan for the years 2013 to 2018, is to build a productive agricultural and fisheries sector that provides food security for the country.

Strategies have been developed to advance this objective. This includes (1) promoting productivity in the agri-food sector by investing in the development of technological, physical and human capital, including research and development, modernization of infrastructure, promotion of trade, support for increased farm production and income, and development of the capacity of primary producers in Mexico; (2) promoting partnership models that generate economies of scale and greater value-added for agri-food sector producers, such as the development of agri-business clusters that link smallholders with integrating enterprises, and implementing new agri-business models that generate increased value-added throughout the supply chain and improve farmers' income; (3) promoting increased certainty in the agri-food sector by promoting risk management mechanisms, establishing a comprehensive insurance mechanism against climatic and market risks, promoting financial inclusion and efficient risk management, and strengthening food safety to protect the health of the population and enhance the sector´s competitiveness; (4) promoting the sustainable use of natural resources, by promoting sustainable irrigation technology and efficient water use, tools for preserving and enhancing genetic resources, and use of bio-technology to protect environmental and human health; and (5) modernizing Mexico's regulatory and institutional framework, to help promote a productive and competitive agri-food sector.

2.1.3. U.S.

Agricultural policy in the U.S. is established under the so-called Farm Bill. The Farm Bill is legislation redesigned approximately every five years and includes numerous Titles covering a variety of programs relating to the agricultural and the food system, including conservation programs, food and nutrition programs, rural development programs, and investment in the land grant colleges and agricultural research and development. The latest farm legislation was signed into law as the Food, Conservation, and Energy Act of 2008. The 2008 Farm Act expired September 30, 2012. In order to establish new legislation, the U.S. Senate and U.S. House of Representatives (House) must agree on the legislation and the President must sign it into law. In 2012, while the Senate passed its version of the legislation, the House did not, so the 2008 Act was simply extended for one year. To date, the Senate has again passed new legislation, and the House has passed a significantly different bill, leaving farm legislation in question for 2013-2018.

Aside from lack of new legislation it is difficult to characterize U.S. policies affecting agriculture because such a wide variety of policies are addressed in the farm legislation and the details of the policies change approximately every five years. In general, beginning in 1985, the farm legislation moved toward greater market orientation following concerns with liberalizing world trade and competing in world markets, encouraging producers to make decisions based on supply-and-demand conditions. However, the issue receiving the greatest support among politicians in the current debate is the elimination of direct payments, which were established to increase market orientation. Direct payments have been highly criticized because they largely go to farmers in a financially strong position due to currently high market prices. Another area of general agreement is to strengthen risk management programs for farms, for example, through subsidized premiums for crop insurance. Still other policies of great importance to agriculture are not treated in the context of farm legislation, such as policies affecting interest rates and the recently passed Food Safety and Modernization Act (signed into law on January 4, 2011). State and local levels of government also establish policies affecting agriculture, such as education programs for beginning farmers and farmland tax advantages to preserve farmland within their jurisdiction.

2.2 Sources of agricultural statistics

The development of farm classification systems depends on and is limited by available data sources. In all three countries the censuses of agriculture build the foundation of the agricultural statistics programs. In Canada and the U.S., agricultural censuses are conducted every five years and in Mexico every ten years. The most recent censuses were undertaken in 2011, 2007, and 2012, in Canada, Mexico and the U.S., respectively[6].

2.2.1 Canada

In Canada, the Census of Agriculture data can be linked with Census of Population data, enabling analysis of farm operator household characteristics as well as the Farm Environmental Management Survey (FEMS), which collects data on farm-environmental practices. Other sources of micro-level farm data include the Farm Financial Survey (FFS), the Agricultural Taxation Data Program (TDP), and program administrative data[7]. FFS is a biannual survey that collects data on farm characteristics, balance sheet information, and farm revenues and expenses. The survey also includes a limited number of changing questions on policy relevant topics (e.g. on-farm food safety, business management practices), and thus allows for cross-tabulation of the responses with farm financial performance. The TDP data set consists of detailed farm financial information from income tax returns, and also provides information on the family income of the owners of unincorporated farms.

Since 2007, Agriculture and Agri-Food Canada (AAFC) has been developing a more comprehensive and integrated data base and a micro-simulation model to estimate current and future behaviour of farm businesses. The model, called the Canadian Agriculture Dynamic Micro-Simulation Model (CADMS) utilizes the data from the FFS, TDP, Census of Agriculture and program administrative data to create a simulated longitudinal data set of income statement and balance sheet data, as well as physical farm inventories and assets. The CADMS is used to produce 2-year forecasts of farm-level income, wealth and financial indicators. It is also used for scenario analysis related to proposed program development and/or market conditions and for program performance measurement. In addition, it is used to analyze the structure and competitiveness of the individual agricultural sub-sectors, and the impact of innovation adoptions, such as new crop varieties.

2.2.2 Mexico

The current agricultural statistical system in Mexico collects, compiles, analyzes and publishes a wide range of information on the agricultural sector in the country. Two information capturing methods are fundamentally converged in this system: the agricultural censuses, conducted by the National Institute of Statistics and Geography (INEGI) and the use of administrative registers mainly by the Ministry of Agriculture. Information related to cultivated lands, animal species and the means of production used by the producers of all the production units that exist in the national territory are captured with the census. The census is conducted generally every ten years.

During the period between censuses, INEGI, the Ministry of Agriculture (through the Agri-food and Fisheries Information Service (SIAP) and other institutions conduct surveys that complement the census information. For example, SIAP makes use of the administrative registers to obtain information periodically. The information includes planted area, harvested area, damaged area, the observed crops and estimations, the observed and estimated production, and the rural average price. Data on livestock includes stock, production, weight and prices of livestock (cattle, pigs, sheep, goats and poultry); as well as production and prices of the agricultural and animal products, such as milk, eggs and others.

Currently in Mexico there is demand for agricultural information that has not yet been satisfied. Although the agricultural census is generally performed every ten years, sixteen years past between the last two census, which were conducted in 1991 and 2007. There is currently no a continuous survey system in Mexico. For this reason, INEGI is working on the design and development of an Agricultural Information System that will integrate the Agricultural Census, a continuous Survey System and information from Administrative Registers. INEGI has the support of the FAO for this project.

2.2.3 U.S.

The major agricultural statistical agency in the U.S. is the National Agricultural Statistics Service (NASS) of United States Department of Agriculture (USDA). NASS conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture, in addition to conducting the Census of Agriculture every five years.

To complement and expand the economic detail of the Census, the Economic Research Service (ERS) of USDA partners with NASS to conduct the annual Agricultural Resource Management Survey (ARMS). The ARMS was created in 1996 by merging two previous surveys, the Farm Costs and Returns Survey (FCRS) with the Cropping Practices Survey. The former survey provided whole farm economic information while the latter survey provided field-level environmental practice data. The FCRS was established in 1984 by merging the Farm Production Expenditure Survey, a whole farm survey, with the Costs of Production Survey, a survey of individual commodity production costs and returns. Both the 1984 and the 1996 merger were implemented to improve the richness of the farm-level data, to minimize data collection costs, and to minimize respondent burden.

Box 1: Concepts and definitions.

Canada	Mexico	US
Farm A census farm is defined as an agricultural operation that produces at least one of the following products intended for sale: crops (hay, field crops, tree fruits or nuts, berries or grapes, vegetables, seed); livestock (cattle, pigs, sheep, horses, game animals, other livestock); poultry (hens, chickens, turkeys, chicks, game birds, other poultry); animal products (milk or cream, eggs, wool, furs, meat); or other agricultural products (Christmas trees, greenhouse or nursery products, mushrooms, sod, honey, maple syrup products). The sample frame of the Farm Financial Survey (FFS) is the population of farms with gross revenues of C$10,000 or more, as per the most recent census of agriculture, and updated by survey programs. Excluded are institutional farms, community pastures, farms on First Nations reserves, and farms that are part of multi-holding companies. The sample frame of the Agricultural Tax Data Program (ATDP) consists of incorporated farms with revenues from agricultural activities (according to NAICS) of C$25,000 or more and unincorporated and communal farms with operating revenue of C$10,000 or more.	**Agricultural Production Unit** It is the economic unit that in a specific reference period and with certain production means performs agricultural activity under the same administrative control. This economic unit is determined by: one or more land plots in the same municipality in which at least in one of them the agricultural activity is performed; the ownership of animals for the exploitation of meat, milk, egg, skin, honey or work, independently of the place where they are located, including those that are located in backyards and that are generally bred in a limited scale, constituting an occupation and income source for families.	**Farm** The National Agricultural Statistics Service, USDA defines a farm as any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the year. Since the definition allows for farms to be included even if they did not have at least $1,000 in sales, but normally would have, a system is developed for determining when a farm normally would have. These are called point farms. If a place does not have $1,000 in sales, a "point system" assigns dollar values for acres of various crops and head of various livestock species to estimate a normal level of sales. Point farms are farms with fewer than $1,000 in sales but have points worth at least $1,000. For farms with production contracts, the value of the commodities produced is used, not the amount of the fees they receive. The Economic Research Service, USDA defines a family farm as one in which the majority of the business is owned by the operator and individuals related to the operator by blood, marriage, or adoption, including relatives that do not live in the operator household. Since the inception of this definition in 2005, family farms have been at least 97% of all U.S. farms.
Farm Operator The Census and the FFS define farm operators as the persons responsible for the management decisions of the agricultural operation. The Census allows for up to three operators, without identifying a primary operator. For the TDP, the persons of reference are those who declare positive gross farm income or non-zero net farm income on their income tax return, accompanied by the statement of farming activities. Personal and family income data is only available for unincorporated farms, and the data set is limited to those with gross operating revenues of C$10,000 or more.	**Producer** It is the natural or legal entity that has the responsibility of the production unit's administration. It is the one in charge of decision making for the activities related to the production unit, it can be the owner or the leaseholder of the unit's land plots. Any person designated by the owner for decision making in the production unit is also considered as the producer or responsible.	**Farm Operator** The farm operator is the person who runs the farm, making the day-to-day management decisions. The operator could be an owner, hired manager, cash tenant, share tenant, and/or a partner. If land is rented or worked on shares, the tenant or renter is the operator. In the case of multiple operators, the respondent for the farm identifies who the principal farm operator is during the data collection process. See USDA, ERS (2013) for more information.
Land Area Census and FFS: Land area equals Land owned minus land rented to other plus land rented from others. Includes crop land, fruit trees, Christmas trees, summer fallow, pastures, woodlands and wetlands, and all other land.	**Land Area** Total area that occupies the area sum of the land plots that constitute the production unit. The area that the producer took as leased, borrowed, bartered or other. But the one the producer leased lent, bartered or other is excluded.	**Land Area** Land in farms equals Land owned minus land rented to other plus land rented from others. Includes crop land, fruit trees, Christmas trees, summer fallow, pastures, woodlands and wetlands, and land in farmsteads and with farm buildings. Excludes land rented on an AUM basis.

Canada	Mexico	US
Gross Farm Receipts / Gross Farm Revenues Census: Gross Farm Receipts consist of receipts from all agricultural and forest products sold, program payments, custom work receipts. It does not include sales of capital items (quota, land, machinery, etc.) or receipts from the sale of any goods purchased only for retail sales. Taxation Data Program: Gross Farm Revenues consist of livestock and crop revenues, program payments and insurance proceeds, custom wok and machine rental, rental income forest products, sand and gravel, sale of agricultural inputs and outputs bought for resale.		**Gross Cash Farm Revenues** Includes gross farm receipts of farming operations, including sales of agricultural commodities, farm-related income such as indemnities from insurance and income from farm recreational and agri-tourism, and government payments. For production contracts, the fee the grower received is included, but the value of the commodity removed is excluded.
Market revenues Market revenues are Gross farm receipts/ gross farm revenues less program payments.		**Market revenues** Market revenues include only the cash sales of crop and livestock commodities.
Program payments Available in the FFS and ATDP. Includes provincial crop, production insurance, AgriInsurance, AgriStability, other direct program payments, rebates (e.g. on hail insurance, fuel tax and property tax) subsidies, etc.	**Program payments** Includes all government support received to enhance production and natural disaster programs.	**Program payments** Includes all government payments received under commodity, conservation, and disaster programs.
Off-farm income Available in the Census as non-farm income linkage of Census of Agriculture and Census of Population provides accurate off-farm income. FFS data is less reliable because it is self-declared.	**Off-farm income** It should also be noted that, information on gross revenues and incomes are not included in Mexico's Census of agriculture questionnaire, so this information is not provided.	**Off-farm income** Includes earned and unearned sources of income for the principal operator and the principal operator's household. This item is not collected for the 2-3% of farms classified as nonfamily farms.

Beginning with the FCRS in 1985, ERS was permitted access to individual farm records to allow it to expand its program of research beyond what was possible from the published tabulations of the Census of Agriculture. This advancement has allowed researchers to engage in international comparative analysis, which requires that data sets be tailored to harmonize with the statistical conventions and systems of other countries.

While the available data sources differ in the three North American countries, in all rely on the census of agriculture as the foundation of their agricultural statistics programs. For comparative analysis, differences in the definitions used and limitations need to be kept in mind, such as for instance the inclusion of forested land and receipts of forest products (Box 1).

3. Comparative agricultural economic analysis

3.1 Farm type

In recent decades, agricultural markets and value chains have become increasingly integrated, including the Canadian, Mexican and U.S. agricultural markets, partly through the North American Free Trade Agreement (NAFTA). The North American Industry Classification System (NAICS) was developed by the statistical agencies of Canada, Mexico and the United States, against the backdrop of NAFTA. The NAICS is a production oriented classification system. It provides common definitions of the industrial structure and a common statistical framework to facilitate the analysis of the three North American economies (Statistics Canada 2012)[8,9].

The NAICS classifies businesses and other organizations that produce goods and services according to the similarity of production processes (Statistics Canada, 2012). The hierarchical structure of the NAICS divides the whole economy into 20 sectors (2-digit level)[10]. Agriculture is part of 2-digit sector "11," "Agriculture, Forestry, Fishing and Hunting", and consists of two 3-digit sub-sectors (Crop Production, 111, and Animal Production and Aquaculture, 112), which are in turn divided into eleven 4-digit "industry groups" and 34 "industries" at the 5-digit level. Up to the 5-digit level data are comparable among Canada, Mexico and the United States. An additional 6-digit level enables each country to separate specific industries that are of importance to that country[11].

Farms are classified based on the production activity that generates the majority of estimated production. Farms with diversified production are classified as "Other Crop Farming" or "Other Livestock Farming." The revenues received for

production of commodities other than the one that defines the farm is not separately accounted for.

In all three countries, there is no requirement that the agricultural activity is the dominant revenue generator for an enterprise to be included in agricultural statistics, and therefore the enterprise can fall into other NAICS codes. Rather, the requirement is that the enterprise satisfies minimum levels of agricultural characteristics, as described in the definition in Box 1. They are then included in the total number of farms (Canada, U.S.) and production units (Mexico). In Canada and the U.S., non-farm NAICS codes are not assigned to farms, because the Census in Canada does not gather information on non-agricultural receipts, and the U.S. census includes only questions of a limited number of other on-farm activities, such as forestry, on-farm value-added production (e.g. jams), and tourism. In Mexico, data enables identification of non-agricultural NAICS codes. In the 2007 census, the total number of agricultural production units included 20.9% that were engaged in the majority in non-agricultural activities (Table 2b).

In both Canada and Mexico, the largest group of farms are involved primarily in Oilseed and Grain Farming (1111), represent 30 % of all farms in Canada and 33% of all production units in Mexico (Tables 2a – c). In the U.S., the largest groups of farms were beef farming (30%). In Canada, oilseed and grain farmers also managed the largest share of agricultural land (48.8%), while in the U.S., farms specializing in Cattle Ranching and Farming managed the largest share of land (42.8%). In Mexico, most land was managed by production units that did not have the majority of their production from agricultural activities.

3.2 Farm size

Farm size using farm land area operated is a common classification system, which provides indication of the farm size distribution. Cross-tabulating land area with farm type provides an indication of the differences in production systems of commodities.

Tables 3a-c illustrate that while the distribution of farms according to size, as measured by land area, is similar for Canada and the U.S. for some farm types, beef, hog and dairy farms tend to have a larger land base in Canada than in the U.S., while poultry farms tend to have a smaller land base in Canada. In contrast, most Mexican farms are significantly smaller. Beef and dairy farms tend to be larger than the other farm types in Mexico.

Table 2a: Canada: Share of farms, their land area, share of gross cash revenues, commodity market revenues, program payments, and program participation rate, by NAICS code, 2007.

	Share of Farms [%] (1)	Share of Land [%] (1)	Share of Total Revenues [%] (1)	Share of Market Revenues (2)	Share of Program payments (2)	Percentage of farms receiving program payments (2)
1111 Oilseed and grain farming	30.0	48.8	35.7	34.4	57.4	68.2
1112 Vegetable an melon farming	2.3	1.0	4.2	3.9	3.9	62.5
1113 Fruit and tree nut farming	4.0	0.5	1.9	1.8	2.4	47.9
1114 Greenhouse, nursery and floriculture production	3.9	0.4	6.6	6.7	2.6	41.1
1119 Other crop farming	18.2	10.0	3.9	2.4	2.5	43.3
11211 Cattle ranching and farming	18.2	29.5	14.3	19.2	15.1	50.8
11212 Dairy cattle and milk production	5.9	3.3	12.3	12.0	3.7	69.4
1122 Hog and pig farming	1.7	1.0	8.1	8.2	8.3	77.4
1123 Poultry and egg production	2.2	0.4	7.8	8.0	1.2	37.6
1124 Sheep and goat farming	1.9	0.3	0.3	--	--	--
1129 Other animal farming (3)	11.7	4.8	5.0	3.4	2.8	36.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**57.9**
Totals, absolute values (4)	**205,730**	**64.8M ha**	**$60.6 B**	**$57.2B**	**$3.4B**	**99,670(5)**

Note: Highlighted boxes refer to the most frequently reported category.
Sources:
(1) 2011 Census of Agriculture, 2010 reference year
(2) TDP, 2011 Reference year
(3) Includes sheep and goat farming
(4) C$61.2B (Gross Revenues); C$57.8B (Market Revenues); $3.4B (Program Payments)
(5) The number of farms that received program payments in 2011 is a subset of the TDP file for the 2011 reference year, and therefore is not 57.9% of the 2011 census farms

Table 2b: Mexico: Share of production units, their land area, and program participation rate, by NAICS code, 2007.

	Share of Farms [%]	Share of Land [%]	Share of farms receiving program payments [%]
1111 Oilseed and grain farming	33.4	12.6	48.66
1112 Vegetable an melon farming	2.5	1.6	42.93
1113 Fruit and tree nut farming	10.2	3.5	35.81
1114 Greenhouse, nursery and floriculture production	0.5	0.1	22.31
1119 Other crop farming	5.7	4.6	31.31
11211 Cattle ranching and farming	5.7	30.6	51.33
11212 Dairy cattle and milk production	2.7	3.4	46.90
1122 Hog and pig farming	3.8	0.7	35.14
1123 Poultry and egg production	3.4	0.8	31.26
1124 Sheep and goat farming	4.3	1.3	44.69
1129 Other animal farming	6.9	2.6	53.13
11 Total	79.1	61.8	
Other NAICS codes*	20.9	38.2	13.02
Total	**100.0**	**100.0**	**37.77**
Totals, absolute values	**4,847,818**	**97.1 M ha**	**1,831,461**

Note: Highlighted boxes refer to the most frequently reported category.

* "Other NAICS" consists of the following: 'Production units with no agricultural activity' 16.47%; 'Exploitation of milk and meat cattle' (2007 NAICS code 112131), 0.01; 'Exploitation of cattle for other purposes' (NAICS code 112139), 3.86%; 'Collection of forestry products' (NAICS code 113212), 0.21%; and 'Felling of trees' (NAICS code 113310), 0.31%, Total 20.86%.

Source: VIII Agriculture, Livestock and Forestry Census 2007.

Table 2c: U.S.: Share of farms, their land area, share of gross cash revenues, commodity market revenues, program payments, and program participation, by NAICS code, 2011.

	Share of farms [%]	Share of land [%]	Share of gross cash revenue [%]	Share of commodity market revenues [%]	Share of program payments [%]	Share of farms receiving program payments [%]
1111 Oilseed and grain	14.6	29.4	37.0	37.0	51.9	84.3
1112 Vegetable and melon	1.5	0.8	5.2	5.3	1.1	17.7
1113 Fruits and tree nuts	2.9	1.0	6.9	6.8	1.3	11.7
1114 Greenhouse, nursery, and floriculture	2.3	0.3	3.8	4.1	0.2	5.9
1119 Tobacco, cotton, peanut, and general crop	22.6	13.3	8.6	7.5	23.4	48.4
11211 Beef cattle	30.1	46.7	15.1	15.1	15.0	25.6
11212 Dairy	2.5	2.3	13.8	16.0	2.9	59.9
1122 Hogs	0.8	0.6	3.3	3.3	1.3	36.2
1123 Poultry	2.4	0.7	3.6	2.4	0.9	13.0
1124 Sheep and goat	2.7	1.7	0.3	0.3	0.2	7.8
1129 General livestock	17.4	3.3	2.5	2.3	1.6	5.9
All	100.0	100.0	100.0	100.0	100.0	35.1
Absolute level	**2,172,843**	**365.0M ha**	**$299.5B**	**$247.6B**	**$8.0B**	**762,141**

Note: Highlighted boxes refer to the most frequently reported category.

Source: 2011Agricultural Resource Management Survey, ERS, USDA.

Table 3a: Canada: Distribution of farms by NAICS and land area, 2010 (per cent).

[ha]	1111 Grain & Oilseed	1112 Vegetable	1113 Fruit & tree nut farming	1114 Green-house & nursery	1119 Other crop farming	11211 Beef cattle	11212 Dairy	1122 Hog and pig farming	1123 Poultry & egg	1124 Sheep & goat farming	1129 Other farming	Total
< 2	0.1	10.2	9.0	19.3	9.0	0.9	0.8	7.9	19.1	6.9	6.1	3.1
2 to 5	0.2	14.6	25.0	21.9	25.0	2.2	0.5	6.9	22.7	14.4	11.6	5.4
5 to 20	2.5	18.9	29.0	24.8	29.0	5.0	1.0	11.3	20.0	21.0	20.8	9.5
20 to 50	11.1	17.5	19.1	17.3	19.1	12.1	7.0	18.1	14.2	25.4	22.5	15.3
50 to 100	15.5	11.7	9.1	8.6	9.1	17.4	24.5	18.9	10.2	18.4	18.0	17.8
100 to 200	16.6	9.4	5.3	5.0	5.3	17.7	38.4	17.3	7.5	9.5	10.2	16.6
200 to 500	21.5	11.0	2.8	2.4	2.8	20.7	24.0	14.0	4.9	3.7	6.9	15.8
500 to 1,000	17.9	4.2	0.4	0.5	0.4	12.7	3.1	2.7	1.1	0.5	2.4	9.2
1,000 to 2,500	12.4	2.2	0.2	0.2	0.2	8.0	0.7	1.8	0.2	0.1	0.9	5.8
2,500 to 5,000	1.8	0.4	0.1	0.0	0.1	2.1	0.0	1.0	0.0	0.0	0.5	1.1
> 5,000	0.4	0.0	0.0	0.0	0.0	1.1	0.0	0.2	0.0	0.0	0.3	0.4
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Total [thousands]	**61.7**	**4.8**	**8.3**	**7.9**	**37.4**	**37.4**	**12.2**	**3.5**	**4.5**	**3.9**	**24.1**	**205.7**

Note: Highlighted boxes refer to the most frequently reported category.

Source: 2011 Census of Agriculture.

Table 3b: Mexico: Distribution of production units by NAICS and land area, 2007 (per cent).

[ha]	1111 Grain & Oils seed	1112 Vegetable	1113 Fruit & tree nut farming	1114 Green-house & nursery	1119 Other crop farming	11211 Beef cattle	11212 Dairy	1122 Hog and pig farming	1123 Poultry & egg	1124 Sheep & goat farming	1129 Other farming	Other codes	Total
< 2	48.49	44.04	46.95	77.42	23.78	12.99	22.29	72.49	69.76	65.02	51.40	41.47	45.32
2 to 5	25.01	24.32	28.1	13.24	26.91	13.01	17.37	16.14	15.77	20.27	27.26	18.90	22.50
5 to 20	21.23	22.64	21	7.04	36.26	36.95	36.45	9.45	11.24	11.91	17.82	24.76	22.64
20 to 50	3.48	5.42	2.76	1.35	8.63	18.16	14.16	1.36	2.3	1.8	2.34	7.47	5.42
50 to 100	1.11	1.96	0.71	0.47	2.67	8.22	5.64	0.38	0.62	0.56	0.64	3.24	2.04
100 to 200	0.42	0.88	0.27	0.22	1.1	4.5	2.51	0.1	0.18	0.23	0.25	0.18	1.00
200 to 500	0.19	0.5	0.14	0.12	0.48	3.22	1.17	0.05	0.1	0.14	0.17	1.28	0.62
500 to 1,000	0.04	0.15	0.04	0.06	0.11	1.33	0.28	0.01	0.03	0.04	0.07	0.51	0.23
1,000 to 2,500	0.01	0.07	0.02	0.07	0.05	0.87	0.09	0.01	0.01	0.04	0.03	0.33	0.14
2,500 to 5,000	0.01	0.02	0.01	0.01	0.02	0.42	0.03	0	0	0.01	0.01	0.14	0.06
> 5,000	0	0.01	0	0	0.01	0.34	0.01	0	0	0	0.01	0.08	0.04
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Total [thousand]	**1,621.8**	**122.0**	**496.2**	**22.8**	**278.0**	**274.9**	**128.7**	**185.0**	**165.8**	**207.7**	**334,0**	**1,011.0**	**4,847,8**

Note: Highlighted boxes refer to the most frequently reported category.

Source: VIII Agriculture, Livestock and Forestry Census 2007.

Table 3c: U.S.: Distribution of farms by NAICS and land area, 2011 (per cent).

[ha]	1111 Oilseed and grain	1112 Vegetable and melon	1113 Fruits and tree nuts	1114 Green-house, nursery, and flori-culture	1119 Tobacco, cotton, peanut, and general crop	11211 Beef cattle	11212 Dairy	1122 Hogs	1123 Poultry	1124 Sheep and goat	1129 General livestock	Total
< 2	<1.0	12.0	10.8	19.3	1.5	0.6	<1.0	4.7	6.9	11.6	8.7	3.2
2 to 5	<1.0	24.4	22.5	28.0	7.0	4.8	1.4	20.6	17.1	23.3	20.7	9.0
5 to 20	6.5	29.6	31.7	32.8	26.7	20.9	4.5	18.8	33.6	36.6	42.1	23.9
20 to 50	14.9	13.2	15.1	11.6	30.6	24.7	17.5	14.8	21.6	17.7	17.6	22.1
50 to 100	17.0	8.0	8.7	4.7	16.8	19.1	26.1	13.1	9.7	5.9	6.9	15.6
100 to 200	17.9	3.1	6.6	1.4	8.9	13.7	28.4	7.9	6.4	0.9	1.9	10.8
200 to 500	25.2	6.7	3.1	1.8	4.8	8.3	17.8	14.0	3.5	2.5	1.6	9.1
500 to 1,000	10.2	1.7	0.8	<1.0	1.9	3.4	3.0	5.5	1.0	<1.0	0.3	3.8
1,000 to 2,500	6.1	0.8	0.5	<1.0	1.6	2.9	1.1	0.7	<1.0	<1.0	0.1	1.9
2,500 to 5,000	1.1	0.2	0.2	<1.0	0.2	0.9	<1.0	<1.0	<1.0	<1.0	<1.0	0.4
> 5,000	0.2	0.2	<1.0	<1.0	0.0	0.7	<1.0	<1.0	<1.0	<1.0	<1.0	0.2
Total	**99.1**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Total [Thousands]	**318.0**	**33.0**	**64.0**	**50.0**	**490.8**	**654.2**	**53.7**	**18.0**	**53.0**	**59.6**	**378.7**	**2,172.8**

Source: 2011 USDA Agricultural Resource Management Survey.

In Canada and the U.S., the majority of revenues are generated on farms with between 200 ha and 2,500 ha (Table 4a and 4c). These farms generate the majority of market income and also received the bulk of program payments. While in Canada and in the U.S., farms are more likely to receive program payments as land area increases (except for the largest U.S. farms), in Mexico farms with

Tables 4a: Canada: Share of farms, land area, gross cash revenues, commodity market revenues, program payments, and program participation, by farm size, 2010 (per cent).

[ha]	Share of Farms [%] (1)	Share of Land [%] (1)	Share of Total Revenues [%] (1)	Share of Market Revenues [%] (2)	Share of Program payments [%] (2)	Percentage of farms receiving program payments [%] (2)
< 2	3.1	0.0	3.2	2.3	2.4	16.9
2 to 5	5.4	0.1	2.5	1.6	1.6	13.5
5 to 20	9.5	0.4	5.4	4.5	4.6	17.6
20 to 50	15.3	1.7	6.5	5.8	5.9	27.1
50 to 100	17.8	4.0	8.3	8.4	8.6	35.2
100 to 200	16.6	7.6	12.1	12.1	12.1	44.4
200 to 500	15.8	16.2	17.5	17.7	17.6	52.7
500 to 1,000	9.2	20.6	14.6	15.1	14.9	57.5
1,000 to 2,500	5.8	27.1	17.8	18.5	18.2	59.8
2,500 to 5,000	1.1	11.3	7.9	9.3	9.4	50.4
> 5,000	0.4	11.1	4.1	4.8	4.7	65.2
	100	**100**	**100**	**100**	**100**	**100**
Total	**205,730**	**64.8M ha**	**$49.4B**	**$46.8B**	**$2.1B**	**42.5**

Note: Highlighted boxes refer to the most frequently reported category.

Source: (1) Census of Agriculture, 2010

(2) Farm Financial Survey, 2011 Reference year; farms with more than C$10,000 in gross revenues

(3) U.S. amounts are equal to C$50.9B (Gross Revenues), C$48.2B (Market Revenues), and C$2.1B (Program Payments)

Tables 4b: Mexico: Share of farms, their land area, and program participation, by farm size, 2007 (per cent).

[ha]	Share of Farms [%]	Share of Land [%]	Share of farms receiving program payments [%]
< 2	45.32	2.33	28.98%
2 to 5	22.50	4.04	44.24%
5 to 20	22.64	11.72	47.13%
20 to 50	5.42	8.57	44.78%
50 to 100	2.04	7.40	42.64%
100 to 200	1.00	7.09	38.89%
200 to 500	0.62	9.75	32.83%
500 to 1,000	0.23	7.96	29.27%
1,000 to 2,500	0.14	10.74	25.36%
2,500 to 5,000	0.06	10.21	25.84%
> 5,000	0.04	20.19	29.19%
Total	**100**	**100**	**37.78%**
Total	**4,847,818**	**97.1 M ha**	**1,831,461**

Source: VIII Agriculture, Livestock and Forestry Census 2007.

Tables 4c: U.S.: Share of farms, their land area, share of gross cash revenues, commodity market revenues, and program participation rate, by farm size, 2011 (per cent).

[ha]	Share of farms [%]	Share of land [%]	Share of gross cash revenue [%]	Share of commodity market revenues [%]	Share of program payments [%]	Share of farms receiving program payments[%]
< 2 hectares	3.5	<1.0	0.6	0.6	<1.0	1.1
2 to up to 5 ha.	9.7	<1.0	1.7	1.7	<1.0	4.1
5 to up to 20 ha.	24.8	1.7	4.4	3.8	2.2	15.3
20 to up to 50 ha.	22.1	4.4	5.7	5.1	5.5	31.7
50 to up to 100 ha.	14.9	6.3	6.9	6.7	7.7	44.5
100 to up to 200 ha.	10.3	8.7	11.0	11.1	11.1	61.2
200 to up to 500 ha.	8.5	16.0	23.5	24.4	23.4	73.0
500 to up to 1000 ha.	3.2	13.3	17.0	17.1	18.3	75.3
1000 to up to 2500 ha.	2.2	19.4	18.4	18.5	21.6	79.7
2500 to up to 5000 ha.	0.5	10.6	6.2	6.3	6.1	74.5
5000 ha. or more	0.3	19.5	4.6	4.7	3.7	52.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**35.1**

Source: 2011 USDA Agricultural Resource Management Survey.

between 2 and 100 ha are more likely to receive program payments.

These tables generated using available census and other micro-level data and the NAICS codes and land size as classification systems provide an initial comparison of the structure of the three agricultural industries.

3.3 Other collaborations on agricultural classifications

Access to farm-level data has allowed agricultural economists to collaborate across international jurisdictions to develop harmonized cross-country comparisons. This is especially the case for OECD countries, since several member countries have

access to micro-level, whole farm data bases. Canada, Mexico and the U.S. all collaborate as members of the OECD. Canada and the U.S., for example, collaborate on analysis of farm household income (OECD, 2003), asset capitalization of agricultural programs (OECD, 2008), the potential impact of climate change on business risk management (Kimura, Antón and LeThi, 2010), and agricultural risk management (OECD, 2011). Mexico has participated with the U.S. in comparative analysis of the impact of policy and trade reform on household income (OECD, 2006).

Related more specifically to farm structure, a variety of comparative research projects across select countries (e.g. Canada, U.S., Brazil) have been conducted, such as on cost of production as a mechanism for evaluating international competitiveness (Ahearn, Culver, Shoney, 1990), issues surrounding farm family income (Ahearn, Bollman, and Fuller, 1990), multiple job holdings among dairy farm families (Weersink et al., 1998), farm family dynamics (Kimhi and Bollman, 1999), farm structure (Hoppe et al., 2004), and the role of farm families in agricultural production (Poppe, Ahearn, Salvioni, 2009).

Canada and the U.S. have also developed multi-variate farm classification systems for farm-level analysis, while Mexico does not currently have such a classification system.

3.3.1 Multi-variate classification systems in Canada

AAFC developed its typology in the 1990s, to capture the characteristics of Canada's diverse farm sector and to better understand why particular subsets of farms behave differently than others. The AAFC typology classifies farms into more homogeneous groups based on five factors: organizational structure; age; dependence on off-farm income; total family income; revenue class. By capturing the life cycle or different business intentions among farmers, it is possible to explain some of the challenges facing particular subsets of farms and to develop policies that better target the needs of individual farms. The AAFC farm typology is similar in many respects to the Economic Research Service's (ERS) farm typology for the United States (ERS, 2001), see below.

The AAFC typology distinguishes first between family farms and non-family farms, i.e. communal operations, cooperatives and non-family corporations. Family farms are then distinguished between non-business and business-focused farms[12]. Non-business focused farms are determined according to total family income and age, while the remaining farms are considered based solely on their gross farm revenues. Analysis using AAFC typology shows that groups differ in their contributions to agricultural production, product specialization, program participation and dependence on farm income.

Analysis using AAFC typology has been used to analyze farms in their differences in contribution to agricultural production, farm income, program participation, investment, program payments and farm income to operators' family income and business goals (Niekamp and Zafiriou, 2000, Niekamp, 2002, Mitura et al., 2004)

3.3.2 Multi-variate classification systems in the U.S.

Farm structure classification systems in the U.S. have evolved as structural issues have evolved and data collection capabilities have been advanced. However, it is also remarkable how similar issues have been over time. Major farm classification systems have been advanced by NASS and ERS (and their predecessor agencies) based on the Census of Agriculture (the first one conducted in 1840 as part of the Sixth Decennial Census of Population) and farm-level sample surveys. Publications based on the Census data have featured a variety of farm classifications over the years. Early classification schemes were based strictly on single-variable farm criteria, such as farm size or the tenure status of farm operators. The 1930 Census featured farms classified by their commodity specialization, an early precursor to the NAICS.

As early as the 1935 Census, classification systems were based on farm household characteristics, as well as farm characteristics, and based on multiple variables. In particular, in 1935, the concept of part-time farming was recognized in the statistics and the volume featured a special article on part-time farms, defined as small farms with an operator who worked off the farm at least 100 or more days per year. The 1940 Census introduced a classification system based on the gross value of farm products which is a highly relevant system to this day. Bachman and Jones (1950) of the Bureau of Agricultural Economics (ERS' predecessor agency) published a report based on the 1945 Census where they classified farms based on the gross value of sales and introduced the terms part-time farms and nominal farms. Beginning with the 1954 Census and continuing until the 1974 Census, the major classification scheme was called the Economic Class of Farms. Under this system, large farms, called commercial farms, were further classified based on their gross value of sales and having an operator who worked less than 100 days

off the farm, and smaller farms were classified based on whether or not the operator worked 100 or more days off the farm or having off-farm income less than farm income. The term residential farm was also introduced with the 1954 Census and was defined as those with less than $250 in sales. In 1959, the classification scheme was modified to introduce age into the criteria so that commercial farms excluded those 65 years old or older, who were considered to be of retirement age. It also classified those farms with an operator of 65 years or more as a new category, labelled part-retirement farms. The 1969 Census began collecting data on production contracting on operations and raised new issues on how to classify farms by size who were engaged in production contracting and without market sales. In 1978, the multiple-factor Economic Class of Farms classification was dropped in favor of a simpler classification based solely on gross value of sales, including the value of commodities removed under production contracts.

Access of ERS to individual farm records data in 1985 and the expansion of farm household data in the early years of the Farm Costs and Returns Surveys opened the door for ERS to explore various alternatives for developing policy-relevant classification schemes. In 1991, using the newly-available farm household data Ahearn and Lee (1991) classified farms based on the major occupation of the principal operator and the major income source of the farm household (i.e., farm or off-farm income). Perry and Ahearn (1993) introduced the limited resource farm household categorization, again, made possible by access to the Farm Costs and Returns Survey. Having access to individual farm records meant that ERS recognized that some farms did not have a single household associated with it that would freely share household resources with the farm business since they were not closely held businesses and some farms had more than one household associated with the farm business. To address this issue, presentation of farm household well-being indicators from 1988-1990 classified farms as family farms (Ahearn, Perry and El-Osta, 1993). Rather than relying on age as an indicator of retirement status (as has been done since at least the 1959 Census), ERS added a question on the ARMS to ask whether or not the principal operator consider himself or herself retired from farming.

Based on the 1995 Farm Costs and Returns Data, ERS introduced a classification scheme in 1998 still used today, referred to as the ERS typology of farms, which was based on multiple characteristics of farm businesses and farm households used in previous classification schemes. The most defining farm characteristic in the classification scheme is farm size, measured as gross value of farm sales. Other variables included family farm identifier, major occupation of the principal operator, retirement status, and limited resource status. The ERS typology has been used in a variety of publications, such as the Family Farm Report series (see Hoppe and Banker (2010) for the latest) and occasional studies such as (Hoppe and Newton, 2001). Very recently, the ERS typology classification system has been updated in various ways, including dropping the limited resource farm category (Hoppe and MacDonald, 2013).

4. Discussion

Farm characteristics, as well as demographic, socioeconomic and regulatory conditions are continually changing, and therefore classifications must evolve to meet the policy challenges and the economic and structural changes over time to remain an effective tool for analysis. Individual countries have developed classification systems over time that meet the requirements of their domestic users, whether classification systems are based on single indicators of farm structure or multi-variate classification systems. Historically, basic farm classifications have largely been focused on the size and type of the farm income. For the multi-variate classification systems of Canada and the U.S., farm size based on gross sales has been used as one of the main variables.

Development of an inclusive classification system for North America will remain a challenge, as it must simultaneously recognize the policy, economic, and structural issues of the whole continent, as well as the data systems of each nation. At the same time, development of a useful classification system must look to the future and assess what the future needs are likely to imply for a classification system.

A case must be made in each country to allocate the resources to collect the necessary data to develop a harmonized classification system. Though challenges will continue, the integration of the economies through NAFTA has facilitated the progress towards an integration of our statistical systems that is very likely to continue into the future. Issues include availability and harmonization of farm financial information, given the importance

of an economic-based measure of size, i.e., based on gross sales. Furthermore, developing an integrated classification of national agricultural industries as different as Mexico compared to Canada and the U.S., in terms of current per capita productivity and the share of small subsistence farms, may very well provide some lessons for the development of a harmonized classification system for the world, with agricultural systems at every stage of development.

Bonnen (1977) identified systematic data deficiencies in agricultural economics; he suggested that these deficiencies arise from two main causes, (1) changes in the organization and nature of the agri-food industry, and (2) shifts in the agricultural policy agenda. Bonnen (1977) suggested that when the issue or question changes, it is often the case that the conceptual base of data is no longer completely appropriate and also that data critical to the new questions are not being collected. Evidence of this is found when we assess the data that is currently being collected against the backdrop of current policy agendas. These have broadened and increasingly focus on issues like competiveness, productivity, innovation and environmental sustainability.

For example, in the context of innovation, further empirical analysis is warranted to better understand farmers' decisions to innovate (Nossal et al., 2011). This could include the effort allocated to innovation, the adoption of innovations, and the impacts of these decisions on farm productivity. Certain farm characteristics have been previously identified as influencing innovation, such as age, education, farm size, and investment (Nossal and Lim, 2011; Sauer and Zilberman, 2009). However, these findings are based on how data is currently being collected. A more precise measure of innovation efforts would be preferable, along with the necessary data collection effort.

Environmental sustainability is another important emerging policy issue across international jurisdictions. In order for agricultural economists to address these policy needs, a better understanding of the drivers that motivate producers to implement environmentally sustainable practices is necessary (e.g. efficiency, regulatory, market, management of social licensing, supply-chain). Furthermore, information on the level of adoption is required. An added challenge in developing a classification system focused on environmental sustainability is the regional specific nature of environmental sustainability. Regional characteristics (e.g. soil properties, soil hydrology, air and water quality, climate) may play a larger role than farm-level characteristics. Previous research has shown farm characteristics like farm size, education, and soil zones were significant factors correlated with the adoption of environmentally sustainable practices (Smith et al., 2013). However, similar to research on farm-level innovation, these findings are based on currently available data resource, and may not capture the necessary characteristics. Developing proper linkages between regional characteristics and farm-level characteristics may help enhance our understanding of environmental stewardship at a farm level.

Given the increasing complexity of farms, classification systems that incorporate farm characteristics outside of size and type should be explored. There are several arguments for creating a classification system based on an integrated set of indicators. This type of classification offers a tool to synthesize and assess farm indicators as an integrated set rather than as single indicators, thus highlighting linkages among the various indicators of interest (Andersen et al., 2007). Most multi-variate classification systems include farm size, along with other variables often characterizing the personal characteristics of farm households, depending on the targeted goal of the classification system. Multi-dimensional classification systems recognize the linkages of farm business and farm household decision making and can therefore be an effective tool in policy design. Multi-variate farm classifications have been developed in the U.S. and Canada; however, they do not currently reflect the emerging policy issues such as innovative capacity or adoption of environmentally sustainable practices.

Freshwater (2012) suggests that for the most part, the data collected in the context of the agriculture industry seems 'trapped' in the use of the older concept of the family farm. While farms remain the basic production unit of agriculture, and the vast majority of farms are family owned and operated, they are now production units integrated into more complex decisions making environments. Also, while larger farms behave differently than smaller farms, they are both complex in their motivations and structures. This is evident when we incorporate for example factors like types of off-farm income into farm classifications. Multi-variate classifications systems allow us to dissect the large group of small complex farms into smaller more homogeneous groups, like business focused small farms, pension farms, lifestyle farm etc. To develop better information on how these farms

behave, it is necessary to think of them differently than in the past.

To be useful in a policy context, the data collected, as well as the farm characteristics included in farm classification, should be based on indicators identified as being relevant to policy discussion. To develop an effective classification that addresses these emerging policy issues, context is key. For example, if the purpose of a classification system is to analyze farmlevel innovation, it should be designed with this specific purpose of analyzing farms from an innovation standpoint. To do this, data specific to the issue of innovation is required, in addition to data that will provide insights into behavioural incentives for adoption. This is a challenging issue given that in many instances, such as when focussing on innovation and environmental sustainability, also data on production and regional characteristics are important.

The issue of data requirements is addressed by the World Bank, the FAO, and the United Nations jointly-produced publication "Global Strategy to Improve Agricultural and Rural Statistics" (FAO, 2010). The Global Strategy to Improve Agricultural and Rural Statistics assessment found a serious decline in the quantity and quality of agricultural statistics, which is occurring at the same time as many new data requirements are emerging. Among these emerging data requirements are those relating to global warming, land and water use, the increasing use of food and feed commodities to produce biofuels, poverty and food security. The evaluation also found a need to improve the coordination between national statistical organizations and the other national agencies that produce agricultural statistics (FAO, 2010). The focus of the Global Strategy was to identify the minimum core data that should be collected, but left unexplored the issue of farm classifications.

For Canadian and the U.S., broad set of data currently exist, which include detailed farmlevel data related to farm and farm operator characteristics, farm assets, liabilities, revenues, expenses, capital investments, capital sales and environmental practices. Nevertheless, in Canada the accuracy of certain variables, namely off-farm income and labor resources dedicated to agriculture, could potentially be improved. While environmental management information is collected at a farm level, this information is not collected in conjunction with demographic information, making it challenging to establish a classification based on environmental sustainability and farm characteristics. Currently, limited information is collected related to farm level innovation, and data that does exist tend to focus on specific activities, which may not be applicable to all farm types (e.g. conservation tillage practices). These shortcomings could potentially be addressed by improving linkages across data resources (i.e. Census of Agriculture and other surveys). In this way, the information collected could be used more effectively, particularly in the absence of longitudinal data.

In Mexico, within the context of the national statistical system, it is difficult to collect information on variables related to revenues, farm assets, liabilities, capital investments and profit margins for the agricultural production units due to the characteristics of these units, as well as producers' socio-demographic conditions. This has been highlighted in the different census editions that have been conducted since 1930. For this reason, the classification criteria of the production units used in Mexico so far have been the NAICS, the size in terms of area and the type of unit: agricultural, livestock and forestry. However, in order to support both the development and evaluation of public policies, multi-variate classification alternatives are being analyzed, considering labor, purchase of machinery and the volume of production, among other variables. INEGI is initiating the development of an Agricultural Information System, which will consist of the Agricultural Census, a Continuous Survey System and Administrative Registers. This system will aim to meet the current and emerging major demands of information. In addition, Mexico is working with FAO in the implementation of the Global Strategy. These Mexican challenges will take time to address, but progress is being made in the right direction, so that in the future there may be additional information for additional classifications.

To achieve a harmonized classification system across jurisdictions will require collaborative efforts to ensure that the data requirements are met. A harmonized classification system would facilitate cross country comparisons and add context to discussions pertaining to the structure and performance of agriculture across regions. It could facilitate the identification of best management practices across regions, and identify similarities which might otherwise be overlooked at first glance.

The current approach under the FAO's World Programme for the Census of Agriculture (2005) places emphasis on conducting agricultural censuses within the framework of the system of integrated

agricultural censuses and surveys and in the broader context of the national statistics system. The programme recognizes the high cost of conducting an agricultural census and emphasises the coordination of the agricultural census with other censuses, especially the population and housing census, which can result in considerable cost savings and added value (FAO, 2005).

In Canada, Mexico and the U.S., efforts are currently under way to reduce the cost of data collection, reducing response burden especially for large farms, and the search for efficiencies without impacting the usefulness of data collected, for monitoring and policy analysis.

5. Conclusion

While farm structure and policy environments differ among Canada, the U.S. and Mexico, all three countries aim to increase the productivity, innovative capacity and environmental sustainability of their agricultural industries.

An effective way to analyze these emerging policy issues is to use farm-level classification systems. The most common classification systems for farms are typically based on size, or production type. An example of this is NAICS, which is based solely on the main type of production of a farm. Perhaps, the next most basic classification that could be developed is a classification of farms based on size, measured as gross sales or revenue, rather than land area as is compared here. Moving beyond a land area measure of size is especially important for a harmonized classification system across countries because of the great diversity in the climatic and resource characteristics of land. Moreover, looking to the future, multi-variable classification systems, including those that link farm and household characteristics, developed with current policy priorities in mind, would provide more in-depth insight.

As agriculture continues its path to global integration, the value of harmonized farm classification systems across borders may increase. However, the cost of data collection and data discrepancies across international jurisdictions are challenges. The use of administrative data and targeted surveys may facilitate access to the data required to develop farm classifications that are effective tools to address current policy questions and analyze industry trends at the farm level, but these sources of data also interject definitional differences that must be overcome in a harmonized system.

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Endnotes

1 Farm classifications are also frequently referred to as farm typologies. In the context of this report, it will refer to classification.

2 The Annex has been removed due to space restrictions. The complete paper can be found at the conference website.

3 NAFTA followed the Canada-US Free Trade Agreement, which had become effective January 1st, 1989. NAFTA was signed under the General Agreement on Tariffs and Trade (GATT) framework; the purpose was to liberalize and increase trade between the three partners beyond what would be possible under the most favored nations (MFN) status of GATT, and later the World Trade Organization (WTO). NAFTA and the WTO were negotiated roughly around the same time, and consequently, in the vast majority of cases, NAFTA provisions are in line with the various WTO Agreements.

4 Due to market support to dairy, poultry and egg producers through the supply-management system in Canada.

5 The Assurance Systems stream will support the development of Canadian national assurance systems and standards, such as food safety systems, animal and plant health surveillance systems, market attribute/quality standards and traceability systems, and their related tools.

6 U.S. census data will be released in February 2014.

7 Program administrative data refers to data collect from producers apply for support programs. For example, under the current suite of programs, program administrative data is collected for participation in the Business Risk Management programs.

8 The NAICS aims to also maintain cohesion with the International Standard Industrial Classification of All Economic Activities (ISIC), and international efforts are under way towards greater harmonization with the European classification system, NACE (Nomenclature statistique des activités economiques dans la Communauté européenne (Statistics Canada, 2012).

9 Canada, Mexico and the U.S. established the North American Tripartite Committee for Agricultural Statistics (NATCAS), which consists of representatives of the three statistical agencies. Its objectives are to develop and publish North American agriculture and agriculturerelated statistics and to promote the adoption of common classification systems and standards. http://webpage.siap.gob.mx/.

10 While the NAICS uses the terms "sector" and "industry" very specifically in the hierarchical classification of production activities, this paper uses the terms for the most part interchangeably.

11 In agriculture, Canada and the U.S. have specific industry 111211 for potato farming, while Mexico designated that code for tomato farming. In addition, Canada has 111993 for combination fruit and vegetable farming and 111994 for maple syrup and products production, while the U.S. classification has specific industries 111991 sugar beet farming and 111992 peanut farming. Mexico has additional codes 112131 for cattle raised for both milking and meat production and 112139 for cattle raised for other purposes, which includes working cattle, cattle for bullfights or bull-riding, as well as other purposes not considered in other NAICS codes.

12 Non-Business-Focused farms categorized in the following order: First, *Pension Farms*, which are farms with revenues less than $252,524 (C$249,999) in gross farm revenues managed by an operator 60 years of age or older and receiving pension income, with no children involved in the day-to-day operation of the farm; *Lifestyle Farms*, which with revenues of less than $50,505 (C$49,999) managed by families with off-farm income greater than $50,505 (C$50,000); *Low Income Farms*, which have with gross farm revenues of less than $252,524 (C$249,999) managed by families with total income below Canada's Low-Income Measures. The remaining farms are Business-Focused Farms, which are grouped according to gross revenues, in the ranges of less than $101,009 (C$99,999, *Small Business-focussed*); $252,524 (C$249,999 *Medium Business-focussed*); $505,049 (C$499,999, *Large Business-focussed*); and $505,050 and more (C$500,000 *Very Large Business-focussed*). More recently, the category of *Million-dollar farms* has been added in some analysis recognizing the significant differences in the *Very Large Business-focussed* group.

IDCB 6

Reconciling Data and Integrating Systems

Organizer and chair: Jacques Delincé, EC - Joint Research Centre

Agricultural statistics are part of the wider national statistical plan what should ensure full coherence among the different sectors of the economy in term of the national accounts system. Reconciling the various datasets and integrating the different sectors imply working rules covering the time and space aspects, integrating the whole agri-food chain components and linking the agriculture sector to the rest of the economy.

Possible topics for papers include: coherence in agriculture statistics: role of the national strategy for the development of statistics; forward and backward linkages in Agriculture; Agricultural Social Accounting matrices; integrating international statistical databases for agricultural modeling.

Papers:

- Pratap Narain (India), “Integrated System for Food and Agriculture Decision Makers”
- Vladimir Bougay (USA), Ayca Donmez (Spain), “Global Agriculture Repository & Africa Food Price Volatility Project”
- Vladimir Eskin, Sophie Hélaine, Robert M’barek (Belgium), “DataM – Integrating Global Agricultural Datasets”

Integrated System for Food and Agriculture Decision Makers

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Abstract

Need for a coherent and sound data base for policy making and decision taking on food and agriculture related issues was recognized while creating Food and Agriculture Organization of the United Nations (FAO). FAO, recognizing this need, developed food balance sheet in 1949 to bring together data on food supply and production for individual country. This basic work was subsequently developed by release of the publication "Agriculture sector accounts and tables: a handbook of definition and methods" in 1956, "Handbook of Economic Accounts for Agriculture (EAA)" in 1974 and a "System of Economic Accounts for Food and Agriculture" (SEAFA) in 1996. While the 1956 publication was developed to standardized definitions and improving methods of collecting food and agriculture data, the EAA introduced concept of national accounting for improving quality of data and providing macro information to policy makers. SEAFA was designed to meet analytical needs for the formulation of plans and policies relating to food and agriculture by integrating various databases on production, consumption, capital formation relating to crop & animal husbandry, forestry, fishery and food production.

SEAFA provided support for analyzing efficiency of production of food and agricultural products and evaluating supply and use of food to determine people's level of nutrition. Main objectives of agricultural policies go much beyond this. Policy makers would very much like to look into ways and means to secure improvements in the production and distribution of food and agricultural products which could lead to improving the living condition of rural population. Some of these issues have been discussed at various international forums. However, to make a dynamic decision making it is necessary to integrate all issues in a single envelop.

Basic architecture of SEAFA is based on production units viz. institutional units (like agricultural households), agricultural establishments and food & agricultural products. This approach does not allow linking other issues like infrastructural needs, state of environment, etc. to the production system. In the present paper a revised extended system based on area as a unit for compiling the database has been proposed. The new system based on micro-macro linkage using bottom up approach for collection, compilation and analysis of food and agriculture data. The system propagates use of indicators. The approach has in-built advantage of optimum use of partial data.

Keywords: UNSNA; integrated system; food & agriculture.

1. Introduction

Need for a coherent and sound data base for policy making and decision taking on food and agriculture related issues was recognized while creating Food and Agriculture Organization of the United Nations (FAO). FAO, recognizing this need, developed food balance sheet in 1949 to bring together data on food supply and production for individual country. This basic work was subsequently developed by release of the publication "Agriculture sector accounts and tables: a handbook of definition and methods" in 1956, "Handbook of Economic Accounts for Agriculture (EAA)" in 1974 and a "System of Economic Accounts for Food and Agriculture" (SEAFA) in 1996. While the 1956 publication was developed to standardized definitions and improving methods of collecting food and agriculture data, the EAA introduced concept of national accounting for improving quality of data and providing macro information to policy makers. The System of Economic Accounts for Food and Agriculture (SEAFA) is a decision support tool for use of economic planner and policy makers dealing with matters related to food and agriculture. The system is based on System of National Accounts. SEAFA was designed to meet analytical needs for the formulation of plans and policies relating to food and agriculture by integrating various databases on production, consumption, capital formation relating to crop & animal husbandry, forestry, fishery and food production at national level. The system provided following types of data:

- production, productivity and income accruing from the activities of agriculture, forestry, fisheries and food production;
- input and labor required for carrying out these activities;

- consumption pattern and food habits, along with nutrient content of the food;
- status of infrastructural development related to agricultural and food production activities and their financing requirements.

SEAFA, continuing from earlier efforts, provided a limited support for analyzing issues relating to agricultural production and food consumption. Main objectives of agricultural policies go much beyond studying efficiency of production of food and agricultural products and evaluating supply and use of food to determine people's level of nutritional intake. Policy makers would very much like to look into ways and means to secure improvements in the production and distribution of food and agricultural products which could lead to improving the condition of rural population. An analysis like this would cover issues relating to infrastructural developments, conservation of natural resources (land, soil and water), use of improved technologies, state of labor force engaged in agricultural activities (particularly unpaid family labor and women). These issues have been raised in various international forums and are becoming increasingly important in today's state of development. The present paper goes into details of needs of policy makers & economic planners and suggests an information system for creating an integrated database that provides linkage between cause and effect.

2. Recent developments

Agriculture is primary source of food. Forty-eight percent of total population of the world lives in rural areas, of which ninety two percent belongs to the developing world. In general three fourth rural population depend on agriculture. In many poor developing countries, primary activities such as agriculture still constitute the backbone of the economy. Agriculture is also a major stakeholder for maintaining sustainable ecosystem. These facts have always remained centre of policy maker's interest and to improve the situation there has been a persistent demand of data.

Narain (2001) has recognized that two major new issues, namely, the need for a comprehensive approach for environmentally sound and sustainable economic development and the right to have access to safe and nutritious food, were raised at three important World Summits organized in early nineties. The first issue which was debated in the seventies and eighties was raised at the 1992 United Nations Conference on Environment and Development (Earth Summit) in the form of Agenda 21. This agenda highlighted the need for a comprehensive approach for environmentally sound and sustainable economic development. The second issue was recognized at the 1996 Copenhagen World Summit for Social Development (the Social Summit) and the 1996 Rome World Food Summit (Food Summit).

The **Earth Summit** was convened to address urgent problems of environmental protection and socio-economic development. Environmental statistics are multidisciplinary. They include a large set of physical databases on climate (solar energy and light, water, wind, heat & temperature), flora, fauna, etc. which are collected using various techniques and methods for a comparative analysis of their impact on the ecosystem and the social, demographic and economic conditions of the people. In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

At the **World Food and Social Summits** it was recognized that world population is growing and steps need to be taken urgently for eradicating hunger and malnutrition. The World Food Summit declared that "Poverty is a major cause of food insecurity and sustainable progress in poverty eradication is critical to improve access to food. Conflict, terrorism, corruption and environmental degradation also contribute significantly to food insecurity. Increased food production, including staple food, must be undertaken. This should happen within the framework of sustainable management of natural resources, elimination of unsustainable patterns of consumption and production, particularly in industrialized countries, and early stabilization of the world population."

WFS recommended that a more complete and user-friendly sources of information at all levels shall be put together to foster greater efforts in this area. In order to do this, the Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS) concept was established to provide accurate and timely information relating to agriculture, health and ecosystem to enable the better assessment of the current situation of food insecure and vulnerable people, for the design and evaluation of possible policies and interventions, and for monitoring purposes. The immediate objectives of FIVIMS (Annex A) at the national level are:

- to increase national and international attention to food security issues so that they receive higher priority in policy and program formulation;
- to provide reliable, quality, and timely national and sub-national food security related data;
- to enable multi-sectoral analyses through better integration of complementary information components;
- to promote better use of information through better understandings of users' needs;
- to enable effective information dissemination for FIVIMS advocacy and implementation; and
- to improve users' access to information through networking and sharing.

Major thrust of the WFS/FIVIMS as well as the Social Summit was on food for total population as a whole and did not make direct focus on agriculture. The multi-dimensional nature of the follow-up to these Summits includes actions at the national and international levels. These actions are related to people and institutions engaged in agricultural activity and the ecosystem. At the end of nineties and beginning of third millennium UN jointly with other international agencies initiated two major programs, in these initiation OECD remained at the centre. The two initiatives are "**Partnership in Statistics for Development in the 21st Century (PARIS21)"** and **"Statistics, Knowledge and Policy: OECD World Forum on Key Indicators"**.

The PARIS21 was founded in November 1999 by the United Nations, the European Commission, the Organization for Economic Co-operation and Development, the International Monetary Fund, and the World Bank, in response to the UN Economic and Social Council resolution on the goals of the UN Conference on Development. PARIS21's vision is to reduce poverty and improve governance in developing countries by promoting the integration of statistics and reliable data in the decision-making process. The effort is dedicated to encourage a better use of statistics in developing countries, by providing support and strengthening their National Statistical Systems through improved coordination between data users, producers, policy-makers. In partnership with FAO, technical support (software and guidelines) is being provided to help all countries document and archive all the resources of their most recent agriculture censuses.

"Statistics, Knowledge and Policy: OECD World Forum on Key Indicators" addressed key issues for the development of modern democracies including: the transparency and accountability of public policies; people's abilities to understand the characteristics and the evolution of their societies; and the role of the media in developing fact-based knowledge among citizens. All these issues require a special effort by modern societies to develop high quality statistics, to develop a shared knowledge about the state and the development of the society and to build accountable decision-making processes based on reliable statistical evidence either through traditional economic accounts based on GDP to capture the environmental or social concerns or by way of a composite indicators of wellbeing or by identifying a certain number of key indicators covering economic, social and environmental domains.

In all these initiative, although data on agricultural and rural areas are needed, no specific efforts were made to integrate various databases to the decision making process. At the beginning of the third millennium, therefore, member countries have the primary responsibility for creating an economic and political environment that assures the sustainable maintenance of the global ecosystem and provides food security to their citizens. Agriculture is at the centre of both of these issues. The Agricultural statistics system needs to be geared up to meet this new demand. Going a step further from earlier efforts two significant steps have been taken in the last decade.

In 2003 the Inter-secretariat Working Group on Agriculture and Rural Indicator (IWG.AgRI)[1] created a Task Force on Rural Development Statistics and Agriculture Household Income which drafted a proposal entitled **"Handbook on Rural Households' Livelihood and Well-being: Statistics on Rural Development and Agriculture Household Income"** in 2007 which was also accepted by the UN Statistical Commission and designated it as **"Wye Group"** proposal. Among many important conclusions drawn by the Group, some of the important one included – (1) For collecting important statistics a shift is required from a sectoral to a territorial policy approach to improve coordination and integrate various sectoral policy issues, (2) increasing use of partnerships between public, private and voluntary sectors for speedy implementation of policies measures, (3) area specifics characteristics need to be considered for preparing policies, and (4) giving

importance to agriculture is essential in framing rural development policies. The Group has gone into many critical issues for framing concepts and definitions for collection and compilation of data. The basic work done by the Group is a step in right direction but at many places details included are predominately related to developed countries.

Another step in the same direction is Development of Global Strategy to improve Agricultural and Rural Statistics prepared jointly by the World Bank, FAO and UN Statistical Commission in 2011. ***"The Global Strategy to Improve Agricultural and Rural Statistics"*** provides the framework essential to meeting the current and emerging data requirements and the demands of policy makers and other data users so that they can fill these urgent needs. The conceptual framework presented in the Global Strategy brings together the economic, environmental and social dimensions of agriculture to monitor how the well-being of households is determined by the productivity of agriculture, the land they use and the environment they share. The work received strong support by donors and regional Commissions/ International bodies.

The Global Action Plan has recognized three pillars, i.e. establishing a minimum set of core data, integrating agriculture into national statistical systems, and importance of governance and statistical capacity building, for building a sound foundation for decision makers. Comprehensive documents have been prepared on action plan to cover aspects like, country assessments, minimum set of core data, technical assistance plan, training plan, research plan, process to implement the Global Strategy, indicative budget and timeline and monitoring, evaluation and reporting.

In the same period some efforts[2] were also made to compile economic and environmental accounts for agriculture. These attempts have linked physical or monetary data on agri-environment related to economic accounts. In actual practice it is not always possible isolate each and every expenditure/ physical assets at the sectoral level. Furthermore, scope of decision making on each issue does not fall under the preview of decision makers working on agriculture. This is truer for developing countries.

Yet another issue which has been discussed at length in last three decades and is equally important is the role of women in agriculture and rural development. The monitoring of gender related social processes generally concerns inequalities in the distribution of resources between women and men or unequal outcomes of equivalent efforts. This issue has been raised in the many international conferences such as World Conference on Education for all (WCEFA, Jomtien, Thailand 1990), UNECD - Earth Summit on environment (Rio de Janeiro, 1992), World Conference on human rights (Vienna, 1993), International Conference on population and development (Cairo, 1994) and Fourth World Conference on Women (Beijing, 1995). All these forums have discussed the issue from their perspective. Role of Women in agriculture and rural development are very wide, and need careful examination to identify the issues and linkages. They relate to increased demands on female labour; changing sex roles and responsibility for farm management, gender differences in access to resources, including land, water, credit and technologies; time use, etc. These matters have considered in detail by the FAO, IFAD, etc. However, it is essential to integrate this aspect also with the other issues.

It goes without saying that the hard work done in the last 10 to 12 years is of immense value, but one question remains – for whom? Who needs this system? Does a decision maker sitting in a remote developing country realize importance of such a system? And last but not the least, if external support is withdrawn can a country continue to maintain this system.

3. Information system needed by the food and agricultural decision makers

The fundamental purpose of decision makers making policies relating to the food and agriculture have been set out in the Preamble of the FAO Constitution, which affirms the determination of Members "to promote the common welfare by furthering separate and collective action on their part for the purpose of:

- raising levels of nutrition and standards of living of the peoples under their respective jurisdictions;
- securing improvements in the efficiency of the production and distribution of all food and agricultural products;
- bettering the condition of rural populations;

and thus contributing towards an expanding world economy and ensuring humanity's freedom from hunger (FAO – Basic Text)". A system that would meet

these requirements efficiently need data to carry out development, measure impacts of various policies and prepare plans for efficient use of scared resources by taking into account the social, economic and environmental factors. These three components include:

A. Development

- ***Input needs of the sector***: ensure availability of agricultural inputs needed by the sector to guarantee plant nutrition and maintain soil fertility.
- ***Technological developments:*** encourage adoption of improved production technologies with respect to the utilization of labor, capital and natural resources (land and water).
- ***Resource monitoring:*** improved availability of credit.
- ***Human resource development***: strengthen human resources (education, training and extension services) and institutional capacity.
- ***Social welfare:*** improve nutritional and health status and food quality.
- ***General economic growth:*** monitor needs for overall infrastructural development (roads, storage facilities, infrastructure for agro-industries, etc.) to induce rural development.

B. Impacts of various policy measures

- ***Agricultural policy analysis:*** living standards of the population dependent on agriculture, terms of trade between agricultural and non-agricultural households, price behavior of agricultural products and subsidies, grants and taxes related to the agricultural sector, generation of employment opportunities, development of agro-industries.
- ***Linkages between agricultural activities and the ecosystem:*** contribute to the development of irrigation systems that induce changes in the cropping system and improve the general environment.

C. Allocation of increasingly scarce natural resources

- ***Land and soil:*** initiate programmes for land conservation and rehabilitation.
- ***Biological diversity:*** provide resources for conservation and improvement of plant and animal genetic resources.

These issues have been discussed at various forums and suggestions have been made for collection and compilation of data. The basic questions about these suggestions are – (a) Do each country requires same set of data? (b) Why these proposals are not acceptable for a longer period? and (c) Why the program stops as soon as external support is withdrawn? Simple answer to all these questions is – all proposal/suggestions made are top-down and not bottoms-up. Countries do feel that all these information are generally available in most of the countries. Efforts are required to update and review the basic data and assumptions. Further, it generally believed that this information is required either to review macro-economic situation in the country or for international community to monitor current trends and do not answer what policy actions are required for inducing development in the country. For a more acceptable proposal it is necessary to build a data base that could reveal **cause and effect relation** at grass root level. This calls for a bottom-up approach.

Basic architecture of the integrated system would, therefore, start from bottom most units that are linked to national level macro aggregates/ accounts. For formulation and successful implementation of economic plans and polices relating to agricultural production and distribution information/data are needed on - (a) economics of agricultural production units, (b) pattern of land use, (c) economic activity of the people living in the area, (d) status of infrastructure in the area, and (e) status of agricultural resources (land, irrigation system, etc.,). Study of the later type needs geo-referenced database on agricultural resources for direct linking policies and program to the place of action. In the present paper a new system has been proposed which is based on area as a unit for compiling the database.

The system is created as a three tier set with accounts (recommended by SNA) and supporting statements. While the socio-economic data are common, data on natural resources (climate, soil and water) differs from one unit to other depending on the agro-climatic zone to which the unit belongs to. This system enables statistician to economize on resources needed for collection of data on natural resources that may also sometime need special high-tech scientific methodology and instruments. This system provides basis for “cause and effect analysis” suitable for the area. An over view of the system is given in Annex B. The system assumes existence of three tier government having a regional and local level.

This, however, depends on size of country. Integrated system is described below:

1. For creating internationally comparable consistent database the system is based on basic concepts given by UNSNA[3]. Concepts and definitions given by the UNSNA have been supplemented with the concepts given in the SEEA as well as the concepts and classifications of natural resources (land and soil degradation, agro-climatic zone concepts, etc. that are used by agriculture scientists).

2. The system uses concepts of regional accounts and satellite analysis to inter-link various databases. Keeping in view complexity of creating integrated accounts that includes environmental aspects and status of infrastructural support, satellite analysis has been included which link economic statistics to the physical data-base. The approach has added advantage of providing direct information on issues requiring attention. Analysis does not go to indirect measures based on prices, taxes, subsidies which generally considered by the Ministry of Finance etc. keeping in view numerous other activities that may not be related to agriculture.

3. Collection compilation and presentation of food and agriculture data on production, consumption, infrastructure for units of land area which are predominantly agriculture[4] in nature. This is slightly different from rural area. Generally rural areas are determined by number of people living in the "administrative" land area. However, the proposed unit can be treated as a sub-set of the rural area.

4. The system proposes integration of geo-referenced data collected in socio-economic surveys & censuses, remote sensing data and administrative data (See Kabat, at. al. 2000 for further details). The system proposes use of multiple frames based socio-economic surveys as well as remote sensing data. For making the system cost effective use of small area techniques have been proposed.

5. The system propagates use of indicators originating from economic and environmental accounts as well as suggested by other studies. The set of indicators includes general purpose indicators on growth, share, etc.; agri-environmental issues; nutritional status; productivity; levels of living of agri-households; gender main-streaming; terms of trade; infrastructural development at national, regional and local level required for decision making. The system would be having micro-meso-macro level linkage for deciding inter-se priorities. The approach has in-built advantage of optimum use of partial data, even if sufficient/reliable data on all aspects of the economy are not available to compile a full sequence of accounts.

6. To bring out role of unpaid family workers and women in agriculture (which is a common issue in developing countries) use of "Time use surveys" has been included.

7. At national level the system is initiated with Supply and Use Table that has been linked to Accounts for Institutional (Corporate, NPI, households) Units, Agricultural Establishments related to agriculture activity, Satellite Accounts for Food Balances. In addition to this, data on work force, land use[5] and current status of infrastructural development supplement the module as recommended by the SEAFA (see Annex C).

8. At the second level data are compiled on agricultural institutions and establishments. Types of institutional units to be considered in the context of regional accounts are given in SNA 2008 (paragraph 18.47).

9. Data base are build at the third (local) level which is the basic unit for decision making. Data on natural resources are collected based on agro-climatic zone (FAO 2003[6]) in which the unit is located.

Such an information system that could provide support to decision makers in the formulation of policies requires large amount of statistical data relating to (a) economic forces (e.g. production, input, prices, wages, food consumption, macro-economic aggregates, aids and assistance) (b) human resources (population, labour force) (c) natural resources (soil, water, climate). One of the common constraints for creation of such a system is that the various data components used in the system need lot of resources, both in terms of funds as well as technical manpower and equipments. Apart from that collection and processing of data is time consuming process. It is therefore suggested that to give a start, a few local areas may be selected and work may be initiated as a pilot project to illustrate success story.

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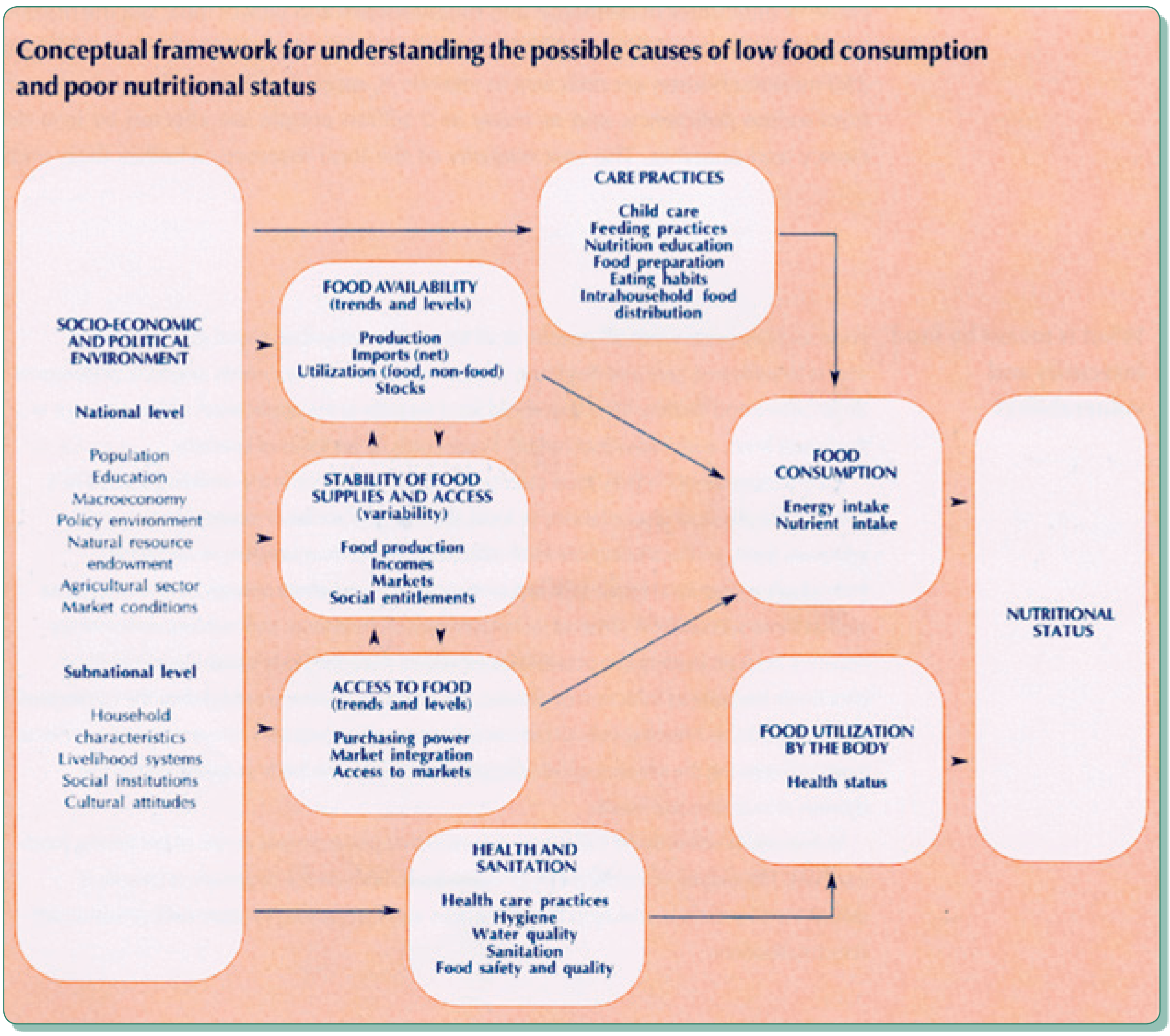
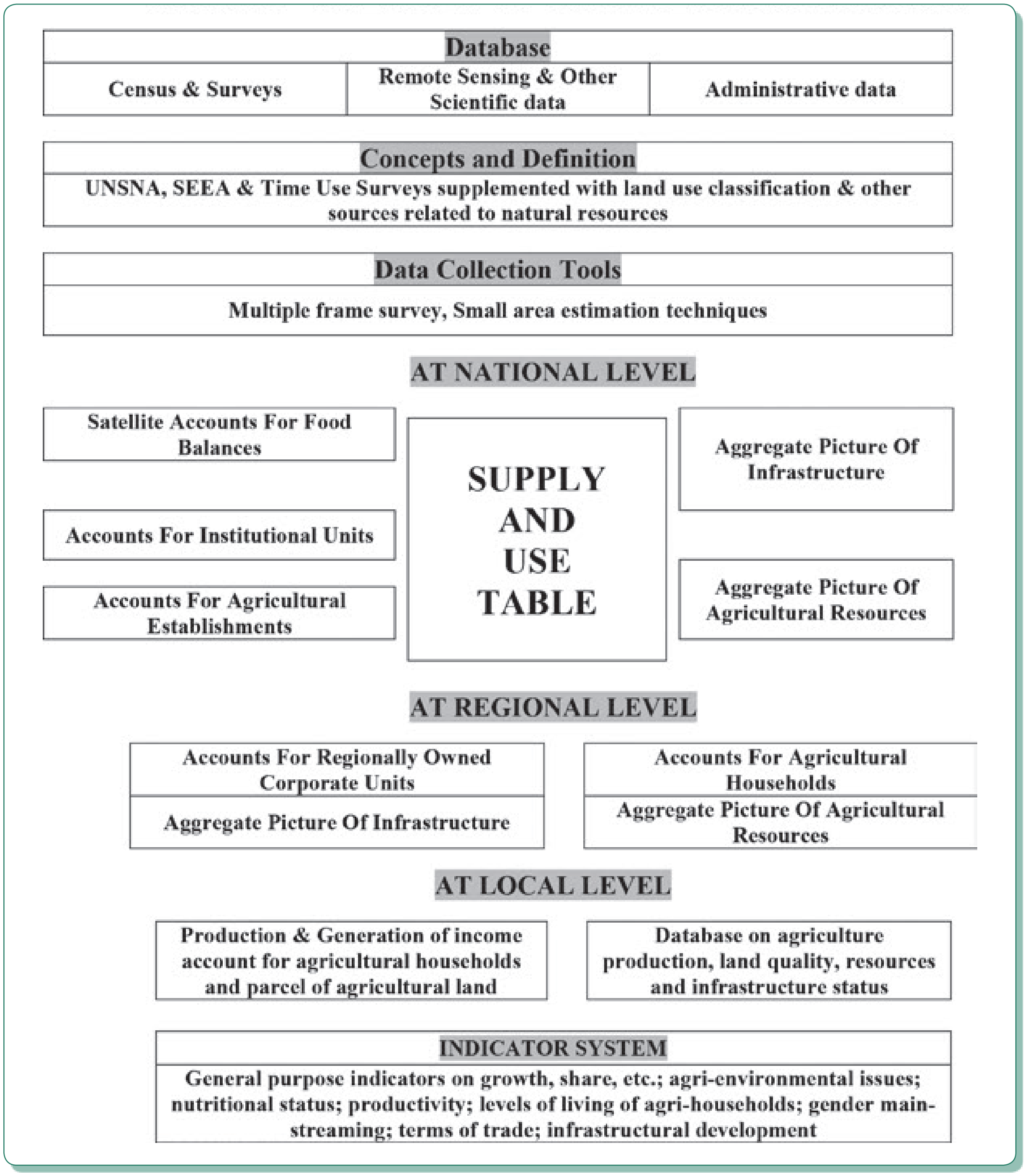
Annexes

Annex A: National FIVIMS.



Annex B: Overview of the Integrated System.



Annex C: Integrated System For Collection And Analysis Of Food And Agricultural Data.

A. FOCAL UNIT OF ANALYSIS	AGRICULTURAL PRODUCT	AGRICULTURAL HOLDING	AGRICULTURAL INSTITUTION
B. COVERAGE	Principal agricultural products and their by-products resulting from economic activities under ISIC 01	Principal agricultural products and outputs of secondary activities performed at the holding whether agricultural or non-agricultural	Total economic activities of all agricultural institutions – household, corporate or government – whose major share of income originates from agricultural activities
C. DATA	Area, production, trade (export and import), utilization (final and intermediate), prices, nutrient content	Area, outputs, inputs, capital and labor used in production, seed variety, details of soil management and farming practices	Income, expenditures, outputs, inputs, capital and labor used, consumption, assets and liabilities, socio-economic and demographic data, taxes and subsidies
D. USES	Total agricultural production Distribution of production by commodity, region, type of institution, agro-climatic zone Index number of production, inputs and prices Input-output projections Studies of nutritional intake of the population Economic indicators	Productivity studies, production functions, capital-output ratios, input-output coefficients Economic and environmental indicators Impacts of agricultural adjustments and government policies ABC analysis of research and extension priorities and personnel development plans	Studies of living standards of population dependent on agriculture Studies on poverty and food security Framing of government policies relating to taxation, prices and subsidies Studies of terms of trade Formulation of macro-level models
E. TOOLS	**SEAFA:** Goods and services account Satellite accounts for food balances and supporting statements Supply and utilization account Food balance sheet Input-output table	**SEAFA:** Production, generation of income, capital accounts and supporting statements Input-output table	**SEAFA:** Production, generation and distribution of income, capital accounts and supporting statements Multi-subject (integrated) household surveys

Annex D - Comprehensive Land Use Classification - Extract

1. Total Area (Total area of the country including area under water, etc.)

1.1 Area not in use (excluding areas that were in use once, but are no longer in use due to degradation, etc.)

1.1.1 Land area

- Land under glaciers and perpetual snow and other land (not elsewhere classified)
- Land under vegetation (closed forest areas)
- Land under desert

1.1.2 Land under water (Area under tidal water)

1.2 Area in use for undertaking economic activities

1.2.1 Land area

- Land under single use (details as per concepts given by ISIC)
- Land under multiple use[7]
  - Net land area under use
  - Gross land area under use (Details as per concepts given by ISIC)
  - Intensity of use [(b)/(a)]
- Land not in use due to degradation
- Other land area (not elsewhere classified)

1.2.2 Land under water (Area under water)

- Land under water in single use (details as per concepts given by ISIC)
- Land under water in multiple use[1]
  - Net land area under water in economic use
  - Gross land area under water in economic use (Details as per concepts given by ISIC)
  - Intensity of use [(b)/(a)]
- Land under water not in use due to degradation
- Other land under water (not elsewhere classified)

In building these associations, one can easily use principles laid down in ISIC for classifying activities into principal, secondary and ancillary activities and their association to the owner of the unit. To meet the needs of multiple users, one may consider taking ISIC classes and superimposing other details at the second level. For example, in the case of crop husbandry, detailed data may also be required on area under different crops or characteristics of soil for considering specific issues[8] like soil degradation/ erosion due to wind, water and sedimentation, water logging, salinization, shifting cultivations.

The classification based on such a framework would be:

- Fully compatible with ISIC. As many users are familiar with ISIC, the system would be simple to understand and flexible to incorporate needs of different stake-holders.
- Fully compatible with FAO's land cover classification and could be used for projecting changes in land cover vis-à-vis land use.
- Independent of legend required by different stake-holders. It would be possible to aggregate data on different scales and mapping units.
- Able to facilitate analysis of impact of different economic activities as well as impact of nature's vagaries on areas under land and water.
- It would be feasible to super-impose further details according to user's need to support better land use planning.

This framework would also provide a correspondence between land and labor and capital employed, as well as with the goods & services produced. However, in order to attempt such a classification, it would be necessary to undertake further inter-disciplinary work to define appropriate classes and guidelines for deciding boundary line issues.

Endnotes

1 Members of the Group are United Nations Economic Commission for Europe (UNECE), Organization for Economic Co-operation and Development (OECD) the Food and Agriculture Organization of the United Nations (FAO) and the Statistical Office of the European Community (Eurostat).

2 (a) Manual Environmental and Economic Accounts for Forestry: a tool for cross-sectoral Policy Analysis, FAO Forestry Department Working Paper (2004), (b) Integrated Environmental and Economic Accounts for Fishries, Studies in Methods, Handbook on National Accounting, United Nations & FAO of the United Nations (2004), (c) Integrated Environmental and Economic Accounts for Water Resources, United Nations Statistics Division (2006), (d) Integrated Economic and Environmental Accounts for Agriculture – Etienne Verhaegen, Hilde Wustenberghs, Ludwig Lauwers and Erik Mathijs (Belgium - http://www.unece.org/fileadmin/DAM/stats/documents/ces/ac.61/2004/wp.48.s.e.pdf), (e) Towards a System of Environmental Economic Accounting for Agriculture (SEEA-AGRI), (ref: http://unstats.un.org/unsd/envaccounting/ceea/meetings/UNCEEA-6-27.pdf).

3 Use of SNA format enhances consistency and supports geo-referenced analysis of various databases in one framework. In the proposed framework, the total structure is based on Supply and Use Table as recommended by the UNSNA (UNSNA 2008, paragraph 29.21) and production units are grouped to show elements of the production account and generation of income account. As recommended by SEAFA, these accounts are compiled for institutional units, establishments (especially agricultural households) and parcels used for producing agricultural products to study their cost of production and income generation aspects. To support this analysis and analyzing income accrual and use of capital, some supplementary accounts have been proposed in the SEAFA.

4 The term “agriculture” is used in a broad sense to cover agriculture, forestry, fisheries, land and water, agro-industries, environment, manufacturing of agricultural inputs and machineries, regional and river development, and rural development.

5 Present classification of land use is not suitable for proper land use planning. A more dynamic classification is required for the present purpose. For further details see Narain (2010)/Annex D.

6 It has been recognized that while some countries are facing problems in selecting appropriate indicators to meet their requirements, others are finding it difficult to define the type of data needed for compiling indicators. This Handbook addresses these issues. Just to illustrate procedure for selecting indicators it has considered four agro-climatic regions (Fragile ecosystem of mountain areas, dry region, high rain fall fertile region and arid to semi-arid region with highly developed irrigation system). The Handbook also provide support for analyzing data by indicating the relevant level at which an indicator could be used.

7 In the final operational classification, it would be useful to classify areas under two activities (activity relates to ISIC concepts) and more than two activities.

8 Over the last two decades the Land and Water Development Division (AGL) FAO has been at the forefront of the development and application of computer-based systems to analyze data and generate information to support decisions on various land and water issues. Separate soil and land and water systems (such as: AEZ - Agro-Ecological Zoning System, SDBm - Multi-Lingual Soil Database, SOTER - Soil And Terrain Database, DSMW - Digitized Soil Map Of The World, FAO/ITC Land Use Database, ECOCROP 1 - Crop Environmental Requirements Database, ECOCROP 2 - Crop Environmental Response Database, WOCAT - World Overview of Conservation Approaches and Technologies, DTIPNS - Database Tool for Integrated Plant Nutrition Systems, MCDA - Multi-Criteria Decision Analysis techniques, CLIMWAT - Climatic Database, CROPWAT - a computer program for irrigation planning and management, SIMIS - Scheme Irrigation Management Information System) have been developed. The soil and land systems focus on methodologies and tools for the assessment of land resources potentials at global, regional and national and sub-national levels. The water systems concern irrigation water use and management at field level and water resources assessment at regional and national levels. For summary please refer to “Information technology and decision-support systems in AGL – Background Paper” prepared by J. Antonie, Soil Resources, Management and Conservation Service, Land and Water Development Division, FAO, Rome, Italy In: Proceedings; World Soil Resources Reports (FAO), no. 89; Sub-regional Workshop on Land Resources Information Systems for Food Security in SADC Countries, Harare (Zimbabwe), 3-5 Nov 1999, p. 9-14.

Global Agriculture Repository & Africa Food Price Volatility Project

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Abstract

Global Agriculture Repository is a part of Knoema knowledge platform, which brings different agricultural datasets from across the world and related data-driven visualizations into a single, easy to use and navigate web site. Researchers, journalists and analysts could use this repository as an ultimate resource for agriculture statistics. One of the important parts of Global Agriculture Repository is Africa Food Price Volatility project.

Africa Food Price Volatility is a joint project of the European Commission's Joint Research Centre - The Institute for Prospective Technological Studies (IPTS) and Knoema. The aim of the project is to explore the possibility and challenges of crowd-sourced food price data collection in Africa using modern web-based tools and technologies. Agricultural commodity prices are started to be collected on a weekly basis in three African countries (Kenya, Ethiopia, Zambia) by a network of people on the field; reviewed and submitted into centralized data repository using web-based crowd sourced data platform. As a result, high-frequency food price database has been built. This paper describes the challenges faced during the initial phase of the project, remedial actions taken and the future plans for the improvement of the data collection process.

Keywords: data; data visualization; food prices; Africa; crowdsourcing; data collection; agriculture.

1. Introduction

A common exercise for statisticians, economists and researchers from various disciplines is to search for agricultural statistics from many different resources. Most of the time those exercises end up with a significant amount of time and energy consumption. Typically, one has to search for and find the required dataset first, then extract the data and combine it from multiple sources. Global Agriculture Repository is a solution for this problem since it allows people to find data and data-driven content on agriculture in a single place.

The Africa Food Price Volatility (AFPV) project is one segment of Global Agriculture Repository and its focus is on food price data in developing countries. Economic and social stability is an important ingredient of a developing world. The large swings in food prices have an impact on domestic food chains and food systems globally. In most cases, magnitude and consequences of food price volatility vary substantially across and within countries. Those variations stem from a variety of factors including geographical differences, patterns of food production and consumption, and differences in institutional capacities to implement alternative policies. The impact in developing countries (particularly amongst the poor ones) may need special care because of the need for accessing to affordable healthy diets and adequate nutrition; overall to conserve food security. In order to mitigate the adverse consequences, including food instability risks, associated with the volatility in food prices, appropriate evidence-based policy responses are often required. The effect on the welfare of consumers and households as well as the extent of that effect can be examined empirically when the required data is available.

In developed countries (such as US, EU, etc.), food price data, which serves as the basis for tracking and analyzing food price volatility, are often captured comprehensively in a detailed/disaggregated way of high frequency while it is also reported in a timely and accurate manner. Those already existing and well established periodic data collection systems supply required environment for conducting empirical analysis of price volatility.

As a striking contrast, in developing countries, particularly in Africa, there is a paucity of timely and accurate food price data with high frequency[1]. As a result, drawing a reliable picture of food price volatility to inform policy makers can be a difficult task to accomplish. The AFPV project is an attempt to address that gap in agricultural commodity price datasets. The IPTS and Knoema are working together in the AFPV project in order to build a high frequency dataset of agricultural commodity prices in Africa.

While feeding food price data series, the objective is also to gain a first insight into the differences between crowdsourcing and the classical data collection techniques and to understand if crowdsourcing with the support of ongoing technological improvements provides reliable results. In crowdsourcing, the tasks are directly outsourced to individuals by soliciting their contributions (Howe, 2006; Brabham, 2013). Therefore, the algorithm behind solicitation should be studied carefully in order to adopt for qualitative changes and reach certain levels of data quality. Unlike on paper survey studies, which have been tested numerous times, it is not too far in time from now that this new technique with applications on modern technological instruments (PCs, tablets, mobile-phones) has been started to be utilized. Hence, the algorithm behind the application is still being questioned (Kleeman, Voss and Rieder, 2008; Ipeirotis and Horton, 2011). Among various areas of applications of crowdsourcing[2], collection of price data is an emerging application. Hamadeh et al. (2013) can be presented as one of rare examples on this specific topic in which the results on the pilot study of crowd-sourced price data collection support that there are various types of problems that can be faced and modifications on the design and operation may be both needed depending on the characteristics of the topic and target geography.

2. Global Agriculture Repository

Global Agriculture Repository, a part of Knoema knowledge platform, has two integral parts interlinked together: Agriculture Hub and Agriculture Data Atlas.

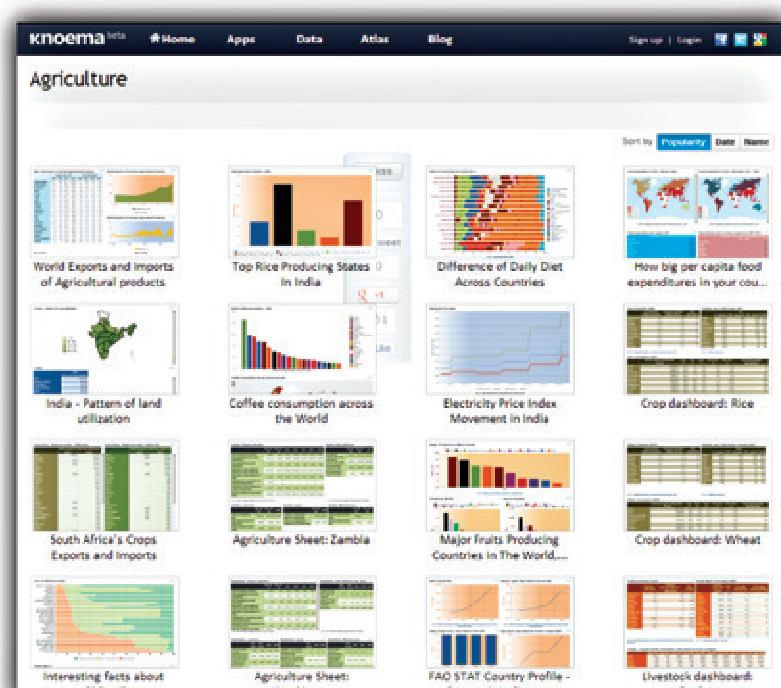
2.1 Agriculture Hub

Agriculture Hub is a collection of datasets and visualizations on agriculture at Knoema, which could be found at the following locations:

- Visualizations - http://knoema.com/tags/Agriculture
- Datasets-http://knoema.com/data#topic=Agriculture

More than 50 datasets and 100s of ready-to-use visualizations are available for users. Users can explore available data, visualize and analyze quickly, create their own visualizations, share them and even make them public and available for other users. Agriculture Hub home page is shown on Figure 1. In addition, users can upload their own data into this hub, mash public and private data, perform cross-dataset analysis and make comparisons. Finally, all presentations could be shared online or exported into various output formats such as PPT, XLS, PDF.

Figure 1: Agriculture Hub screen.



2.2 Agriculture Data Atlas

Agriculture Data Atlas is a web-based tool for providing essential information about the state of agriculture in different countries around the world by few clicks. Agriculture Data Atlas can be found at http://knoema.com/atlas#Agriculture.

Agriculture Data Atlas provides access to the following tools:

- Country profiles
- Interactive maps
- Country rankings
- Commodities

Under country profiles, users can reach essential information about selected country; such as key indicators, links to official web sites for NSO and government, access to detailed indicators and related datasets and visualizations.

In interactive maps and country rankings, users can compare all countries for selected indicators. For instance; as shown in Figure 2 users are able to list top 5 and bottom 5 countries, tabulate specific statistics, and visualize how they change over time.

Finally, users can access detailed statistics of any country-indicator combination that enables comparison of countries side by side, exporting and visualizing the data in the format of their choice.

Figure 2: Agriculture Data Atlas screen.

3. Africa Food Price Volatility project

The Africa Food Price Volatility project is a pilot study on crowd-sourced price data collection across African countries. Weekly price data is collected on selected agricultural commodities in three countries – Kenya, Ethiopia and Zambia – as a key precondition for price volatility analysis. In each country, data is collected from the largest urban commodity market place and one typical rural commodity market. The data collection which is targeting urban commodities focuses on the capital cities and considers the largest or one of the largest markets in those capital cities.

During the initial phases, the AFPV data collection exercise did not seek to capture detailed individual and household characteristics or any institutional or higher level economic, social,

demographic, geographic (including climatic and environmental), political and other such factors. Instead, it is focused solely on the collection of high frequency (weekly) food price retail (spot) data. It is important to mention that the AFPV project has not being finalized yet and the continuous data collection is going to be run for 6-9 months in total. Ultimately, the project aims to deliver a credible methodology for cost-effective collection of high frequency food price data.

As presented in Figure 3, the project relies on a web-based software (Knoema) for data collectors to submit their data into centralized data repository. Data submission screen can be seen in Figure 4. Submitted data passes review from moderator and after approval goes into weekly price database. The software supports submission of price data in local currencies, automatically converts it to USD based on current exchange rates so data can be easily compared across different countries.

3.1. List of commodities

The selection of commodities is based on:

- Staple grains
- Staple foods
- Key protein sources
- Key mineral and vitamin sources

The products that are on the International Comparison Program (ICP) product list are particularly selected. The list of commodities is presented in Annex A.

For every product, a set of common measurement units was defined together with consultants. For example, for white rice there are 1kg, 2kg and 500g units. Data collectors can specify a price for any unit. Then system calculates price for a base unit (like 1 kg) automatically.

3.2. Data collection

The following approach has been used to collect food prices data:

- For the initial stage of the project, three data collectors were hired in three countries. In addition, there is one moderator who oversights entire project and data submissions.
- Data collectors were trained on data collection software usage via teleconference.
- Every week data collectors go to the corresponding markets (1 urban and 1 rural) and collect food prices information on the ground and insert the data into price sheet.
- Data collectors submit data from price sheets into the web based system using Internet connection available in large cities.
- Moderator reviews each submission and either approves it or rejects with comments.
- Approved submissions go into electronic database from which data can be downloaded or reused via API.

4. Status, challenges and solutions

The project started in April, 2013 and has been running for 5 months. It is scheduled to last 6-9 months. At the initial stage, the pilot for the software is finalized. Some corrections were needed and currently the project has been running in autopilot mode requiring minimum oversight for the last two months. The collected data can be downloaded up-to-date in various formats. In addition, an interactive dashboard is available to observe data collection status as demonstrated in Figure 5.

4.1 Data quality

The quality of resulting data is a primary concern for this project and some quality issues were mainly observed during initial stages of the project. At the beginning, all submission went directly into electronic database without additional verification. Such an approach was vulnerable to human mistakes because people could simply put number in a wrong field or omit some digits in input value. We introduced two measures to mitigate such issues:

- When data collector enters the data, the system automatically checks input values and compares them with past data to identify sharp jumps. If the difference between the previous entry and the current entry is more than 50%, the system blocks submission and allows data collector to take corrective action or submit value anyway providing a comment. In most circumstances, the prices do not change more than 50% over a week, therefore, it can be used as a reliable check and helps to prevent from various human mistakes.
- The moderator reviews each submission manually and can reject it if it is needed.

Figure 3: The home page screen of the AFPV.

Figure 4: Data submission screen.

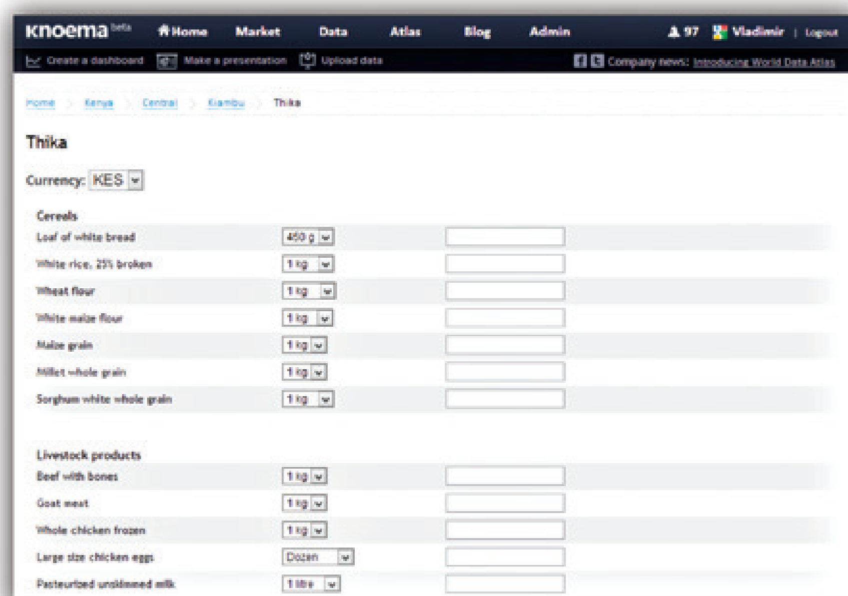


Figure 5: Interactive dashboard with project outputs.

4.2 Currency adjustment

There were two different problems faced related to the currency. First one is related to the submission of data into the system, which is possible both in local currency and in USD. Initially, USD was the default choice for submission; however, prices are collected in local currency. It is observed that some data collectors missed switching to local currency and as a result they ended up by submitting incorrect numbers. In order to mitigate that problem, the default choice was changed from USD to local currency.

Second currency related problem is specific to Zambia. During the course of the project, Zambia experienced denomination of its currency Kwacha. The old currency ZMK was discontinued effectively starting from July 1, 2013 and new currency ZMW that is ZMK/1000 has been introduced. Data collector from Zambia has submitted data in a new currency once without corresponding exchange rate adjustment, which leads to incorrect data submitted into the system. Moderator recognized this issue and reached us for clarification on how to handle such situation. Finally, the specific submission was adjusted manually once to accommodate for old currency and new currency was introduced into the system for subsequent submissions. The resulting dataset was not affected by this.

4.3 Stable data collection cadence

Initially, data collectors went to markets on different weekdays therefore there were fluctuating submissions and outputs. Although it was not a major problem, they were asked to collect all samples on Fridays so that regular weekly updates on the same day can be applicable across all locations.

5. Data Collection Platform

Knoema is a generic crowd-sourced data collection platform well integrated to the rest of its data and visualization tools. It serves to various companies and organizations in conjunction with network of data collectors and participates in its global initiative for collecting and aggregating data on various topics/requests on a worldwide scale. Moreover, it provides data to interested parties through Knoema platform.

In general, this service provides a capability for companies/organizations to request a data to be collected for specific indicators/regions, executed via data collection platform provided by Knoema and then delivered to respective customer(s) on a regular basis via standard Knoema data dissemination tools.

5.1. Data collection projects

Any data collection activities at Knoema are organized around data collection projects. Data collection project is a combination of scope, geography, people and activities representing specific collection project or task.

5.2 Basic functionality

Each project has its scope or collection of categories/indicators defined at its creation, geography or locations where data will be collected and participants doing actual work of collecting and submitting data. Also each data collection has its frequency set as daily/weekly/monthly/quarterly or annually. Multiple participants can do submissions for the same combination of indicators/locations within each collection period.

Submissions will be aggregated across time and geography locations based on the rules set for the project and the final dataset will receive only single aggregated value for a combination of indicator/location/period.

Multiple data collection projects could be run simultaneously and managed independently. Data collection projects have integrated security features so project owner/admins could define whether the project is public and private and who can view and submit data.

5.3 Data dissemination

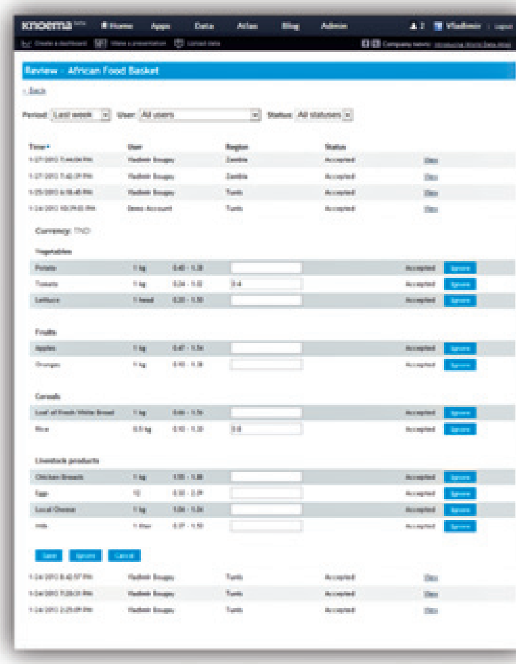
For every collection project the system automatically creates a standard dataset with locations/indicators as defined in the project scope. This dataset is being updated automatically according to collection frequency so it always contains up-to-date, cleaned and aggregated data from the project. This dataset can be further used in all Knoema data visualization and analysis tools or simply downloaded by people having access to it.

5.4 Data quality and review tools

Data collection projects provide integrated tools to control data quality and review submissions both automatically and manually.

Project administrator can enable automatic submission monitoring to detect outliers and sharp jumps with a certain threshold set (Figure 6). When automatic submission monitoring is enabled the system will analyse each every submission and flag suspicious values for the user submitting data and project admins.

Figure 6: Review tool.



Project administrators can review all submissions in the system and take actions on it such as correcting values, ignore certain submissions or even ban users consistently providing problematic data.

5.4.1. Automatic outliers' detection

There is an option in project settings to enable automatic detection of outliers in submissions. Once enabled every user's submission goes to outlier check tool, which is using 3-sigma rule. For any given indicator within current collection period system, the system accumulates all submitted values in a set and passes 3-sigma rule check on it. If outliers are detected, they are flagged as suspicious values and submission is being blocked until user corrects value or overrides check explicitly.

5.4.2. Automatic sharp jumps detection

Another automatic validation option available in project settings is sharp jump detection. Once enabled by administrator every user's submission goes into corresponding check tool. The system compares submitted value with the value (if any) received for the same indicator in the previous collection period and automatically flags submission as suspicious once certain threshold set by administrator was exceeded.

5.4.3. Manual reviews

In addition to the automated checks as described in previous sections, project administrators are allowed to perform manual reviews on submitted data. There are different options for reviewing: all/only suspicious submissions, submissions from specific user and submissions in a certain period. For every submission, it is possible to see exact values submitted and adjust or ignore them. Entire set of submissions can be ignored as well.

6. Future developments

The AFPV project has passed its first important milestone which proved that low data collection in Africa using web-based technology is possible. The project team is considering the future development in the following directions:

6.1 Extending the number of inputs for the same commodity

Currently, we are working on enlarging the team of data collectors. It is planned to introduce redundancy into the collected data and for every location collect data by multiple, independent data collectors. This will introduce additional quality check because it would be possible to compare prices for the same location/date, detect outliers and reduce human factor by calculating average values out of data collected for the same commodity at the same market. Note that the collection of data through crowd-sourcing may require additional control mechanisms (especially the payment algorithm for data inputters) on the crowd and it should be examined carefully.

6.2 Extending geography

As we mentioned earlier the data collection happens in three African countries now. It is planning to extend it to a few more countries in the near future and in a mid-term, across entire African continent (all countries) with a support of African Development Bank (AfDB).

6.3 Extending the series

This study can be considered as a pilot for the collection of a larger dataset; larger both in time and in geographical dimensions. As already mentioned, the pilot targets first the development of the new software and its applications. It was not aimed to capture detailed individual and household characteristics or any institutional or higher level economic, social, demographic, geographic (including climatic and environmental), political and other such factors at the very beginning. However, in order to use the collected data efficiently in the econometrical and statistical analysis, additional information is planned to be collected; starting from the quantity of items sold that week, for instance.

6.4 Data collection via mobile phones

Mobile phones are becoming an important daily instrument for people in Africa to be in connection with the society and to get access to information. In fact, majority of Internet users in Africa are mobile-based smartphone and feature phone users.

It is planned to develop mobile version of data collection software in order to enable more people (while empowering the crowd) participating in the project and minimize the period in between the time of the data entry and the time that the data becomes available to use. Since the number of steps to insert the data into the system also lessens, mobile-phone applications are expected to minimize the error in data entry[3]. During the following phase of the project, data collection is going to be conducted partly using mobile technology.

7. About JRC-IPTS and Knoema

7.1 JRC-IPTS

The Institute for Prospective Technological Studies (IPTS) is one of the seven scientific institutes of the European Commission's Joint Research Centre (JRC) (http://ipts.jrc.ec.europa.eu). Its mission is to provide independent, evidence-based scientific and technical support to the EU policy-making process while considering both socio-economic and technological dimensions. The Agriculture and Life-sciences in the Economy Unit (AGRILIFE) of the IPTS specializes in the development of the agricultural sector; especially rural development, food security, trade and technological innovation in the EU and globally. The scientific support on those areas is supplied by the development of advanced economic modelling tools and statistical methods including easy data access.

7.2 Knoema

Knoema is a knowledge platform and public website on Internet (http://knoema.com) which provides

end-to-end experience for data users from data access to data analysis to content building to sharing/dissemination.

Knoema collected over 2000 datasets and more than 100M time series on various topics in a single place and provides a very convenient search engine on top of it. It gives instant results to users' queries for data.

Users can build tables/charts very quickly, download data in Excel format, save data views and share them with friends. Knoema allows for creation of highly visual, interactive dashboards. Users can build their own dashboards with combination of tables, charts, maps and text supporting a specific story they are trying to tell. These dashboards can be shared to other users through the web or social networks, exported to Excel/PowerPoint, embedded to blogs or external web sites. Users can upload their own data into Knoema through Dataset Upload tool, visualize it and create data "mashups" from public and their private data.

8. Conclusions

Global Agriculture Repository is a useful resource for researchers, journalists and analysts on agriculture statistics. Users could explore various agricultural datasets and related visualizations in a single place, download and export data, locate necessary information quickly.

Africa Food Price Volatility project is a successful attempt to collect near real-time, high frequency and high quality data on food prices in Africa using web-based technologies. For this project, web-based crowd sourced data collection platform was developed and utilized for data collection in three African countries: Kenya, Ethiopia and Zambia. The resulting dataset is available on the system and it is downloadable.

During the course of the project, the project team faced several challenges mostly related to the new software. However, the problems were all resolved and the new web-based interface for data collection started to work properly.

The ultimate objective of the study should be considered in a wider aspect. The welfare loses at both ends of the market chain (producers and consumers) can be ameliorated by decreasing the level of asymmetry in information acquired by producers and costumers. Especially when Africa is considered, rural and urban populations' access to information is an important factor to consider. The markets that are farther apart, farms which are linked by unpaved roads, many (small) farmers having no regular sense of communications between each other and global markets are just a sample of causes of information asymmetry in Africa. Passing the price information in rural and urban markets correctly to the farmers can help making the pricing structure more robust and less volatile. Studying the ways of sharing the information is surely an important part of that system. However, before all, improving the accessible information at hand should be the first lesson to complete. With the help of the high frequency and timely collected food price datasets, that kind of an improvement can be achieved in a less costly way.

The objective of this exercise is to be helpful in solving food security problems. Overall, collection of high frequency data (having weekly rather than monthly as in many studies on the topic) is an important step to improve the information retrieved from price analysis. With the help of the high frequency data, we will be able to capture the differences in local prices of the same commodity in different geographical locations faster, examine the relationship of the prices of not only related commodities in the same market but also competing commodities in the same or different markets. That analysis is going to be done through Granger causality tests and regression analysis. When the required size of data collected, panel data analysis may be helpful for us to study such relationships while considering the differences in time and location. At the end, we will be able to decide whether prices in different markets are affected by each other or not; if it is so, how much they are affected and how long it takes to observe that effect (in other words, if there is any time lag or not). Given that we will be able to build a longer time series of price data in more locations, it will also be possible to question whether there exists a long-term relationship between the prices among markets. Those questions are all referring to the pattern followed by agricultural commodity prices and it is mainly shaped by trend and seasonal components. Therefore, the following step is to search for the ways of using the high frequency timely data in price prediction models in order to be useful to inform the policy makers in a timely manner while they are fighting for food security problems.

Annexes

Annex A: List of products

Cereals
Cereals
Loaf of white bread
White rice, 25% broken
Wheat flour
White maize flour
Maize grain
Millet whole grain
Sorghum white whole grain
Livestock products
Beef with bones
Goat meat
Whole chicken frozen
Large size chicken eggs
Pasteurized unskimmed milk
Fish products
Bream fish
Nile perch
Vegetables
Vegetable oil
Onion
Round tomato
Green cabbage
Sweet potatoes
Spotted beans
Flavours
White sugar
Cooking salt

Annex B: The list of markets and details on types and locations of those markets

Ethiopia

Consultant: Befekadu Gashaw
Town: Addis Ababa
Urban Market: Merkato Market located in Addis Ketema sub-city of Addis Ababa.
The exception will be a few products that will be collected at specialized shops namely Shoa,
Lydia and Shisolomon Supermarkets.
Rural Market: Weslo and Ambo markets

Kenya

Consultant: Collins Omondi
Town: Nairobi
Urban Market: City Market (for the meat and fish products), Nyamakima (maize and other grains) and Gikomba(maize and other grains) markets in Nairobi. The exception will be a few products that will be collected at specialized shops specifically Tuskys.
Rural Market: Thika, Kiambu and Kajiado markets

Zambia

Consultant: Sydney Silupya
Town: Lusaka
Urban Market: Soweto Market in Lusaka. The exception will be a few products that will be collected at specialized shops such as Shoprite, Spar (Z) ltd and Pick n Pay stores.
Rural Market: Chongwe Markets in Chongwe district

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Endnotes

1 Global Information Early Warning System (GIEWS) of Food and Agriculture Organization of the United Nations (FAO) compiles domestic and international retail and wholesale food prices for many different countries including developed and developing countries however the data is available monthly.

2 Different examples can be found in Yang, Adamic and Ackerman, 2008 as well as Mason & Watts, 2009.

3 The data entry through desktop PCs requires more steps (recording the data on paper first and later inserting the observation into the PC at home or anywhere a PC with the internet connection is available) than the mobile-phone version if the internet access is available at the field.

DataM – Integrating Global Agricultural Datasets

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Abstract

While access to global agricultural statistics has improved significantly over the last 10-15 years, the issues of data/indicator comparability, compatibility and normalization as well as timely availability remain most challenging aspects to ease the use of agricultural statistics in research and policy decision making. In addition to different nomenclatures for commodities/crops, countries/regions and attributes used by reporting agencies, the actual scale/units of measure are also diverse. At the moment, there is no data system that provides complete agriculture and trade datasets compatible and comparable across all countries for most common crops. A few attempts have been made in this direction (mostly for research purposes) but for a very small set of indicators and countries.

The present paper highlights the steps taken over the last four years to create DataM, a very large mapped/compatible data set for global agriculture.

DataM is a tool and database system developed to simplify the daily data work of analysts and modelers in agriculture, either to feed economic models, to check data or to analyze results. With itsunique interface users can rapidly access the main global agricultural and trade databases (e.g. from EUROSTAT, FAOSTAT, OECD, USDA, World Bank) as well as in-house model databases. The tool addresses different needs: from data collection and checks to advanced reporting with the possibility to export data. The main feature is the linkage implemented between the databases nomenclature ("mapping"), meaning that users can retrieve all the available data from different sources related to a particular item more quickly without specific knowledge of the nomenclature used by the different data providers. The DataM initiative ultimately aims at providing a complete package (data and software) for analysts, modellers, policy-makers – all those working with agricultural and trade data – to base the analysis on most recent, comprehensive and well- documented data.

The paper covers key conceptual issues of DataM, managerial aspects as well as technical challenges such as keeping the large number of data sources updated on a regular basis.

Keywords: agriculture and trade data; data comparison and integration; modelling; software.

1. Introduction

While access to global agricultural statistics has improved significantly over the last 10-15 years, the issues of data/indicator comparability, compatibility and normalization as well as timely availability remain most challenging aspects to ease the use of agricultural statistics in research and policy decision making. In addition to different nomenclatures for commodities/crops, countries/regions and attributes used by reporting agencies, the actual scale/units of measure are also diverse.

At the moment, there is no data system that provides complete agriculture and trade datasets compatible and comparable across all countries for most common crops. A few attempts have been made in this direction (mostly for research purposes) but for a very small set of indicators and countries.

In times where agriculture and trade analysis have regained importance due to the increase in food prices and the implications for global food security, the need of tackling these challenges is evident. Likewise, agriculture is increasingly becoming more integrated into the macroeconomy and linked to other sectors such as the energy sector. Consequently the tools for quantitative analysis, as well as the management of data and models, are confronted with new and more complex challenges.

In 2007, the agro-economic modelling group at the European Commission's Joint Research Centre IPTS (JRC IPTS) started to develop concepts for data consolidation, harmonisation and management together with external partners. Building on the experience of this project, the JRC IPTS began a second initiative in 2009, together with the PROGNOZ software company, to design and implement a software platform for data harmonisation and management. The resulting product, DataM, is a database management

tool intended to simplify the daily data work of analysts and modellers. DataM facilitates the access of data, input of data into economic models, verification of statistical information and/or analysis of data/results.

Over the course of its development it turned out that including a multitude of important statistical databases makes DataM a valuable product on its own right and not only as an input for economic models. The rich data content and the powerful IT framework offer a unique opportunity to provide data dissemination tools on top of the DataM platform. Thus the current developments also focus on improving the accessibility for users; both in terms of access to the software (a web-based solution that is accessible with a simple web browser) and in terms of access to the relevant information (the introduction of ‘dashboards’). The DataM initiative ultimately aims at providing a complete package (data and software) for analysts, modelers, policy-makers – all those working with agricultural and trade data – to base the analysis on most recent, comprehensive and well-documented data.

The present paper highlights the steps taken over the last four years to create DataM. It also covers key conceptual issues of DataM, technical challenges such as keeping the large number of data sources updated on a regular basis as well as managerial aspects.

2. Main features of DataM

DataM is a database management tool focusing on data on agriculture and trade from the main data providers as well as economic models. The main strength of DataM is its ability to link these different databases by their nomenclatures. Users can quickly retrieve information from different sources without specific knowledge of the nomenclature used by the data providers. Using one interface only, users can rapidly access and compare the main agricultural, macroeconomic and trade databases as well as the model databases. The tool addresses different needs, ranging from data collection and data checks to advanced reporting, with the possibility to export data.

2.1 Databases included in DataM

The choice of databases is oriented to the needs of the users. One of the main tasks of the agro- economic group at JRC IPTS is to provide policy support in the agricultural field using different agro-economic models. As a consequence, besides model databases, the main agricultural databases with historic data on balances, the major agricultural outlooks, trade and prices databases are included in the tool. The number of databases in DataM can evolve over time according to the needs. The databases currently available in DataM are listed in Table 1.

Figure 1: Summary of the main features of the tool.

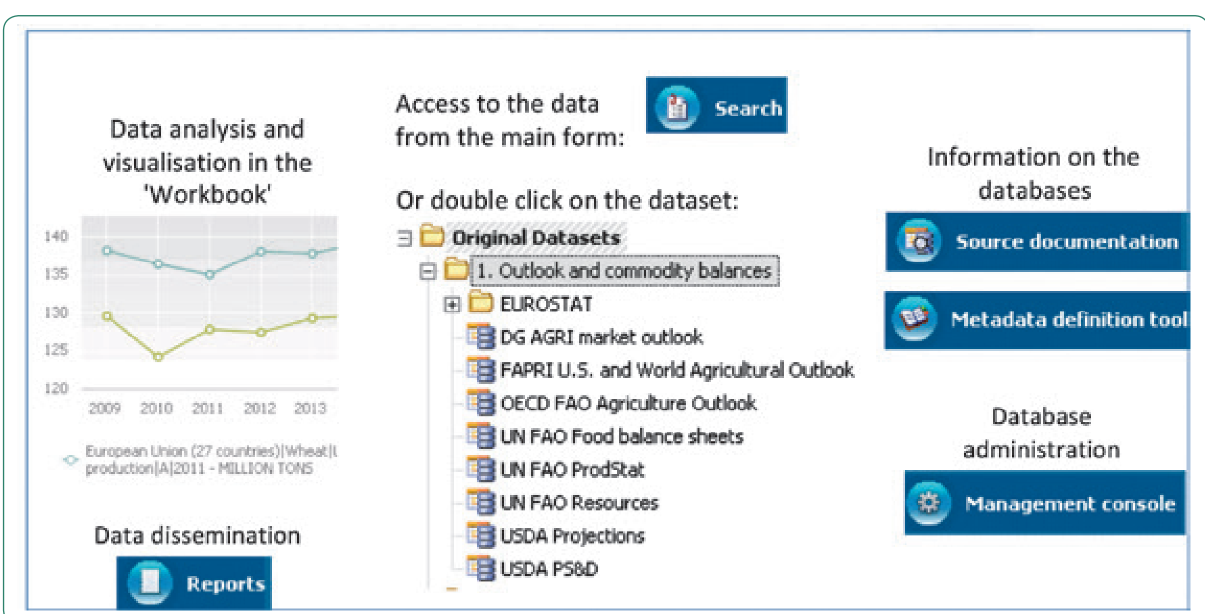


Table 1: Main data sources available in DataM.

Commodity balances and outlooks
DG AGRI market outlook
OECD-FAO outlook
FAPRI US and world outlook
USDA projections & USDA PS&D
Eurostat Balance sheets and Production
FAO Balance sheets and Production
Oil World database
Prices
DG AGRI prices
Eurostat Prices
Oil World Prices
FAO Prices
World Bank Commodity prices
Futures (Wall Street Journal, MATIF, LIFFE)
Macroeconomic data
AMECO – DG ECFIN database
Eurostat
IMF
Global Insight (selection of macroeconomic data)
UN Population Demographic Statistics & UN World Population
Trade
UN COMTRADE (HS1992, HS2002, HS2007, SITC2, SITC4)
Eurostat – COMEXT
FAO trade
Model databases
AGLINK-COSIMO
ESIM
CAPRI
GTAP
AGROSAM
Structure&Income
Eurostat (EAA, FSS)
FADN data
Other
OECD PSE
DG AGRI Budget expenditure
World Development Indicators (WDI)

Certain databases are under licence (e.g. COMTRADE) and DataM allows user rights to be defined at the level of each database. Specifically, users or a group of users may have no rights to access a database, have read-only rights or editing rights depending on the databases.

2.2 Easy access to the data

With DataM, users can access most of the databases they need through a unique user-friendly interface. They can retrieve information from several databases with only one account and using a single query tool. The databases are in a unique format regardless of the data origin. It accelerates the data work as users no longer need to handle different file formats or perform certain transformations, and they can directly compare the data through the graphical interface.

2.3 Up-to-date data

The data in DataM is updated regularly: the daily and weekly databases are updated twice a month; the monthly databases are updated every month and the databases released once a year are updated within 5 or 10 working days depending on the urgency of the work. The information on the data version (i.e. last update of the data by the source provider) available in DataM is displayed in the main form of the tool.

2.4 Source documentation and meta-information

The source documentation (methodology, variable definitions) is stored in the tool and is directly accessible from the main form of DataM. In addition, a summary report informs the user of the data source provider, the potential need for a licence, the data frequency, the update frequency in DataM and the geographical coverage. The meta-information can also be consulted directly when visualising the data. The availability of the main information on the databases directly in the tool is particularly useful in the context of a high turnover of DataM operators.

2.5 Data analysis and reporting

DataM provides visualisation tools (tables and graphic presentation) for data analysis and for the comparison of different data sources:

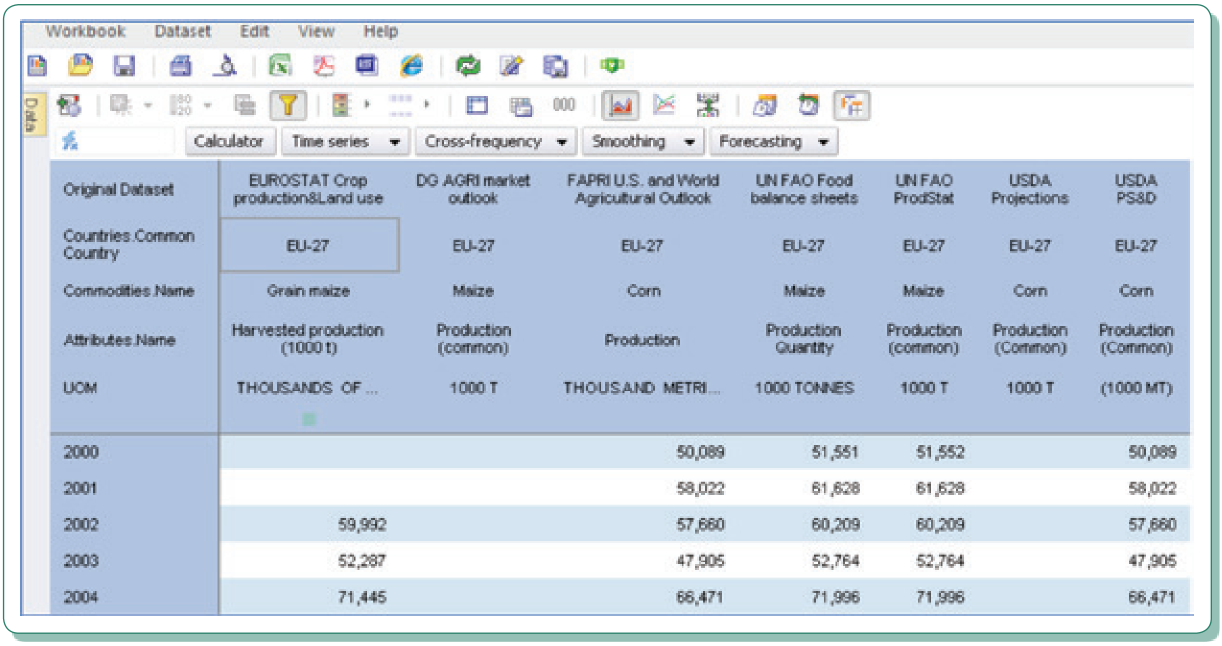
- historic data versus model input data;
- different scenario results of a single model;
- projections of different institutions and in-house models.

The data can be analysed using time series' statistical/econometric functionalities: time series'

calculations (percentage change, summations, moving averages…), collapse (from Monthly to Yearly data) or basic econometric analysis. For data validation, rules can be defined to look for missing data or detect outliers, e.g. 'abnormal' growth rates and levels.

DataM is also equipped with a reporting tool. Reports for repeated data analysis, extraction tasks or for dissemination purposes can be pre-defined. Ready-to-use and customisable report templates allow an analysis to be updated rapidly, for example in one click a report can display new scenario results.

Figure 2: The workbook in time series mode and graphic visualisation.



Original Dataset	EUROSTAT Crop production&Land use	DG AGRI market outlook	FAPRI U.S. and World Agricultural Outlook	UN FAO Food balance sheets	UN FAO ProdStat	USDA Projections	USDA PS&D
Countries.Common Country	EU-27	EU-27	EU-27	EU-27	EU-27	EU-27	EU-27
Commodities.Name	Grain maize	Maize	Corn	Maize	Maize	Corn	Corn
Attributes.Name	Harvested production (1000 t)	Production (common)	Production	Production Quantity	Production (common)	Production (Common)	Production (Common)
UOM	THOUSANDS OF ...	1000 T	THOUSAND METRI...	1000 TONNES	1000 T	1000 T	(1000 MT)
2000			50,089	51,551	51,552		50,089
2001			58,022	61,628	61,628		58,022
2002	59,992		57,660	60,209	60,209		57,660
2003	52,287		47,905	52,764	52,764		47,905
2004	71,445		66,471	71,996	71,996		66,471

3. Learning from each other – mapping of databases

3.1 Data harmonisation

To ease the data search and comparison, the nomenclature of the databases are linked via common dictionaries. These enable the user to work with data from different sources under one unique nomenclature (the common one). They include a list of countries, commodities and attributes (like feed use or production). For example 'maize' is part of the common dictionary of commodities and is linked to 'maize' or 'corn' according to the nomenclature of the different databases. A search on 'maize' will therefore return all data series on 'maize' and 'corn'. As a result, as long as users are familiar with the common dictionaries, they do not need to know all the specific databases' nomenclature to look for data. In institutions with a high staff turnover this harmonisation decreases the entry barrier to work on agricultural data.

Furthermore, for the common dictionaries, data series are converted into common units of measurement, allowing a direct data comparison. Time series from a single data source are also harmonised in case there is a change in definitions over years.

3.2 A pragmatic approach

In building up the common dictionaries (name, code and unit) a pragmatic approach is followed. First, the common dictionaries were limited to the items mostly used at JRC IPTS but progressively the dictionaries are being complemented. It may occur that the elements do not correspond exactly to each other, e.g. the marketable milk production and the total milk production; or China including Hong Kong and excluding Hong Kong. Or the price of wheat of bread-making quality may be linked to an average wheat price. Annual prices calculated over the marketing year may also be linked to the calendar year average. The link is nevertheless established because users are interested in comparing what is available in the different databases. Sometimes some calculations can be defined to ensure a more appropriate correspondence, like for the units, but it is not always possible.

As a consequence of the pragmatic approach, the user needs to be reminded that they should not always compare apples with apples. Thus meta-information is crucial and DataM allows it to be collected and displayed, e.g. with remarks in the attribute descriptions.

It is also possible to map different elements of the original database to the same element of the common dictionary. It can be useful when the attribute does not have the same name according to the commodity. For example, in the DG AGRI outlook the common 'Production' element is mapped to the 'Usable production' used for crops, the 'Production' used for meat and the 'Total production' used for dairy products. Moreover, one original element can be mapped to two common elements; it is used when the 'Food use' and the 'Domestic use' are identical because certain databases display only one of the two attributes and no other 'Use' attribute is available.

3.3 The common dictionaries

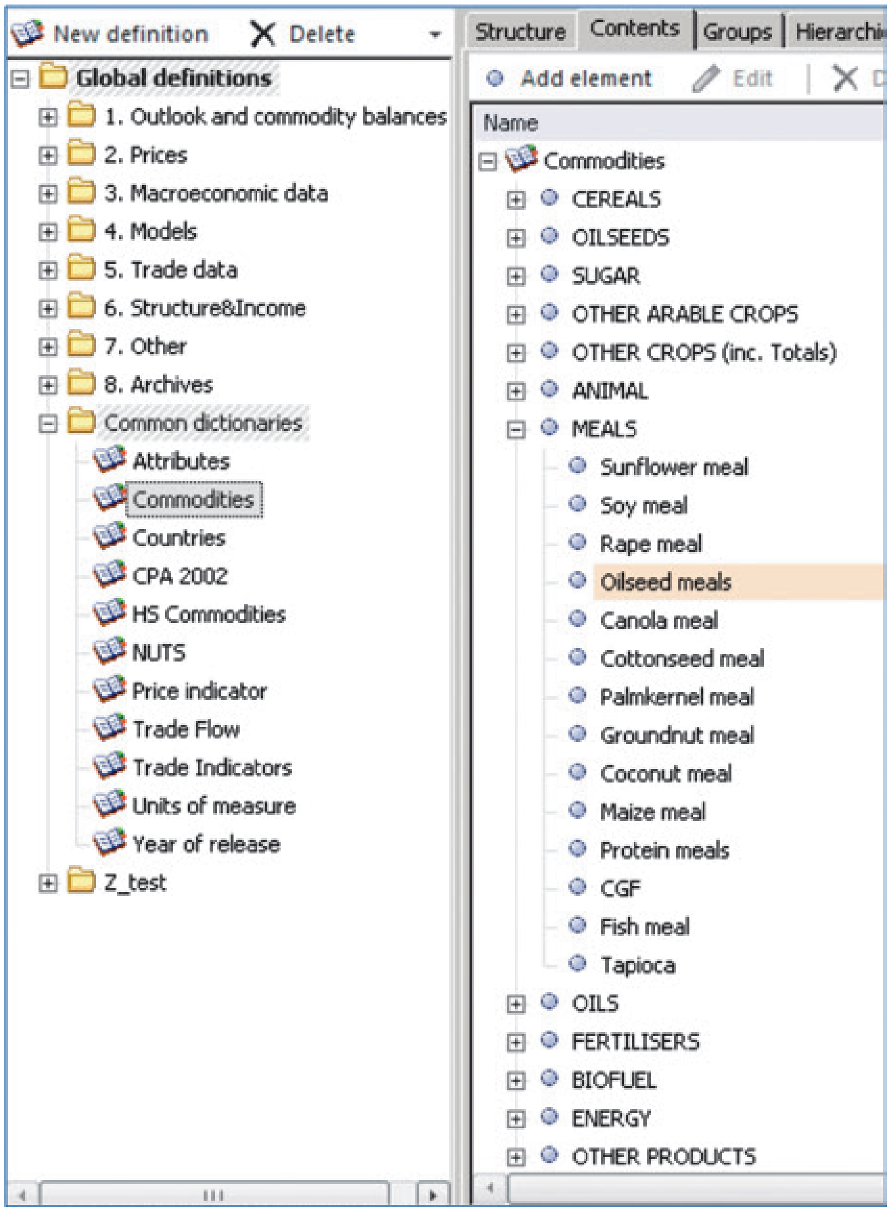
There are 11 common dictionaries: commodities, attributes, countries, NUTS, price indicators, trade flow, trade facts, HS commodities, CPA 2002, year of release and units. In the Metadata definition tool the elements of each dimension are listed, together with the name, the code, the unit and meta- information.

Countries are organised by continent with a specific entry for the EU (as for the 'by continent' hierarchies) and the names of the countries are as per the UN classification. The NUTS nomenclature is separated from the country dictionary because most of the databases contain information only at country level and NUTS are specific to the EU, as well as because selecting countries in a simpler list is easier. Trade flows are only two: imports and exports. Trade facts are the quantity and the value. The Harmonized Commodity Description and Coding System (HS) of tariff nomenclature of 2007 is used as common dictionary for all the trade databases by tariff nomenclature.

The common attributes are the most important elements of the balance sheet, as well as yields, prices, macroeconomic data and income/labour indicators. This dictionary is displayed in Annex 1. A common unit for the attributes is defined in the common dictionary (1000 t, 1000 ha, t/ha, etc.). The common unit for biofuels is the million t.o.e. and for sugar w.s.e.

The common list of commodities already covers close to 300 elements. Nevertheless, only a few fruit and vegetables are covered so far. The names and codes of the common attributes and commodities were decided by the administrators with the intention of adopting the labels most frequently used in the different databases.

Figure 3: The common commodity dictionary.



Another criterion in defining labels was to keep them short to avoid further formatting work in the tables and graphs, e.g. 'EU-27' is used instead of 'European Union (27 countries)'. In addition, improving the efficiency of the search is an important aim. As a consequence manioc is labelled 'Manioc (cassava)', the code of 'Maize' is 'Corn' or the code of 'EU-27' is 'EU27'.

The HS of tariff nomenclature of 2007 is used as the common dictionary for all the trade databases by tariff nomenclature.

The common list of price indicators was created from the metadata of different databases to link world prices. For a given commodity, it allows different world prices commonly used as reference for a given commodity to be linked. The most used price indicator for a commodity is labelled 'World reference price'.

3.4 Linking databases to the common dictionaries

In the Metadata definition tool, the harmonisation is managed by dimension. A double click on the

original element of the database opens a window where the common element can be selected from the list of elements of the common dictionaries. In case the link is not direct, meaning a calculation such as a unit conversion is required, elements are added to the original list under a sub-folder called 'Common items'. For example in DG AGRI Market Outlook, the 'Imports' are not mapped directly to 'Imports' of the common dictionary because the units have to be changed. Therefore a new element called 'Imports (common)' is created and linked to the common dictionary and in the comments the implemented calculation is explained. The final step is then to define the transformation rule (refer to chapter 4.6).

In order for the linked elements to be seen from the workbook or the reporting tool under their common name, a common hierarchy has to be defined for each dimension of each database. This hierarchy is created automatically.

In order to map COMEXT and COMTRADE to the databases focusing on commodity balances, groups of tariff nomenclatures are being created progressively. It started with the COMEXT database for which groups' definitions were collected close to the DG AGRI units. The trade by commodity is calculated in value and product weight but also in carcass weight equivalent and grain equivalent.

For prices, at first no conversion to a single currency like the Euro was foreseen as users such as researchers may prefer to decide which exchange rate to use (average, end of year, source, etc.). Nevertheless, in the continuing data harmonisation process, in the most important price databases conversion to Euro and USD is gradually being introduced. As far as possible the annual AMECO and the monthly Eurostat average exchange rates are used for the conversion. In addition when monthly data is available like in the World Bank price database, the average prices over the marketing year are added. In that case a dimension is added with three elements: calendar year, marketing year and not available.

3.5 Examples of benefits for using the common dictionaries

The most obvious and direct benefit of the common dictionaries is the efficiency of the data search. For example a search of the 14 Outlook and commodity balance databases for 'EU-27 maize production' (or 'EU27 corn production') using the common nomenclature will return results for 8 databases while a search in the original classifications returns no results for 'EU-27 maize production' and 3 results for 'EU27 maize production'. In addition, after a search on the common nomenclature the datasets are displayed in the Workbook directly in the comparable common unit.

In the workbook and in the reporting tool users can display the common hierarchies to select the required elements more rapidly. Moreover, the common labels can be displayed in the data area of the workbook.

After the original nomenclature is linked to the common dictionary, a 'common' data cube can be created from the original database. The available elements are limited to the common items which are listed under their common names. Using these 'common cubes' in the reporting tool allows dynamic reports from several databases to be created. For example, in a graph comparing the USDA projections, the OECD-FAO Outlook and FAPRI projections two control boxes on the countries and commodities can be added so that users can choose the elements to be graphed.

Finally, the database linkage enables the creation of 'harmonised datasets (HD)'. The difference in comparison to the 'common cubes' is that in a HD the database becomes a dimension whereas a 'common cube' contains data for a unique dataset. Furthermore, the number of dimensions is limited to the common ones whereas it is specifically defined for each HD. For example in the HD dedicated to the models, for AGLINK-COSIMO the dimension showing if the variables are endogenous or exogenous is dropped. These HD are the databases accessible from the DataM web application which is currently under development.

4. Desktop and web-based – technical challenges

Setting up a data management system such as DataM with a large number of regularly updated datasets, visualisation, analysis and dissemination functionalities, requires also a powerful IT framework.

DataM solution is built on the top of PROGNOZ Business Intelligence platform providing the necessary tools to support various steps of the statistical data production cycle, from data collection, processing and reporting, all the way to dissemination.

Figure 4: Steps of the statistical data production cycle.

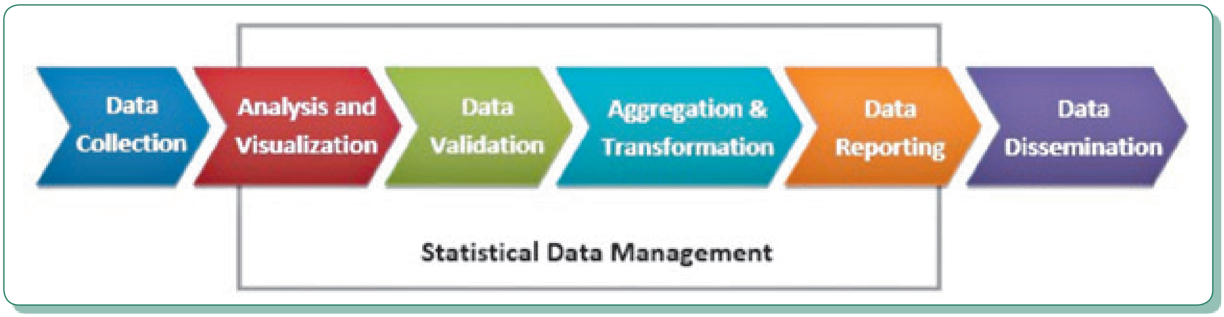
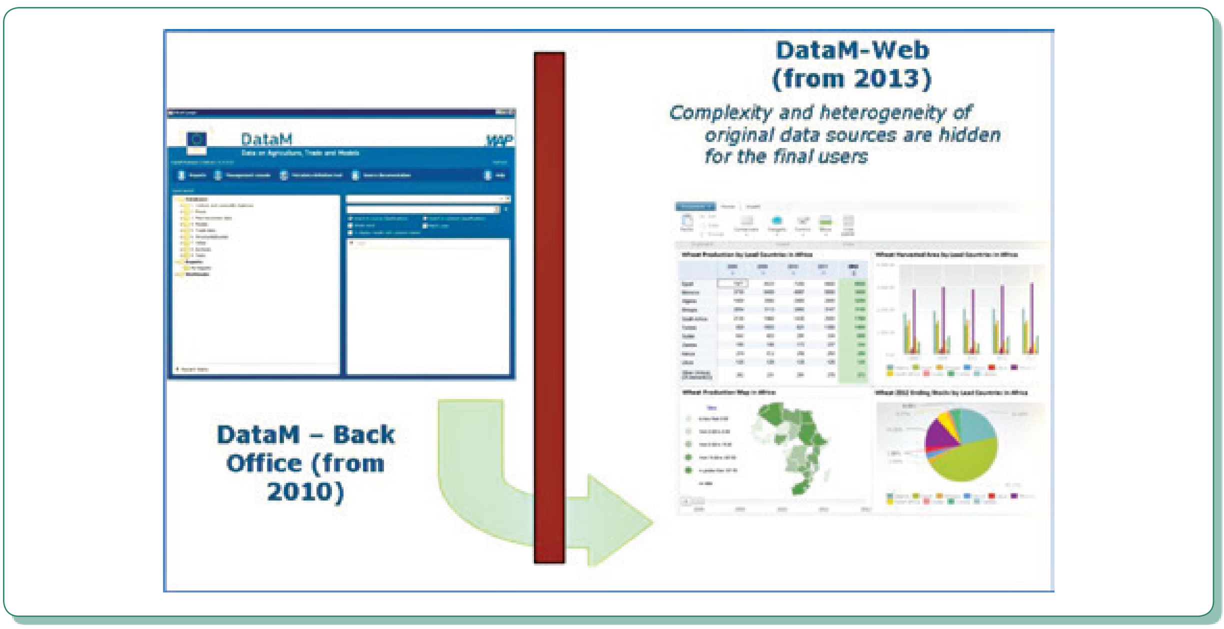


Figure 5: The Back office and Web modules.



Initially, the "DataM Back Office" component was created, a powerful analytical suite to be used for the researcher and analysts. To improve the accessibility for users "DataM Web" has been developed in addition, an online portal sharing enriched views of the data created with the Back Office application.

4.1 Back office application

The PROGNOZ platform runs on Windows and needs to interact with a Database Management System (DBMS). In the case of DataM, the database engine is Oracle running on a Linux machine, which is in line with the standard technologies in use at the European Commission. The Back Office application is entirely hosted by the JRC IPTS.

DataM is in principle a two-tier client-server application; the presentation and application logic layers are concentrated in the Windows executable whereas the data layer is managed by the database server. After various experiences with different configurations, the optimal one that has been adopted consists of installing the platform on a powerful application server, accessed by the client PCs via RDP (Windows' Remote Desktop Protocol). This solution emulates the three-tier pattern of software engineering that separates the software layers responsible for the presentation (User Interface), the application logic (Platform) and the data access (DBMS).

Through the Remote Desktop access, the 'terminals' of the final users take over the elaboration workload of the user interface. The resulting advantages are not only in terms of performance but also given by the optimised maintenance of

the installation, concentrated on the application server. Excellent performance is also ensured for connections from remote locations over the Commission network, e.g. for the DataM users located in DG AGRI in Brussels.

4.2 Web application

The database underlying the web application is an extraction, periodically refreshed, of the full database of the back office application.

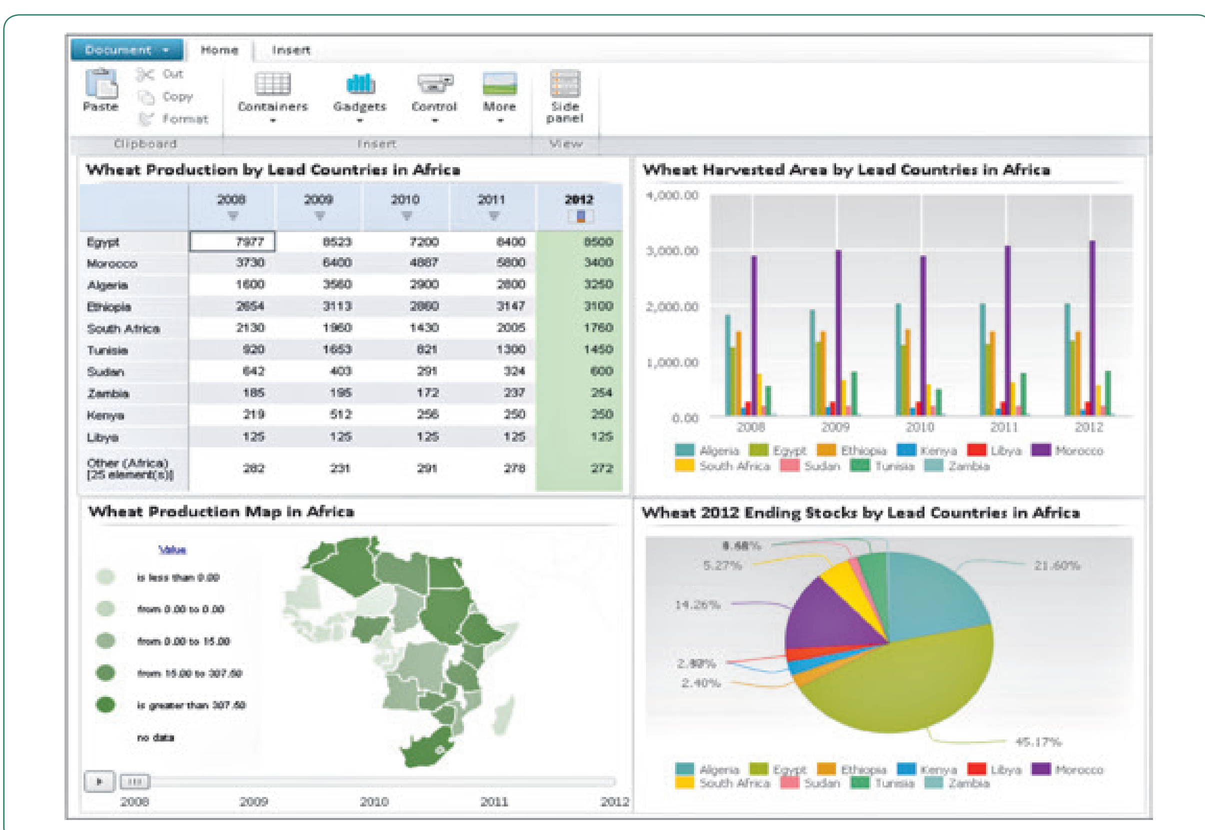
The DataM desktop application is a rather sophisticated tool conceived for client-server use within an enterprise's local area network or extranet. The adaptation to cloud computing and the access for external subjects might be envisaged in the future taking into account the related issues of security, ergonomics and performance. Therefore a web-based version of DataM has been developed which is directly linked to a subset of databases built into the desktop. The web portal eases the access for registered DataM users to the main datasets via the internet and creates the potential for a multi-user environment. Moreover, in a further step it could allow the dissemination of data, e.g. of research projects, to a wider audience.

The DataM web portal is a zero-footprint browser application for analysing and visualising data from a variety of different datasets. It also aims to satisfy the needs of different purposes. A broad range of information and data can be disseminated to different users, distinguished by open or restricted access. A search function enables the user to respond to ad-hoc data queries.

The web application provides end users with a user-friendly interface to produce 'print ready' outcomes without having strong reporting skills (so-called 'dashboard designer'). The data can be visualised in maps, tables, charts and text.

In DataM, the software developer's service includes responsibility for a big share of such efforts. PROGNOZ retrieves data from variegated original sources, often in the form of web pages, and adapts it for DataM. The only exception is when data are not publicly available but the JRC IPTS owns the licence: in this case only the JRC IPTS can make the 'extraction'. Beside this, the JRC IPTS executes only the data load. This is based on data packages that the software developer transmits after having executed the whole ETL chain from their side.

Figure 6: Visualisation of data.



	2008	2009	2010	2011	2012
Egypt	7977	8523	7200	8400	8500
Morocco	3730	6400	4887	5800	3400
Algeria	1600	3560	2900	2800	3250
Ethiopia	2654	3113	2860	3147	3100
South Africa	2130	1960	1430	2005	1760
Tunisia	920	1653	821	1300	1450
Sudan	642	403	291	324	600
Zambia	185	195	172	237	254
Kenya	219	512	256	250	250
Libya	125	125	125	125	125
Other (Africa) [25 element(s)]	282	231	291	278	272

4.3 Synchronisation

The outsourced execution of the first phases of the ETL is in general terms advantageous; even though it implies certain complications. Besides retrieving data subject to licence, the JRC IPTS does not execute anything else for the Extraction and Transformation; however these phases are based on crucial JRC IPTS contributions for interpreting the structure of data at source and for the harmonisation rules. The service provider is therefore obliged to maintain a synchronised copy of the DataM database in order to constantly integrate the evolutions in the knowledge data produced by the JRC IPTS prior to executing the transformation processes.

5. Institutional setting and conclusions

The DataM initiative ultimately aims at providing a complete package (data and software) for analysts, modellers, policy-makers – all those working with agricultural and trade data – to base the analysis on most recent, comprehensive and well-documented data.

The DataM desktop and web portal have been developed in a public-private partnership as an institutional setting which combines research-oriented focus and inspiration with tailored IT engineering and professionalism. In practice, the JRC as DataM's owner provided a licence to PROGNOZ for commercialising the application for public and private institutions. User licences for the tool will be offered to interested parties, together with additional services (e.g. training, documentation, maintenance and technical support). This approach should enable DataM to be maintained and further developed.

As a tool co-developed by a public institution, DataM is already available to pilot researchers within the European Commission and the African Development Bank and should also be accessible under preferential terms to users in other public institutions.

The global coverage of databases in DataM also offers various fields of applications to users outside the European Commission. To this end, a strategic partnership with the African Development Bank (AfDB) has been agreed. As part of the Capacity Building Initiative for African Agricultural Statistics, the AfDB and JRC IPTS, in cooperation with PROGNOZ, are releasing an analytical application of DataM for all African countries.

Current and future users are invited to contribute to expand the link of different databases through common nomenclatures and improve the meta-information of data. Evidently, and as is the case for all intellectual property and as recognition for several years of work, DataM's use as a tailor-made software hub for databases as well as the individual databases must be correctly cited.

Scientific data work is and remains the basis for sound analysis and evidence-based policy-making.

IDCB 7

Estimates, Forecasts, Expert Opinions and Assessment - Their Role in the Official Statistics on Agriculture

Organizer and chair: Flavio Bolliger, IBGE

In the practical production of agricultural statistics, it is very common to use estimation methods different from those recommended in manuals. Many of them are traditional and consolidated: estimates/forecasts, special study, expert opinion, assessment, windscreen survey, expert meeting, board decision, subjective evaluation, etc. The first four methods, for example, are listed as some of the alternatives in the Standard Questionnaire for Reference, Country Assessment of the Agricultural Statistics System for the Implementation of the Global Strategy to Improve Agricultural and Rural Statistics. Considering additional data sources, the Global Strategy (2011) states that "Expert judgment and windshield surveys can be used to collect data from experts whose judgments inform evaluations of agricultural conditions." In many countries, this is the method used to obtain data on quantity and values that will be part of the official statistics. Moreover, according to Galmés (2011), "around one half of the 19 Latin American countries rely on subjective (non-probabilistic) methods of estimation."

In general, those methods have precise definitions and relatively comprehensive descriptions. However, they are not included or fully discussed in the methodological recommendations for agricultural statistics.

The objectives of this session are: (1) report and evaluate the extent to which those alternative or traditional methods can be used; (2) discuss the purpose and the circumstances of their use; (3) discuss the need and the way to surpass them when they are, in fact, not recommended; (4) discuss the need and convenience to include those methods in international recommendations.

Papers:

- Miguel Galmés (Uruguay), "Integrating Expert Opinion in Agricultural Statistics"
- Hubert Hamer Jr. (USA), "Weekly Crop Progress and Condition at the USDA-NASS"
- Naman Keita, Nancy Chin (FAO), "The Place of 'Assessment' in Current Agricultural Statistics for Developing Countries: making best use of available information for timely crop production estimates in the absence of a system of agricultural sample surveys"
- Elisabetta Carfagna (FAO), Andrea Carfagna (Italy), "Appropriate Survey Methods for Different Country Profiles - key challenges, gaps and remaining methodological issues"

Integrating Expert Opinion in Agricultural Statistics

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Abstract

Many countries rely totally or partially on subjective (non-probabilistic) methods of estimation. In particular, expert opinion from qualified informants is widely used.

The present paper deal with the issue of how integrate expert opinion in the methodologies of data collection. Expert opinion is used for many reasons: need to have information more frequently that the one provided by annual or semiannual sample surveys; requirements of information for small administrative areas that sample surveys cannot accurately provide; lack of resources to conduct large scale sample surveys or censuses. In other cases, expert opinion serves to assess the magnitude of non-sampling errors in sample surveys.

The paper highlights the need of establishing a system that can integrate different methodologies of data capture (probabilistic methods, remote sensing, administrative records) with expert opinion. Ideas about the way of selecting the informants, the method for obtaining the information and the way that information should be presented are also drafted.

Keywords: agricultural statistics; sampling survey; expert opinion; probabilistic methods; estimation.

1. Introduction

Statisticians widely advocate the use of sampling methods of estimation. In fact, probabilistic sampling is the only scientific way to provide measures of sampling errors in terms of precision and accuracy of estimates. However, is well known that non-sampling errors sometimes are greater than sampling ones and there is no scientific way to measure them (J.T.Lessler & W.D.Kalsbeek, 1992). On the other hand, agricultural sampling surveys at national or sub-national level are not efficient in providing reliable estimates for small areas or regions. Besides, the design and implementation of probabilistic sampling is expensive and national budgets cannot bear the taking of agricultural surveys on a continuous basis.

Against such limitations, decision makers demand information about agricultural statistics for small administrative areas and on an almost continuous basis. The point is: How do statisticians solve such contradiction? The combination of sampling surveys and expert opinion can be a way to face that dilemma.

The *"Global Strategy"* includes expert opinion into the integrated survey framework (second pillar, Chapter 4): "Expert judgment and windshield surveys can be used to collect data from experts whose judgments inform evaluations of agricultural conditions. For instance, the Sourcebook (World Bank, 2008) refers to a procedure in which experts travel a specified route on a periodic basis and record the condition of crops, which provide an input into crop yield forecasts." (World Bank-FAO, 2010).

Present practices in Latin American and Caribbean countries show that expert opinion is more widely use than the one expressed in the quoted reference. Main reasons are:

- Lack of personnel trained in statistical methods and sampling;
- Lack of budget to face continuous sampling surveys;
- Need of information at levels that sampling inferences cannot provide (municipal, district or even lower levels);
- Need of information at intervals that sampling surveys cannot give (monthly or bimonthly);
- Difficult access to some areas.

Usually a combination of the above mentioned factors is observed.

Faced with this situation the question is: Must expert opinion be avoided in all circumstances until sampling surveys are implemented? If the answer is "Yes": How decision makers would manage? If the answer is "No": If expert opinion is in place, are probabilistic surveys needed?

The present paper advocates for the use of sampling surveys as the main source of agricultural and rural data. Sampling surveys are "objective", "scientific" and they allow the computation of sampling errors. At the same time, the paper also

advocates for the complementary use of other sources integrated to sampling estimates as the Global Strategy does. Expert opinion should be one of the main of such sources.

Why several integrated methodologies are needed? Because, despite the availability of resources for implementing sampling surveys, they will neither be able to give accurate estimates for small administrative areas (because of workloads and budget, sample surveys are designed to provide national or state estimates) nor with a periodicity less than one semester or so. Besides, non sampling errors can affect the estimates and their assessment is impossible without external information.

The demand for small area estimates is high. The only sound statistical method for obtaining agricultural information for small administrative areas is the agricultural census. Unfortunately the agricultural census is a big and costly operation taken every ten or more years and oriented to collect structural data. Decision makers demand it for the conjuncture variables on a continuous basis. For example a survey conducted among the main users of agricultural information in Costa Rica reported that more than 75% of asked users demanded data at district level (INEC-SEPSA, 2007).

2. Criteria for expert opinion collection

So, if expert opinion is widely used, if it is useful for obtaining information demanded by decision makers but it does not comply with acceptable standards of quality because it is "subjective", with no measurable errors and sometimes assessed as "not accurate", the questions are: Is it possible to improve it?, How integrate expert opinion to the National Agricultural Systems?

What does expert opinion mean? The expert giving opinion on area, yield, production, livestock, prices, etc is usually known as "qualified informant". Generally speaking a "qualified informant" is one person, a group of persons or an organization that because of it activity has direct knowledge of the state of agriculture in a particular geographic area. In an integrated system as the one advocated by the Global Strategy, information provided by qualified informants is very important. However that information usually is not accurate or it has important biases as a result of several factors. Intentional or non- intentional deviations can be observed.

To minimize such biases the following rules are suggested:

1. Select more than one qualified informant for each geographical domain.
2. As far as possible, select informants with conflict of interests. An example could be: a farmer (or farmer group) and the agricultural bank official responsible for approval of credit to farmers. Another example: an agricultural extension officer and the buyers of agricultural products.
3. Clearly define the geographical area to which the subjective estimation is concerned.
4. Use a structured form to collect the information.
5. Prepare manuals containing clear explanation of:
   a) scope of the exercise;
   b) area to be covered;
   c) concepts and definitions;
   d) activities to perform;
   e) administrative procedures.
6. Qualified informants need to be periodically trained.
7. Strong supervision is also paramount. Deviations from previous reports; large differences between informants and anomalous data should be explained. Supervision must include periodical visits to the field offices to verify that data were not invented from a desk and the informant was effectively contacted. This is crucial when data are sent to the central office by phone or e-mail.
8. Assessment of the work of each qualified informant restoring the evaluation results and using them to improve the quality of reports.
9. Provide some type of retribution.
10. The qualified informant should provide the information along with some (subjective) assessment of the accuracy of the data. In some cases the informant would be able to give precise information (for example the official responsible of an irrigation area knows precisely the area irrigated) but in other cases (the majority perhaps) he/she only knows it approximately. The qualified informant can do that giving ranges instead of round numbers. It is important to remind that the expert opinion data are not expanded, no statistical inferences are performed and they must serve as a guide to be confirmed by the sampling surveys.

Expert opinion is also important during the assessment of statistical inferences from probabilistic surveys. In fact, as said, non sampling errors are sometimes greater than sampling ones. So, checking the statistical produced estimates with the opinion of experts, along with the crosscheck with other sources, the final estimates can considerably improve.

3. Integrating expert opinion in the National Agricultural Statistical System

Expert opinion should never substitute agricultural sampling surveys but it is an important element to integrate to them in order to improve the estimates (assessing non-sampling errors) and to satisfy the demand of main decision makers referred to scope and periodicity of data. Expert opinion is very important to follow up the growth conditions of crops in the inter-survey period satisfying in such a way the need for continuous information.

A typical situation could be:

- An agricultural sampling survey every 6 months to obtain national or state estimates of planted area, area that is intended to plant in the next campaign, harvested area and production and yield for the main temporary crops;
- Qualified informants provide opinions about crop and harvest progress, growing conditions and any specific factor that can influence decisions of farmers;
- Qualified informants along with administrative registers and other external data give inputs to disaggregate the survey data for sub-national or sub-state administrative divisions;
- The next sampling survey will allow the adjustments to the estimates and a new cycle begins.

Developed statistical systems rely in integrated sources of data. For example, the National Agricultural Statistical Service of the United States Department of Agriculture (NASS/USDA) integrated the quarterly sampling surveys with objective counts and measurements, remote sensing data and expert opinion about crop progress and growing conditions.

The joint mission FAO-IFAD visiting Nicaragua past February in the framework of the project on Improvement of the System of Information and Agricultural Statistics recommended: "The estimates of parameters coming from the agricultural sampling surveys will be the basis of the system of "Continuous Statistic" and the progress of planting and crop growth stage will be followed starting from planting intentions using expert opinions to be provided on a monthly basis... In the first stage the follow up will be at departmental (state) level and in future instances it will try to have data at municipal level".

4. Presentation of final data

The presentation of final data to be disseminated should clearly separate probabilistic survey data from those coming from expert opinion. The former, to be disseminated after each sampling survey (yearly or semiannually or, quarterly) should be accompanied of measures of error (coefficient of variation, confidence intervals, etc.), the latter must be presented only as indications of values for small administrative areas and of the values of the parameters in the inter-survey period.

5. Conclusions

In summary:

- Expert opinion is a procedure that adequately performed can help in filling the gaps between consecutive sampling surveys and also approximate estimates for small administrative areas.
- Expert opinion should never substitute probabilistic methods of estimation.
- Expert opinion also integrated with other non-probabilistic methods such as information coming from administrative registers and remote sensing is an useful procedure to assess the magnitude of non-sampling errors in agricultural sampling surveys.

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Weekly Crop Progress and Condition at the National Agricultural Statistics Service

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Abstract

In 1914, the United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) published its first weekly reports during the growing season based on the expert opinion of knowledgeable reporters in over 3,000 counties across the United States. These reports were frequently referred to as "crop weather" reports since they tried to answer the primary question of "How did the weather affect agriculture last week?" For much of the 20th century, the weekly reports varied significantly for each state due to lack of national oversight, varying geographical environments, and timing of local crop and livestock production practices. Comparisons between states were difficult due to different definitions, reference dates, and summary procedures. Nonetheless, the weekly reports provided valuable and frequent updates on the current progress and condition for both crops and livestock. Common questions included percent of crops in each phenological stage (planted, emerged, headed, mature, harvested, etc.), crop and livestock condition (percent very poor, poor, fair, good, and excellent), livestock roughage requirements provided by pastures, and soil moisture content. In 1985, NASS standardized the weekly survey process and questions asked in order to summarize consistent information at the national level.

Today, the report includes input from approximately 4,000 reporters whose occupations provide them opportunities to make visual observations and frequently bring them in contact with farmers in their counties. Based on standard definitions, these respondents subjectively estimate the progress of crops through various stages of development as well as the progress of producer activities. All across the United States and around the world, farmers, railroads, agronomists, agricultural market analysts, disaster recovery specialists, fertilizer providers, cargo shipping lines, seed companies, and many others use the weekly information to help make decisions for their businesses. The power of the weekly report lies in the flexibility of asking over 3,000 potential questions each week, the panel of experts who provide data, and the fast processing time.

Keywords: crop; progress; weekly.

1. Introduction

The National Agricultural Statistics Service's (NASS) mission is to provide timely, accurate, and useful statistics in service to U.S. agriculture. NASS conducts hundreds of surveys annually and produces nearly 500 agricultural statistics reports, which are disseminated on a weekly, monthly, quarterly, or annual basis and cover most aspects of U.S. agriculture. Production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use, and changes in the demographics of U.S. producers are only a few examples. Most of the official reports are based on sample surveys and the quinquennial census of agriculture.

The Crop Progress program relies on a non-probability based survey that includes input from reporters whose occupations provide them opportunities to make visual observations and frequently bring them in contact with farmers in their counties. Based on standard definitions, these reporters subjectively estimate the progress of crops through various stages of development as well as the progress of producer activities. They also provide subjective evaluations of soil moisture, days suitable for fieldwork, and crop and livestock conditions.

2. The report and the reporters

The Crop Progress report is the most requested of all published reports on NASS' release calendar. Published each Monday after 4:00 p.m. Eastern Time during the U.S. primary growing season, which is the beginning of April until the end of November, the report strives to answer the basic question of "How did the weather affect agriculture last week?" The report publishes the current estimate of the phenological progress (planted, emerged, headed, mature, harvested, etc.) and growing condition of major crops and livestock for both national and state levels.

Remarkably, this report is the only "expert opinion" survey NASS conducts. There are approximately 4,000 reporters across all states and counties in the United States. Each state maintains a group of trained reporters who are knowledgeable about agriculture and come into contact with many farmers in their local county as part of their daily routine. Reporters are instructed on how to use the automated wed-based computer system NASS provides, taught standard terms and definitions, and asked to report each week. NASS provides written instruction at the beginning of the season and state offices touch base with reporters periodically throughout the season to answer questions and ensure all are reporting correctly.

Most counties in most states have only one reporter. However, some states have two or three reporters in each county to ensure county representation in the state-level estimates. Where two or more reporters report for the same county, a weight between zero and 100 is applied to each reporter. For example, more experienced reporters may be weighted more heavily than inexperienced reporters.

Many reporters work for other USDA agencies such as the Farm Service Agency, or they work for the Cooperative Extension System of USDA's National Institute of Food and Agriculture. Some reporters are farmers or agribusiness personnel who travel regularly throughout their county. A few reporters are enumerators who help gather data for other NASS surveys. The information reporters submit is their "opinion" of the local growth and condition of both crops and livestock. Many individuals serve as crop progress reporters for 10 to 20 years or more.

The questions reporters are asked vary throughout the growing season. The growth stages for each crop are added or removed from the report in each state as the crop is planted, grows to maturity, and is harvested. Planting progress and emergence are published at the beginning of the crop's growing season while maturation and harvest progress are published at the end. Estimates of crop condition are published after crop emergence until most of the crop is harvested.

Each week, NASS Headquarters staff determines the items to be published in the national Crop Progress report. NASS field office staff in the major-producing states, which account for approximately 90 percent of the crop's production, are required to ask all of the questions in the national report. States have the flexibility to ask additional questions in earlier or later weeks as needed for the local growing conditions. For example, both Texas and Iowa are corn-producing states. As a southern state, corn planting begins in Texas in late-February or early-March. In contrast, in Iowa, a northern state, farmers usually don't start planting until mid-April or early May. Nationally, corn planting is published for the first time at the beginning of April. In the first national release, Texas will often show planting progress nearing completion while Iowa planting is still in early stages.

In states that are not "major-producing" states for the commodity at issue, state offices may ask reporters questions at any time but tend to follow the national schedule so their data are comparable to the major states. In addition, state offices may ask questions about crops that are not included in the national publication such as fruits, vegetables, or field crops with a state or regional-level impact.

Although the report title refers to "crop progress," the report also addresses the weather's effect on livestock. Pasture and range condition is published for the country as a whole and for all states each week. In addition, states have the flexibility to add questions about roughage requirements being met by pasture, disease or insect outbreaks, calving/lambing progress, movement of livestock to high or low elevation pastures, etc. Many states will also periodically ask questions about snow, heat, or other weather events and their impact on feed supplies or animal health. States also have the flexibility to ask other agricultural or weather-related questions such as snow depth, fertilizer application progress, area flooded, etc. NASS maintains a list of over 3,000 standardized questions that can be added or removed each week. Over the last century, NASS has developed a list of questions that can quickly provide expert opinion on a vast array of events that can affect agriculture.

3. Automated reporting and data analysis

An automated, national computer system is used to collect, process, and publish the survey data each week. Reporters also provide comments in addition to their numerical evaluations of crop and livestock progress and condition estimates. A few reporters complete their responses late Friday afternoon, but the vast majority report early Monday morning using the secure website. In some cases, reporting by telephone or fax is allowed and state office staff enter the data into the national system. State staff turn questions on and off each week. When activating

the current week on Thursday, state personnel select which questions will be asked and turn them on in what is called a “key file.” This key file is the trigger for all steps in the reporting, analysis, and publication computer system. The power of the key file is in allowing maximum flexibility each week in each state, but limiting computer processing time to only the needed questions.

The secure website is accessible to all reporters, is compatible with both desktop computers and mobile devices, and requires a secure username and password to log in. Once a reporter logs in, he or she sees the questions for the upcoming week. All terms and definitions are posted on the website in case reporters have questions. Edit checks built into the website ensure accurate reporting. For example, progress items must be greater than the number reported last week. Planting cannot go from 20 percent complete to 15 percent complete the next week. If no planting occurs, then a reporter must enter 20 percent. If planting occurs, then the reporter must enter a number of 20 percent or more. In addition, condition percentages (very poor, poor, fair, good, and excellent) must equal 100. Reporters cannot submit their report if errors are present. This saves considerable analysis time for the office staff.

All reports are weighted by county and summarized to the state level. Some larger states also summarize to a district level, which is a pre-defined grouping of counties smaller than the state. Weights are established according to standardized national rules. Generally, published annual county estimates of crop acres or number of livestock are used to weight county data to the state level. Census of Agriculture data (published every five years) are used as county weights in the absence of annual data. Once the system creates the summaries, state staff review them for reasonableness relative to previous week estimates, earlier stages of development, and historical averages.

State-level data are weighted and summarized to the national level using the same standardized rules for state-level crop acres and livestock numbers. Using the standardized weighting rules is one of the major changes made in 1985. The Headquarters staff performs the same review for reasonableness. Analysis screens are built into the computer system so review can occur at a very quick pace. Report creation is automated and streamlined to reduce the time needed to generate the final report. This allows the maximum amount of time for data review.

4. The weekly survey process

The Crop Progress report requires rigid timing to maintain the weekly publication schedule. Prior to April of each year, NASS Headquarters and state staff provide reporters with a schedule showing each week’s expected questions for the growing season, standardized terms and definitions, weekly due dates, and step-by-step reporting instructions. The actual questions asked each week may vary from the initial schedule due to weather events such as major flooding or drought. However, because NASS has been conducting the weekly survey for about 100 years, there is a vast amount of data on which to base the initial schedule and it often proves true. The general goal is to publish each progress item when it reaches about 5 percent and to stop publishing when it reaches about 95 percent. Reporters and state staff are trained to monitor progress and anticipate the next week’s requirements, so little Headquarters oversight is needed.

Because the reporting window is so small, especially on Monday, NASS makes every effort to prevent anything from going wrong by preparing reporters as much as possible before the growing season begins. Headquarters staff, located in Washington, D.C., provide state staff training on the survey process and computer systems. State personnel work with county reporters. Reporters often have a backup identified in their county if they are unavailable to report for a week.

Beginning the last week of March or in early-April, the national weekly survey process begins each Tuesday. Headquarters staff determines the items to be published in the national release. By Thursday, state personnel determine the items to be published in the state release and activate the computer system for the reporters. The reporters are notified the system is ready and they are able to enter their estimate for all questions asked. They are asked to provide progress and condition for the week ending on Sunday. Reporters have until Monday morning to submit their responses. This provides a longer window to report over the weekend and Monday morning, but also provides some statistical rigor so the reports are comparable and reliable. The common Sunday reference date was one of the biggest changes made in 1985. Prior to 1985, the reference varied by state from Friday to Monday.

NASS strives for an 80 percent response rate week, but there is little time Monday morning to

contact reporters if response falls below this level. Many states reach 80 percent easily, but some do not. States may call a few reporters to obtain as many reports as time allows. However, time is short and all states must analyze, summarize, and submit their estimates for all items by 1:00 p.m. or 2:00 p.m. Eastern Time depending on time zone.

Each week for each item published, the state must submit the current year estimate, last year's estimate, and the five-year average. Last year's estimate and the five-year average must be adjusted to the current year reference date and calculated at the beginning of each year. For example, if the current year reference date is June 9, 2013, then the closest reference date to this week last year is June 9, 2012. However, last year's reference date was not June 9, but June 10, 2012. State personnel adjust the value to reach the current reference date by following standard procedures established by Headquarters.

About mid-morning on Monday, state personnel review individual reports for accuracy, evaluate response rates, and call reporters if needed. Staff then summarize all reports, analyze the results compared with last week's summary and the weather conditions across the state, and finally, set the official recommendations for the state. Senior staff at the state level review these recommendations, then submit them to Headquarters.

By mid-day Monday, Headquarters staff start to see state recommendations and can begin the national analysis and review of the major-producing states. Once all state recommendations are received, national-level summaries are run. Maps and charts of the data are generated allowing the Headquarters staff to quickly review the state recommendations in relation to surrounding states. National recommendations are mostly a summarized weighting of the state recommendations. Headquarters staff compare the national recommendations for each item with last week, the five-year average, and the weather conditions across the country. The Headquarters staff will discuss any anomalies with state personnel and adjust as needed. However, time is short, so any changes must be made quickly. Final national and state estimates are reviewed by senior staff then submitted for publication.

The Crop Progress report is released to the general public "after" 4:00 p.m. Eastern Time. This is the only report NASS may release "after" a certain time. All other reports are released as of a specific time of day. Due to the very short processing time and the potential for issues to occur earlier in the day, more time may be needed to generate the report. Fortunately, delays rarely occur and the release is usually issued on time. When delays do occur, the report is generally released within one or two hours.

The Crop Progress report contains only numerical data. A second, companion report titled "Weekly Weather and Crop Bulletin" is jointly prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and USDA. The companion report provides weather, climate, and agricultural developments, in both numerical and narrative form, along with detailed charts and tables of agrometeorological information. NASS field office staff submit written narratives following a standard format by 4:00 p.m. Eastern Time on Monday. The Headquarters staff uses these narratives to write a national narrative that is published in the Weekly Weather and Crop Bulletin. The bulletin is released every Wednesday by 12:00 p.m. Eastern Time.

5. Report usage and the future

State- and U.S- level progress and condition estimates are used by producers, agribusinesses, and traders to assess current growing conditions in order to reduce or eliminate inherent risks of doing business. Other users include federal, state, and local government agencies, educational institutions, agricultural economists, and others for planning, decision making, and research. The Crop Progress program has been a staple in NASS' survey program for a century and complements one of our newest and most innovative products called VegScape (http://nassgeodata.gmu.edu/VegScape).

Earlier this year, NASS launched this new state-of-the-art, satellite-based U.S. crop condition vegetation assessment and monitoring service. VegScape delivers interactive vegetation indices so that web users can explore, visualize, query, and disseminate current vegetative cover maps and data without the need for specialized expertise, software, or high end computers.

The agricultural community, policy makers, researchers and other interested parties now have a tool for policy decisions, scientific inquiry, and educational efforts. New satellite-based data are loaded on a weekly basis during the growing season. One can compare year-to-year change for 12 years; compare conditions at a given time to mean, median and ratio vegetative cover over the 12 year span; and overlay a crop mask to help identify crop land versus

non-crop land, among many functions. In most cases, the deeper the green color on the maps, the stronger the plant vigor, while yellow/brown indicates poorer conditions.

Vegetation indices, such as the NDVI (Normalized Difference Vegetation Index) and mean, median, and ratio comparisons to prior years have proven useful for assessing crop condition and identifying the land area impacted by floods, drought, major weather anomalies, and vulnerabilities of early/late season crops. Additionally, the National Aeronautics Space Administration's MODIS satellite that NASS uses for this project provides imaging at 250 meter (15 acres) per pixel resolution and 12 years of data history. The high-quality spatial information and daily satellite overpasses deliver detailed timely crop-specific condition information. Additionally, the data can be directly exported to Google Earth for mashups or delivered to other applications via web services.

VegScape supports the ethos of data democracy by providing free and open access to digital geospatial data layers using open geospatial standards, thereby supporting transparent and collaborative government initiatives. NASS developed the service in cooperation with the Center for Spatial Information Science and Systems, George Mason University, Fairfax, VA.

6. Conclusion

This paper explained the various types of survey data available from the NASS Crop Progress report and how data users such as producers, traders, agribusinesses, and researchers utilize the information to monitor crop conditions and production prospects during the growing season. The weekly reports provide valuable and frequent updates on the current progress and condition for both crops and livestock. The use of common questions about crop and livestock condition and the standardized weekly survey process provide valuable consistent information at the national and state level. The power of the weekly report lies in the flexibility of having over 3,000 potential questions to ask each week, the informed reporters who provide data, and the fast processing time. There are many opportunities for use of more high-tech products and advances like the new VegScape product, but data from the Crop Progress program will continue to be a valuable cost-effective resource.

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The Place of 'Assessment' in Current Agricultural Statistics for Developing Countries: making best use of available information for timely crop production estimates in the absence of a system of agricultural sample surveys

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1. Introduction

Accurate and timely information on area, yield and production of key agricultural commodities is essential to design and implement effective agricultural development and food security policies. In many developing countries, early warning information and forecasts on crop production can be critical for timely interventions to help improve the food security of the population at risk.

Data on food and agriculture can be classified in 3 categories depending on their sources (P. Delorme, 1984):

1. Results of statistical surveys (sample surveys or complete enumeration through censuses);
2. By-products of administrative processes (administrative, management reports, technical reports from research);
3. Estimations made by experts and through other qualitative/subjective methods.

It is recognised that sample surveys and censuses using rigorous statistical methods remain the most reliable source of agricultural data. However, the reality in many developing countries is that a large part of current data being produced and disseminated through national, regional or global databases, or publications are from various sources, due to the absence of regular statistical surveys or censuses conducted by countries[1]. Even in more advanced countries, 'assessment' methods have their place in the agricultural statistics system. In an IFPRI discussion paper (2011), A. Fermont and T. Benson report that 'in the 1990s, several European countries, including Germany, The Netherlands, Belgium and Ireland used *eye assessment* to estimate crop yield for their agricultural statistics'. The paper also indicates that the United States and Australia 'eye assessment has been upgraded through combination of visual assessment, field measurement and empirical formulas to a so-called expert assessment method'.

At country level, extensive use is made of methods other than statistical surveys and censuses to generate current data. These alternative methods[2] mainly use subjective/qualitative approaches as opposed to direct measurement from sample surveys. These include use of administrative sources, eye estimates by local informants, expert opinion or assessment, windscreen surveys, rapid appraisal methods, community/village surveys and other subjective methods. The limitations of these methods are well known - namely, a lack of representativeness, high levels of subjectivity and the impossibility of calculating any sampling error or confidence interval.

This is why one of the key objectives of the Global Strategy to improve agricultural and rural statistics (GS) is to develop survey infrastructure and cost-effective survey methods that can be affordable to a large number of countries and build capacity of national staff so that these methods become the main source of key agricultural data.

Nevertheless, despite the criticisms and limitations from the statistical point of view, alternative methods of generating agricultural data will continue to play an important role in any agricultural statistics system in developing countries for several reasons, and statisticians will have to live with this reality.

These reasons are discussed below, namely:

Limited statistical capacity and high cost of sample surveys and censuses

Proper and rigorous scientific statistical methods require substantial financial resources (the cost of the enumeration, including staff and the high travel costs for example, are an important component of any survey in most countries), skilled human resources and strong statistical institutions. These conditions are lacking in many countries, and additionally many surveys are donor dependent and not regularly budgeted for in national

budgets and it will take some time to upgrade the existing systems.

Need for regular, timely data

Even in countries where censuses and surveys are conducted, these activities are likely to be implemented with multi-annual frequency. Governments are increasingly demanding more frequent data on a yearly or even sub-annual basis. This is particularly the case for certain areas such as prices, where economic volatility has resulted periodically in rapid and wide ranging fluctuations from past trends.

Need for small area data

The surveys will also not be able to provide data at very low geographical level which is increasingly a requirement in many countries with governments moving towards decentralisation and development of local plans and monitoring and evaluation systems. In some instances, poverty monitoring, government policies require an understanding of local conditions for implementing poverty relief measures.

Need for timely data for early warning data

For early warning and emergencies, where a rapid response is essential, a balance must be made between accuracy and timeliness of information. It may be more useful to have rapid but imperfect data rather than accurate estimates with a long time lag. In many countries, there is a strong need for early warning and pre-harvest crop forecasting data to inform governments, marketing boards and other users on the prospective food and crop situation and harvest. This need can hardly be met in time from statistical surveys given the time needed for collecting and processing large amounts of data[3]. Therefore, survey estimates are not produced quickly enough to be available for use to provide early warnings of impending problems.

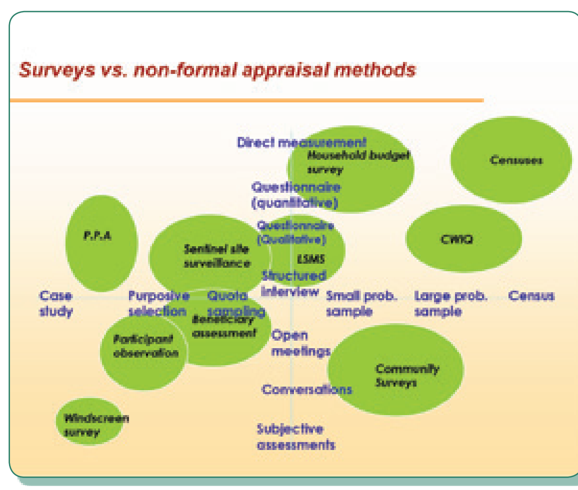
Need for in depth data

Sample surveys using questionnaires are most suitable for describing facts and providing a quantitative measure from a representative sample that can be expanded to the whole population. This type of data collection will provide an overview of what is happening on the ground. However, policymakers often need more detailed information on why something is happening. This is often necessary in order to give a more complete understanding for policy formation. This type of explanatory information is better provided through qualitative methods which can complement the survey data.

One data source is not suited to all data needs. The timeliness, scale and frequency of data for long term agricultural policy development and monitoring will differ from that for emergencies and early warning and responses to rapidly emerging situations in a volatile economy.

Figure 1 (FAO/WB, GDPARD, 2008) shows various ways of collecting information using both qualitative and quantitative approaches. The vertical axis shows an increasing continuum from subjective to objective measures: ranging from subjective assessments such as windscreen surveys to direct measurement using sample based methods. The horizontal axis shows a continuum of representativeness: from the less representative, such as case studies to full enumeration through censuses.

Figure 1: Quantitative and Qualitative approaches to collecting information (FAO/WB/GDPARD, 2008).



2. Analysis of common assessment methods

Some non formal assessment methods currently used in the agriculture sector are discussed below. The basic method is presented together with an assessment of their suitability for different data needs.

Routine reporting through local informants

Informants on the ground, such as extension workers, village and district leaders may be used

for reporting on crop production. The reporting systems range from ad hoc to more formal systems, for instance regular reporting, using standardized forms through the administrative hierarchy (village, wards, district, region, national), with each level responsible for consolidation of data to that adminstrative level. There are well known difficulties with use of local informants on data quality, such as bias in reporting by those whose perfomance is reflected in the results; and increased workload of the extension officers to produce reports which is outside the normal scope of work is burdensome and does not leave enough time to analyse the information collected.

Use of expert opinion/ windscreen surveys

[FAO/WB/GDPRD, 2008] provides an overview of the windscreen method. In this method the investigator (a specialist of a crop) drives around a defined cropping area before harvest and observes the crop of interest through the windscreen. He/she makes note of his observations and derives an expected percentage increase or decrease of the harvest. This method is highly subjective but cheap and quick. It is widely used by private companies for cash crops traded on world market. In Ghana and Cote d'Ivoire, for instance, forecasts for the forthcoming cocoa crop were made on the basis of expert assessment, with the expert viewing the crop by surveying a wide area by vehicle. During his field trip, the expert makes periodically detailed observations on selected trees. For other crops, such as food crops, experimented agronomists are often 'able to estimate crop production by visually assessing the conditions (colour, plant vigour, plant density, etc..) of the crop in the field' [A. Fremont and T. Benson in IFPRI, 2011].

[FAO/WB/GDPRD, 2008] suggests to introduce some systematisation, 'such as establishing a route and following the same route over time; simple counts of fields; and ordinal measures of crop conditions such as "very good", "good", "average", "poor" or "very poor" which can be conducted rapidly, can improve the quality of these information'.

Agronomists and livestock specialists working in the field or in research stations for several years develop an empirical knowledge of crop yield or animal production parameters in the local geographical area that they work in. These techniques depend mainly on the expertise of the person making the assessment and require practical and technical familiarity with the production and yield of the crops and their performance in the specific environment.

More comparative studies are required to evaluate the reliability of the techniques but they should not be dismissed as a source of information as long as they are used as a complement to other more rigorous methods. They are particularly effective as early-warning information and can provide important insights if conducted by a knowledgeable expert.

Use of community surveys

In a community survey a community meeting is called (usually by the community heads) following the *standardized open-ended interview*, where open ended questions are asked by the enumerator to the community at large. Its purpose is to collect information about the community and the environment in which the sample households reside. Such information is collected at the community rather than the household level, because the answers will be the same for all households in the community.

[*WCA 2010*] includes recommendations for collecting community level data during the agriculture census where appropriate. Community surveys may be used to collect information on the communities' physical and social capital. In fact, in countries where the statistical infrastructure is particularly weak – such as in post-conflict situations – a community survey may be the best way of rapidly assessing what public services are most needed. Some countries in Asia such as Indonesia and Vietnam have used village surveys for food security early warning purposes.

A potential weakness of the community questionnaire approach is that the definition of a community is often difficult to pin down, particularly in urban areas, and it may not be feasible to use probability sampling to select the communities to be interviewed. It may also be the case that the views within the community differ, this is a particular concern where the views of the less powerful and marginalized in a community are not expressed. Care must therefore be taken to gather a representative range of views from the community, perhaps by holding separate meetings for those groups.

3. Limitations and principles for improving and making best use of assessment methods

It is therefore important for statisticians to analyze critically the alternative methods and their limitations in order to develop ways of improving (not promoting) and making best use of the information generated to fill statistical gaps or provide timely information for decision making. In assessing the most suitable method for particular data needs, countries should consider the data collection methods keeping in mind the overall purpose of use of information and constraints in a specific country context. Among the key factors to be considered when assessing the value of a particular method are: what is the minimum level of accuracy needed, timeliness, frequency, representativeness, scale and the financial and human resources. The ideal statistical systems are often set up for provision of regular collection through censuses and sample surveys, however, there is an increasing need to diversify data collections for differing data needs. For instance an emergency situation requiring rapid, 'fit for purpose' data will not suit the same data collection method as the data for national accounts which is required yearly and must be accurate at a national level.

How should this be carried out? This section discusses some principles for critical assessment and selection of subjective methods.

P. Delorme (FAO, 1984) classifies the main criticisms to subjective assessment methods in two categories:

- Existence of several assessment figures referring to the same variable. In this case the differences must be explained, a judgement made and synthesis of the figure carried out. The final synthesis is essential and should be carried out by the statistical service.
- Inconsistency between different assessments. These take the form of fluctuations in the time series, logical inconsistencies (large variations) between related variables, often explained by differing definitions and concepts used by those undertaking the subjective assessment, and a lack of cross-checking between related variables.

Delorme categorizes the errors into two types, technical and systematic, related to the cause of the error.

- Technical errors due to errors in the information collected and faulty extrapolation. This may be due to extrapolating from an unrepresenative case or biased sample, which is a particular issue of assessment methods which are not based on probability sampling methods. Technical errors can also be reduced by introducting a formal procedure for reporting.
- Systematic errors due to a conscious biasing of the assesments in a predetermined direction. This was discussed above as a particular problem with use of local informants for instance when there is a vested interest in increasing the estimates or where an informant does not have an objective view of a situation. Local informants are also not trained to be neutral observers and are thus more likely to produce systematic errors. This can be reduced by arranging for discussion group with informants of estimates such as prices, which are likely to be reported differently.

He finally proposes six principles for improving assessments:

1. Confine assessment to the smallest possible geographic area - the zone should be small enough that the informant has direct knowledge and observation of what he/she is estimating and reporting on.
2. Train assessors - in the basic principles or enumeration, common definitions and concepts, visualizaton of units of measurement and standard frames of reference for the measures, and use of a systematic method of recording information.
3. Assess variations and not absolute values as these are easier to perceive. Base year values are calculated from periodic sample surveys.
4. Search systematically for data able to strengthen or support the assessments to triangulate the results on the same variable.
5. Look for connections between the quantities estimated, these relationships between variables provide a useful check.
6. Harmonize and clearly define concepts and nomenclatures. This may be more difficult in practice with systems serving different purposes and run by different agencies, where harmonization would involve some degree of compromise in the concepts and definitions.

Principle 3 is particularly relevant to, and borne out by experience in integrated agricultural statistics systems where benchmarks are provided

by statistical surveys and censuses; and yearly/sub-yearly variations are often derived from assessment. The principles primarily address the issue of technical errors which can be reduced with appropriate training and development. Systematic errors remain more difficult to address, and although triangulation and cross checking of variables is useful, in practice the data sources may be limited and simply not available. Discussion of results among experts however remains valid and is a step forward.

4. Country examples

The country examples described below illustrate how some of the principles stated above have been applied to information from sources other than sample surveys to fill data gaps or by using assessment information in an integrated system articulating this information with statistical data from sample survey and census data.

CAPE VERDE: Filling data gaps in time series (mainly principles 4 and 5)

An FAO/IBGE mission to Cape Verde was requested to fill data gaps in time series regarding main horticulture, cash crop and irrigated agricultural production. The summary below provides an overview of the steps and methods followed by the mission (N. Keita & al., mission report, 2011).

A quick review confirmed that there was no operational statistical survey system for estimation of agricultural production except for rainfed agriculture.

The mission was to provide in a very limited time period, indicative figures on agricultural production for main commodities for compilation of national account aggregates. The mission analyzed the very specific context of agriculture in Cape Verde which is a small island country with irrigated agriculture and cash crops concentrated in a limited number of well known zones, well organized farmer organizations or cooperatives for some cash crops and national experienced experts. Also, the mission identified a large number studies, survey results, that contained sometimes valuable but dispersed and fragmented information relevant to crop production.

A multidisciplinary working group was set-up, including national experts from National Accountants, senior agronomists and livestock specialists from the National Institute of Statistics, Ministry of Agriculture and Research Institutions experimented and knowledgeable in various sub-sectors: livestock, horticulture, root crops, cash crops etc.

The general lines of the 'methodology' used can be summarized as follows:

- A review and evaluation of past methods and assumptions used for similar estimations, together with a detailed review of all existing relevant technical reports, studies and surveys to derive relevant key parameters.
- Data collection was limited to field information was collected on cash crops through regional agricultural offices and research institutions. Use of administrative sources, particularly relevant external trade data. These preliminary estimates were compared and cross checked with data from independent external sources and validated using expert knowledge from within the Ministry of Agriculture.
- Several scenarios were produced to give some idea of the range of the estimates given that differences in parameters could not be resolved in the time available.

A specific method was used to estimate horticulture production using:

- Information on seeds sold by the two main seed marketing Companies.
- Rate of usage of seeds derived from specialised studies and estimation of potential crop area.
- Average yield derived from crop cutting survey by statistical service of MoA.
- Correction factors based on information on seeds from non formal sector.

For 2010 for example, assessments for horticulture were made in two phases:

Phase 1 - estimation of area: by compilation of seeds marketed and estimation of area cultivated using average quantity of seeds per ha established by research institutions (taking into account germination coefficients). This area was cross checked with area estimated from an independent survey, including a recent survey covering irrigated sector.

Phase 2 - estimation of yield: by taking yield data from crop-cutting survey and comparing this to yield provided by research institutions and local experts. The derived production estimates were cross checked with data from recent consumption surveys, particularly regarding the average per capita consumption.

These assessments provide very rough approximations of orders of magnitude in the absence of statistical data and cannot be considered as precise estimates.

Several limitations were identified during this exercise:

Phase 1: The area estimates rely heavily on data on seeds taken from importation by two main marketing companies. However, this data was probably incomplete since in some cases the local production of seeds can be relevant, but no reliable data on this was available. Also omitted were the stocks of seeds by importers were unknown. The effect is a likely underestimation of the quantity of seeds. Some assumptions were made on the informal provision of seeds but with no serious ground.

Phase 2: Initial yield estimates relied on data from research stations and field trials cross checked with crop-cutting data were available. But several inconsistencies were observed and final decision relied mainly on expert judgment even if additional checks were made with per capita consumption where available and relevant.

MOZAMBIQUE: Integrated system using Census, annual survey and early warning information (Principle 3)

For several years there was systematically large discrepensies between Early Warning crop production forecasts (using non standard statistical methods) and post harvest estimates coming from annual sample agricultural surveys leaving the government and partners with two divergent estimates.

Using the Population and Housing Census 2007 (PHC 2007), followed by the second Agriculture and Livestock Census ('CAP II'), FAO assisted the governemnt in developing an integrated system to address the discrepancies between the annual survey and early warning system results. The summary below provides an overview of the methodology proposed (D. Megill and C. Creva, consultancy report, 2011).

A master sampling frame of enumeration areas (EAs) from CAP II was used to draw a sample for the annual production survey ('TIA') and a smaller sub-sample for the early warning system ('Aviso Previo) in order to ensure better consistency between estimates.

Since data from Aviso Previo is needed in a timely manner before harvest, a smaller sample was selected, even if it was known that sampling errors will be high at provincial level, priority being given to timeliness.

Another aspect of integration was to use CAPII results as reference and benchmark for estimation. Therefore, annual estimates were to be calculated as follows:

Preliminary estimates

$$\text{Preliminary estimates}_{2010/2011} = \text{CAPII estimates}_{2009/2010} \times \frac{\text{Aviso Prévio estimates- 2010/11}}{\text{Aviso Previo estimates- 2009/10}}$$

$$\text{Preliminary estimates}_{2011/2012} = \text{Final estimates from TIA}_{2010/2011} \times \frac{\text{Aviso Prévio estimates - 2011/12}}{\text{Aviso Previo estimates - 2010/11}}$$

Official final estimates

$$\text{Final estimates(TIA)}_{2010/2011} = \text{CAPII estimates}_{2009/2010} \times \frac{\text{TIA estimates- 2010/2011}}{\text{CAPII- estimates 2009/2010}}$$

$$\text{Final estimates(TIA)}_{2011/2012} = \text{Final estimates}_{2010/2011} \times \frac{\text{TIA estimates - 2011/2012}}{\text{TIA estimates - 2010/2011}}$$

Annual estimates based on this methodology will take advantage of benchmark data from the Agricultural Census or data from a sample annual agricultural survey.

The Aviso Previo will provide preliminary estimation of variation of the production of the benchmark from CAPII or final estimates from TIA. Improved consistency will be obtaoned between the two estimates.

5. Conclusion

In building cost effective and integrated agricultural statistics systems in developing countries, different sources of data and information should be considered to address different data requirements and needs of users in a specific country context. An effective system of sample surveys and censuses should be the basis of the statistical system. However, provision must also be made for data which cannot be provided by probability surveys: namely, rapid assessment for emergencies, monitoring and evaluation, unforseen economic events etc. In these cases, administrative and assessment information may be necessary. Nevertheless, issues for accuracy are inherent in the methods and there is a limitation as to the extent of improvements.

Where by necessity, non-formal assessment methods also need to be used for estimates of crop production, rather than just for rapid assessment, these limitations should be realized and clearly defined when producing the estimates. Decision makers should also be aware of the limitations of the data produced. In these cases, non formal methods should be seen as an intermediate step to producing data based on sample surveys. However, the usefulness of the methods lies in enabling provision of some information rather than none at all and more research is required to improve the quality of the information provided.

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Endnotes

1 For example, according to FAO monitoring system, about half or less of the data on primary crops production available in FAOSTAT for African countries as well as countries from Central America and the Caribbean countries come from official sources, the remaining data are estimated by FAO.

2 The information obtained using these methods are called here assessment as opposed to estimates from statistical methods in line with proposal by P. Delorme.

1 The increasing use of new digital and mobile technology is reducing the time lag between field data collection and availability to users (CAPI, smartphones etc.).

Appropriate Survey Methods for Different Country Profiles - key challenges, gaps and remaining methodological issues

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Abstract

Several kinds of approaches are followed for producing agricultural and rural statistics. The aggregation of the data collected by the extension workers is often used as agricultural statistics. In other countries, agricultural statistics are given by subjective estimates of experts. Other countries rely mainly on sample surveys, based on list or area frames or both.

Various possible methods for producing agricultural and rural statistics are analysed, in order to identify the most appropriate approach, given the characteristics of the country.

Then, the key challenges, the gaps and remaining methodological issues are discussed.

Keywords: survey methods; agricultural statistics; administrative data.

1. Introduction

In many developing countries, the quality and quantity of agricultural statistics are low and, in the last decades, have undergone a serious decline; see World Bank et al. (2011) and FAO et al. (2012). On the other side, allocating high shares of public resources to data collection for producing agricultural statistics is a difficult choice for most developing countries.

Statistically sound methods, based on probabilistic samples selected from complete and updated lists of farmers allow producing accurate and timely agricultural statistics if good quality data are collected through the interviews. These statistics are essential for knowledge based planning, in order to facilitate rural development and reduce poverty and food insecurity. However, traditional statistical methods are very costly. Consequently, there is a strong need to review the methods adopted in developing and developed countries, in order to assess how their cost efficiency can be improved. Moreover, countries have very different level of statistical information, statistical capacity, farm size, farmers literacy, availability and quality of administrative data, and so on. These differences should be taken into account when developing a survey designs for agricultural statistics. Some considerations on this topic are presented in this paper.

2. Different kinds of statistical information

Several countries follow the traditional approach for producing agricultural statistics, (see Benedetti et al., editors, 2010): a complete enumeration census of farms is carried out every 5-10 years. The census is carried out by interviewing all the farmers in the country. The census list is used for sample surveys of farms and is updated by integrating different kinds of registers or other kinds of administrative data. Data are collected through computer assisted personal interviews or computer assisted telephone interviews, email or mail.

Some developing countries follow the same approach and carry out complete enumeration censuses of agriculture and carry out sample surveys in order to produce annual estimates of the main variables. However, this is a very costly approach that cannot be followed by several developing countries. Moreover, updating the census list properly requests availability of large and updated registers; this is not always the case in developing countries.

Several developing countries follow different approaches. Particularly, in some of them, only the population census is conducted; generally, using an administrative structure in which cartographic or other mapping materials are used to divide the country into enumeration areas. Some of these countries include few specific agricultural questions in the population census questionnaire, in order to build up the list of farms to be used for sample surveys.

In many developing countries, a sample agricultural census is conducted: some enumeration areas of the

population census are randomly selected and screened for farms. These enumeration areas are considered as the agricultural enumeration areas and all or a subset of the listed farms are surveyed.

Finally, few countries generate the list of farms on the basis of administrative sources, such as business registrations or tax collections and do not conduct agricultural censuses.

3. Censuses and administrative data

Several North European countries are using registers more and more extensively, in order to reduce the cost and the respondent burden due to data collection (see for example Wallgren and Wallgren, 2007 and 2010). It is important to clarify that, in these countries, the registers are not used for direct tabulation, they replace the censuses, not the sample surveys. Registers, and not censuses, are used for building the list frame for sample surveys.

Even in Sweden, a country which initiated to make an extensive use of registers for statistics decades ago, the annual agricultural statistics are produced through sample surveys, based on a list frame built through registers, mainly tax files.

Subsidies are an important source of data in European countries; however, their use for direct tabulation is not feasible, as explained in Carfagna and Carfagna, 2010. In Sweden, for crops with subsidies based on surface and for other crops which are generally cultivated by the same farms, the bias is low, but for other crops the downwards bias can be about 20%; moreover, the subsidies in Europe are progressively less linked to the surface of cultivated crops.

Updating the list frame, generated by a census, through the subsidies register is not an easy task, consider that, in 2009, the business register and the farm register at Statistics Sweden were not harmonized yet (Wallgren and Wallgren, 2010).

The census list frame updated through the integration with registers can have a very low coverage for some categories of farms, as showed by a study conducted in Campania Region, in Italy, in 2002, two years after the census of agriculture (Giovacchini 2012). An area frame sample survey of farms cultivating flowers was conducted and the comparison was done with the census list updated with registers, like the register of farmers for the use of pesticides, not the subsidies register, since this kind of farms does not receive subsidies. The under-coverage, came out to be 48%; 54% if only farms with a surface smaller than or equal to half an hectare is taken into account, note that farms of this size account for 74% of farms cultivating flowers detected by the area sample survey. In this study, farms were selected through a grid of points located on the selected square segments; this means that farms were selected with probability proportional to size, thus larger farms are more likely included in the sample.

The cost and the respondent burden of a census of agriculture can be somewhat reduced through the generation of a pre-census list by integrating different kinds of registers or other kinds of administrative data. In fact, the census enumerators can be provided with the pre-census list of farms and a pre-compiled part of the questionnaire.

However, the quality of the pre-census list can be low also with good administrative data, very sophisticated record linkage procedures and geo-location of administrative information.

In several countries, agricultural statistics are computed by aggregating administrative data, like the declarations of extension workers and experts' guesses. The main task of extension workers is facilitating agricultural development by supporting farmers; thus they have a conflict of interest; moreover, generally they are note requested to follow specific rules (like taking into consideration specific fields and farms selected by the National Statistical Office or the Ministry of Agriculture) in order to come up with an estimate. These kinds of statistics show problems in terms of definitions, objectivity, timeliness, reliability and generally are not able to detect relevant changes in the time series, for a detailed analysis see Carfagna and Carfagna (2010).

4. Different surveys for different typologies of countries

Given the kind of information available in the country, the structural characteristics of the agricultural sector and the level of development of the national statistical system, different approaches should be adopted for collecting data for producing agricultural statistics.

Where a recent complete enumeration census of agriculture is available and the quality of this census is high, also from the coverage viewpoint, the list of farms created by this census should be used for sample surveys. In fact, the information at farm level collected through the census can be used

for efficient sample designs and, where possible, for interviews through mail, email, etc. (indeed, data collection through emails is still not widespread even in developed countries).

A major weakness is that the list rapidly becomes out-of-date. An out-of-date list of farms erodes all of the data quality dimensions because the completeness of coverage decreases over time, thus affecting the comparability and accuracy of the resulting estimates. If the quality of the agricultural census is poor, these problems are faced since the first round of the sample survey. Thus, the assessment of the quality of censuses is extremely important and the quality of a recently carried out census is not necessarily high. Despite of this, most countries do not test the coverage of agricultural censuses.

Where the agricultural census is old or its coverage is not complete or other aspects of its quality are poor, an area frame should be conducted. There are two meanings of an area sample survey, a restricted and a general meaning, as stated in FAO 1996 and 1988. An area sample survey designates, in the general meaning, a probability sample survey in which, at least for one sampling stage, the sampling units are land areas. In a more restricted meaning, an area sample survey designates a probability sample survey in which the final stage sampling units are land areas called segments and the selection probabilities are proportional to their area measures. Both approaches foresee the subdivision of the analysed territory into non-overlapping pieces of land, according to specific criteria, to create the area sampling frame.

Data for variables which cannot be directly observed in the fields, particularly socio-economic variables, are collected through interviews of farmers which operate the fields included in the selected area units (some estimators have been developed). When designing the sample, in order to prefix the number of farmers to be interviewed, thus the coefficients of variation for main parameters and increasing the efficiency of the sample design, taking into consideration the spatial autocorrelation, the farms can be selected by points in the sample area units, as described in Gallego et al., (1994).

In case a list of large, commercial farms (easy to update) and, in case, of other kinds of farms, can be created and multiple frame approach should be adopted, in order to reduce instability of estimates and increase their efficiency. A multiple frame is a combination of an area frame with one or more list frames, in order to take advantage of the strengths of the area frame (complete coverage also of small and subsistence farms and link with the land) and of the list frame (possibility to use characteristics of the farm -like size and type- in the sample design, easy identification of selected farms through their addresses, in some cases telephone or mail or email can be used instead of personal interviews, etc.). For technical details see Carfagna (1998) and Carfagna and Carfagna (2010).

If the agricultural census is not a complete enumeration census and some enumeration areas are randomly selected and screened for farms, the sampling frame for sample surveys consists of the agricultural census enumeration areas. This implies a two stage sample design based on the selection of the enumeration areas made before conducting the agricultural census, generally with very poor information related to agriculture. The main alternative to the use of this sampling frame is the multiple frame described above.

If a recent population census has been conducted using an administrative structure in which cartographic or other mapping materials are used to divide the country into enumeration areas, a traditional option is using the list of enumeration areas as sampling frame, although it is not efficient. A sample of enumeration areas is selected, the list of households in selected enumeration areas is created and a sample is extracted from each of these lists, following a two stages sample design. Also in this case, it is worthwhile evaluating if a multiple frame approach is more efficient.

A recent proposed comes from FAO and UNFPA (2012), for avoiding to face the cost of the agricultural census, and has been adopted in some countries like Mozambique and Burkina Faso: a list frame is created based on the population census, the list of farms or agricultural households identified on the basis of specific agricultural questions included in the population census questionnaire. This approach is promising for countries where agriculture is not an important economic sector, like small islands. More work is needed for testing the quality of data collected using long questionnaires and the coverage of the list of farms generated from the populations' census; particularly, the entity of under and over coverage in different categories of countries should be assessed. Finally, it should be taken into account that the list frame of farms generated through the module on agriculture submitted to the households

presents very few auxiliary variables; thus the efficiency of the sample designs for annual sample surveys is very low and this may have a strong impact on annual survey costs. For more details and an analysis of advantages, disadvantages and requirements see Keita and Gennari (2013) and Carfagna et at. (2013).

When a sample survey has to be designed in countries where the list of farms is based on the integration of various administrative sources, such as business registrations, tax collections, and subsidies registers, much attention has to be devoted to the risk of under-coverage, especially units below a threshold required to be registered or pay taxes are generally excluded, as well as those which do not apply for subsidies. The under-coverage and over-coverage have to be carefully checked before using such a list. In fact, while this kind of list generally include commercial farms, they are not likely to include small-scale farms and subsistence farming units (see Carfagna and Carfagna, 2010 and Carfagna et al., 2013).

Concerning the over-coverage, an interesting test has been carried out in Italy on a sample of 15,682 farms included in the pre-census list generated through a very careful integration of registers, including subsidies register, and using sophisticated record linkage procedures. It showed that only 39.15% of the farms in the pre-census list existed and were active at the census date; 44.74% of these farms were not active (over-coverage) and the pre-census test was not able to assess the existence of 16.11% of these farms (Berntsen and Viviano, 2011). This level of over-coverage suggests that the integration of different kinds of administrative data exposes to a high risk of over coverage and should be made only where the reliability of these data is very high and the definitions adopted are compatible with the ones of the census.

In case the over-coverage and under-coverage are high, it is advisable to use the registers for creating the list of commercial or large farms, reducing the size of the list and the risk of over-coverage, and combine it with an area frame for accounting for the under-coverage.

The kind of area frame to be adopted - area frame with or without physical boundaries, clustered or un-clustered points, transepts - depends on the characteristics of the country; for a detailed description see Carfagna (1998 and 2007).

5. Reliability of data collected through surveys

In this session we focus on one aspect of non sampling errors, that is the reliability of farmers declarations.

In principle, this reliability tends to be higher for larger farms and higher education level of the farmer. Indeed, assessing this reliability is quite difficult for variables which cannot be observed on the ground by the enumerator, typically socio-economic variables.

Let us focus on the area of fields and on possible ways for increasing its reliability.

In the framework of the project GCP/INT/903/FRA, the Statistics Division of FAO conducted pilot surveys in Cameroon, Niger, Madagascar and Senegal. For each field, the self reports of the farmers and the estimates of the enumerators where collected and the area was measured with the traditional method (compass and rope) and with a standard GPS (about 250 USD). Unfortunately, the kind of crop cultivated was not reported; thus we can draw just general conclusions; in fact the reliability of self declaration for market crops should be higher.

If we consider compass and rope as the gold standard, we can notice that the self reports of farmers tend to overestimate the area of fields, see Carfagna et al. (2013).

The compass and rope measurements minus corresponding self reported measures against compass and rope measurements confirms the tendency of self reported measures to overestimate the area of fields, particularly for small fields, as already noticed by several authors, see De Groote and Traoré (2005) and Carletto et al. (2013).

Self reported field measures are not a good proxy for estimating the area of fields measured with compass and rope (Stock and Watson, 2003); in fact, the experiment conducted by FAO shows that the R-squared is only 0.5919, the slope is 0.5694091 and the constant 1,022.847.

Additional research is needed for assessing if the self-declarations can be improved if the fields are showed on a map to the farmers during the interview. This is generally the case when an area frame is adopted.

This experiment suggests to be very careful when farmers declarations are used. Indeed, for most of the variables collected through an interview, only some consistency checks can be done and no real comparison with a reliable measurement instrument.

The farmers tend to overestimate the area of the fields, instead the enumerators tend to underestimate the area, in fact the median of the paired difference, on each observation, between the area measured with

rope and compass and the estimate of the enumerator is 50 square meters and the median of the relative difference is 0.0555556%. However, the parametric and non parametric tests (Stock J. H., Watson M. W.,2003 and Student, K. Pearson,1931) we have made have showed that the distribution of measurements with compass and rope and enumerators guesses are not significantly different.

Using the guess of the enumerators as a proxy for estimating the area of fields measured with compass and rope is less risky than using the self reported field measures. In fact, the R-squared is 0.7859, the slope is 0.8293134 and the constant 382.6549.

The objective measurement of the area of fields can be used for benchmarking self reports also for other kinds of information, at least as an alert, in case the discrepancy is high. So, the measurement of the area of the fields should be made even if self declarations of the farmers are collected. Unfortunately, measuring the area of the fields of a farm with the compass and rope proven to be time consuming and very cumbersome.

A standard GPS allows reducing the time needed for the measurements in the average of one third. The same experiment proved that that the measurements with GPS receivers are generally accurate, although the accuracy tends to be lower for very small fields, particularly under dense and partial tree canopy cover (due to the low quality of the signal), for more details, see Keita and Carfagna (2009).

Therefore, we would suggest measuring the area of fields with a GPS, when the quality of the signal is good and the fields are not too small (for very small fields the use of compass and rope is suggested) for two aims: collecting accurate measurements of the area of the fields and using the area of the fields as a warning for the reliability of socio-economic information when the discrepancy concerning the area of fields is high.

When an area frame is conducted, the enumerator sees at least some of the fields of the farm and can play the role of the warning tool even if the area of the fields is not measured with compass and rope or GPS.

6. Conclusions

Different kinds of approaches for producing reliable agricultural statistics have been analyzed, and most appropriate ones are identified, according to the kind of information available in the country and the agricultural characteristics of the countries. Sampling frames based on agricultural census, population census, administrative registers and area and multiple frames have been taken into consideration.

Our conclusions are that the most appropriate approach depends on the specific characteristics of the country and that some aspects of the implementation of some approaches need further research, like the over and under coverage of list frames created integrating various kinds of administrative data or when a module with a few questions concerning agricultural variables is included in the questionnaire for a population census.

Another aspect to be further analysed, in the contest of developing countries, is the identification of the farmers when they are selected through an area frame and they live far from the fields they operate. The average time needed for identifying the farmers and the risk of missing data, in the different typologies of developing countries should be assessed.

Finally, we have highlighted the risk of collecting unreliable data through farmers interviews and proposed some preliminary ways for addressing this problem.

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Statistical Production Process (SPP)

Plenary Sessions

Plenary Session 2

The Role of Agricultural Censuses[1]

Organizer: Pietro Gennari, FAO

For several decades, FAO has been promoting and supporting the conduct of decennial census of agriculture by its Member Countries. On average, about 100 countries have been implementing the programme in each round.

The 2010 round of FAO World Programme for Agricultural Census (2006-20015) included several innovative approaches for improving the relevance and cost-effectiveness of data collected through agricultural censuses. It foresaw the census as a key component of an integrated programme of agricultural census and survey. The new features included use of modular approach to data collection, exploring linkage between population and agriculture censuses and community level data.

As preparations are being made for the next round of Agricultural Census (2016-2025), there is a need to take a fresh look to the programme and discuss questions on the relevance of the agricultural census for addressing emerging data needs and learned from the new approaches recommended during the past round.

This Session will discuss the relevance and future of agricultural censuses for addressing emerging data needs. The Session will also discuss technical issues related to cost-effective approaches to agricultural surveys in different country contexts, including use of information from administrative registers like cadastre, livestock, business, tax and subsidy registries and area frames. Use of new technologies to collect geo-referenced data as well as for reducing the time lag is also planned to be covered under the session.

Paper:

- Naman Keita (FAO), "Vision for the 2020 round of Agricultural Census"

Discussants:

- Fred Vogel (International Consultant), "A new paradigm for agricultural statistics - a world without censuses"
- Jean-Michel Durr (International Consultant), "Lessons for the Agricultural Census from innovations in the Population Census methodology"

Endnote

1 Papers not available. The presentations can be found at the conference website.

Summary

A paper by Naman Keita (FAO), prepared jointly with FAO Statistics Division Census Team, presented the vision for the coming WCA 2020 round. It was noted that the guidelines for the WCA 2020 round will have to take into account the new international development agenda (Post 2015 and Sustainable Development Goals, Green growth) and other emerging policy issues (Rural employment and gender, Food Security, increasing volatility of the agricultural industry). Measuring impact of development policies and programmes is also gaining growing importance. This leads to expanding data requirements. At the same time there are increasing resource constraints and need for more timely data. This implies that in the next round intensive use should be made of digital/mobile/geo information technology and data revolution (PDA, GPS, CAPI). The methodological features of the previous WCA 2010 round which worked well (modular approach, linkages with population census, collection of community level data) will be maintained. Lessons learnt from methodological and technological innovations in Population Censuses (growing use of administrative data, rolling census) could also be useful. New Global initiatives in the area of Statistics (Global Strategy, AMIS, Busan Action Plan for Statistics) create new opportunities. Many issues connected with data items to add/revise, classifications, processing, dissemination (including archiving and access/dissemination of micro–data) and analysis, which arose during the extensive consultation process with users and countries, will be considered during the elaboration of the WCA 2020 Programme and accommodated to the extent possible.

A paper by Fred Vogel (presented by Mark Harris, USDA-NASS) discussed an alternative approach for producing agricultural statistics at the lowest geographical level – a world without censuses. The underlying idea is using surveys based on area frames for obtaining agricultural statistics. In this paradigm the traditional role of census in creating a list frame of agricultural holdings is denied in favour of area frames which also provide a complete coverage of the country territory. The Area frame is more stable over time, but its creation may have high cost implications for developing countries (although with development of technologies this may cease to be an issues). Moreover, area frames may not be appropriate for the collection of certain types of data (e.g. social data).

A paper by Jean Michel Durr described the experience in conducting rolling population censuses in France. A rolling population census means splitting the population into a number of mutually exclusive representative samples and enumerate one sample per year, completing the whole enumeration within a number of years. In case of France the number of years required is 5. The rolling census approach has several advantages: a) the cost of the census is spread over many years; b) high level professional staff is maintained continuously; c) non-sampling errors are reduced; d) is well compatible with the modular approach and integrated survey framework – each year different modules may be attached to the core module; e) each year updated information are produced as available for a large part of the population (traditional census data are 5 or 10 year old at the end of the cycle). The possible disadvantage is that data at lowest geographical levels might not be available. But this will be a problem during first transition years. As more information comes in, moving average method can be used to obtain estimates at detailed level. Transition to the rolling census is a change of paradigm: while traditional census is something like a photo, the rolling census follows changes.

The general conclusion of the session was that Agricultural Censuses must adapt to the new environment and emerging data needs and take advantage of the new technologies and methodologies. The next WCA 2020 Programme must strongly advocate the use of new technologies in both data collection, processing and dissemination. It should also provide countries with various methodological options (like use of administrative data, rolling census, area frames) in their endeavour to decrease costs and respondent burden and meet increasing data needs.

Technical Sessions

SPP 1
Master Frames for Agricultural and Rural Statistics

Organizer and chair: Elisabetta Carfagna, FAO

A master sampling frame is a sampling frame that provides the basis for all data collections through sample surveys and censuses in a certain sector, allowing to select samples for several different surveys or different rounds of the same survey, as opposed to building an ad-hoc sampling frame for each survey.

The aims of the development of a master sampling frame are: avoiding duplication of efforts, reducing statistics discrepancies, connecting various aspects of the sector, allowing the analysis of the sampling units from the different viewpoints, and having a better understanding of the sector.

By definition, a sampling frame, must cover the entire survey population exhaustively and without overlaps. According to the type of information available in a country, different kinds of frames can be used for selecting sample units for sample surveys covering the various relevant aspects of agricultural statistics.

The ways in which the concept of master sampling frame can be applied in the different kinds of countries will be discussed, ranging from the use of population and/or agricultural census to area frame, with a focus on problems linked to the implementation of master sampling frames.

Papers:

- Pietro Gennari, Piero Demetrio Falorsi, Clara Aida Khalil (FAO), "An Extension of Indirect Sampling in the Context of Multiple Frame Surveys as a General Approach for Designing Unbiased Integrated Sampling Strategies"
- Francisco Javier Gallego (Italy), "The Use of a Point Sample as a Master Frame for Agricultural Statistics"
- Aberash Tariku Abaye (Ethiopia), "Master Sampling Frames for Agricultural and Rural Statistics in Ethiopia"
- Nomzwakhe Sephoko, Limakatso Matsoso, Machitja Raphoto (Lesotho), "Master Sampling Frames for Agricultural and Rural Statistics - experience of Lesotho"

An Extension of Indirect Sampling in the Context of Multiple Frame Surveys as a General Approach for Designing Unbiased Integrated Sampling Strategies[1]

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Abstract

The Global Strategy to Improve Agricultural and Rural Statistics, endorsed at the United Nations Statistical Commission in February 2010, underlines the need to ensure the consistency and the integration of agricultural statistics into national statistical systems, allowing building agricultural statistics in which the information on land parcels, households and farms are interlinked. The sample strategy presented in this paper achieves this strategic objective and simultaneously provides consistent statistics on the environmental, social and economic dimensions of agriculture. The methodological approach extends the use of indirect sampling to the case in which one wants to produce integrated estimates on three target populations in the context of Multiple Frame surveys. The proposed techniques are quite flexible and may be tailored to the different informative contexts which characterize the production of agricultural statistics in developing countries. Furthermore, under quite general conditions, they allow to produce unbiased statistics, overcoming the majority of the problems caused by imperfect sampling frames.

Keywords: Generalized Weight Share Method; Multiple Frame surveys; units multiplicity; Global Strategy.

1. Introduction

The Global Strategy to Improve Agricultural and Rural Statistics (GS), endorsed at the United Nations Statistical Commission in February 2010, is a comprehensive international program of statistical capacity development which aims at strengthening the availability and the quality of agricultural statistics in developing countries. The main purpose of the Global Strategy is that of providing a framework for national and international statistical systems that enables them to produce and to apply the basic data and information to guide the decision making required for the 21st century (FAO, 2011). In this context, the GS underlines the need to ensure the consistency and the integration of Agricultural Statistics into National Statistical Systems, allowing building statistics in which the information on land parcels, households and farms are interlinked. In fact, through the integration of different data sources it is possible to achieve a better coverage of specific statistics for which a suitable solution cannot be found only surveying one population. For instance, if the data for the estimation of the production of crops and livestock come from surveys based on separate samples, it is impossible to analyse the economic characteristics of farms involved in both crop and livestock production vs. those specializing in only crop or livestock production, assess how agricultural production activities affect the well-being of the farms and rural households and evaluate their foot print on the environment. Besides that, an Integrated Survey Framework may offers the opportunity to compare sample unit data across time and across sectors, providing a major validation tool to improve data quality.

In order to ensure the consistency and the integration of agricultural statistics into national statistical systems, the GS stresses the need to build a Master Sampling Frame (MSF) where information on land parcels, households and farms are interlinked, thus allowing to simultaneously cover the environmental, social and economic dimensions of agriculture. However, many problems have to be taken into account. For instance, it is not always possible to build a MSF and, even when it is possible, the MSF becomes quickly outdated, and the survey enumerators may encounter an actual situation quite different from that represented in it.

Although the MSF allows establishing an effective link between the different statistical units, important sampling and estimation problems still remain to be

addressed even in a simplified context where a single multipurpose survey is used to collect and disseminate statistics for the three target populations. These problems can be tackled by adopting Indirect Sampling strategies (Lavallé, 2007) as a unified approach for both sampling and direct estimation.

This paper aims at describing the first results of a research project, conducted within the research program of the GS, and illustrates the main elements and properties of a unified survey sampling strategy which ensures at the same time the consistency of survey estimates and the correction of frame imperfections. The present paper is organized as follows. In section 2 brief descriptions of the Indirect Sampling approach and Multiple Frame surveys are given and the concept of multiplicity is introduced. The notation and the parameter of interest are introduced in section 3. In section 4 the alternative strategies for sample selection are illustrated. Then the expression of the estimator to be used in the outlined context is given in section 5, extending the Generalized Weight Share Method estimator. Finally, in section 6 some brief conclusions are given.

2. Background: Methods for dealing with Frame imperfections

In the next sections of this paper, an observational strategy to achieve the Integration in the field of Agricultural Statistics will be developed. The strategic idea of this approach is the following: starting from the direct observation of a first population, the units of the other populations are indirectly surveyed resorting to the existing links with the units of the first sampled population. Thus, as in the indirect sampling approach, the second population can be considered as sampled from an imperfect frame, i.e. the one referred to the first population. Moreover, we consider the hypothesis, particularly plausible in developing countries, of frame imperfection also for the observation of the first population. Thus, a Multiple Frame approach is proposed. In synthesis, in this article we present an extension of methods (indirect sampling and multiple frame surveys) dealing with different kinds of frame imperfections.

Obviously, in any conventional survey the random selection of the sample require the availability of an updated list recording all and only the individuals eligible for the survey, each identified by a label. This perfect list, i.e. the sampling frame, is used to identify the elements of the target population. When the sampling frame is available, one focal statistical issue is the assessment of the actual coverage of the target population. A sampling frame is perfect when there is a one-to-one mapping of frame elements to target population elements. However, perfect frames are seldom the case in the statistical practice and there are always problems that disrupt the ideal one-to-one mapping.

For instance the sampling frame can suffer of either or both of Under-coverage and Over-coverage. Under-coverage happens when the available frame is incomplete, including only a part of the target population; therefore the missing elements cannot appear in any sample drawn for the survey. Over-coverage occurs when the sampling frame contains duplications of the same units or units not included in the target population. However, in statistical practice it is possible to encounter frame imperfections of other kinds. For example, in some circumstances it happens that one does not have the desired collection units, but rather another frame of units linked in a certain way with the list of collection units. Besides that, also when a frame is available, in dynamic environment it becomes quickly outdated representing a situation quite different from the actual one.

In the present paper all this problem are simultaneously taken into account in developing a unified sampling strategy that enables us to achieve the integration in the field of agricultural and rural statistics for developing countries.

2.1 Indirect Sampling

Indirect Sampling (IS) is a recent strategy for dealing with imperfect sampling frame situations first proposed by Lavallée (1995) in the field of social and economic surveys in which there is an actual lack of a sampling frame directly representing all the target population units so that an indirect sampling frame has to be used instead. Thus, we consider two populations U_A and U_B that are related to one another, where one wants to produce an estimate for U_B which is divided in N clusters. Unfortunately, a sampling frame is only available for U_A. It can then be considered to select a sample s_A from U_A in order to produce an estimate for U_B by using the correspondence existing between the two populations. Note that if unit $j \in s_A \subset U_A$ is linked to a unit in the cluster of population, U_B then each unit of k is surveyed too. This can be designated by Indirect Sampling (Lavallée, 2007).

In the field of IS, computation of estimates for a target population U_B can be challenging, especially if the existing links among the units of the two populations considered are not one-to-one. The main difficulty is that of associating an inclusion probability to the surveyed units of the target population.

In order to solve this type of estimation problem, the Generalized Weight Share Method (GWSM) has been developed by Lavallée (1995, 2002), and presented also in Lavallée and Caron (2001). The GWSM provides an estimation weight, basically a weighted average of the survey weights of the units of the sample s_A for every surveyed unit of the target population U_B.

In the following sections, one of the main strengths of the GWSM will be shown, i.e. its ability to overcome the necessity of knowing the selection probabilities of the units observed through IS. In particular, an extension of the classical approach proposed by Lavallée will be presented, considering the case of three target population of interest (the populations of households, farms and land parcels) and assuming that an entire set of frames is available for the population from which the sampling starts.

2.2 Multiple Frames Surveys

As surveys on special, rare and difficult-to-sample populations are becoming more prominent, a single list of population units to be used as a sampling frame is often unavailable or inadequate in sampling practice. In a Multiple Frame (MF) surveys a set of at least two frames, singularly partial and possibly overlapping, is used instead of a traditional single frame of units from the target populations. Multiple frame surveys were originally introduced (Hartley 1974) as a device for reducing survey costs by achieving the same precision as a unique-frame survey. Recent Literature considers multiple frame surveys with the main aim of increasing population coverage, improving response rates and capturing differences and subgroups more accurately. A wide number of estimators have been developed according to alternative approaches to multiple frame estimation but all relying upon the virtual partition of the set of the available overlapping frames into disjoint domains. For instance, by taking Q sampling frames - $A_1, \dots, A_Q$ - (that may overlap) to cover the target population, $2^Q - 1$ domains mutually exclusive can be defined. In particular, for, $Q = 2$ three mutually exclusive domains can be defined: D_1 containing only the units belonging to frame, A_1, D_2 containing the elements that simultaneously belongs to both frames and D_3 constituted by the units belonging to the second frame A_2. Thus, the construction of the estimators requires the identification of the domain membership of each sampled units that could be a strong limitation for practical applications. In the present paper a different approach, named Multiplicity approach and first introduced in Mecatti (2007), to estimation in MF surveys is adopted. Multiplicity estimators require less information about unit domain membership hence they are insensitive to misclassification.

Following Mecatti (2011), we will see how the concept of multiplicity can be viewed as a unifying tool for Indirect Sampling and Multiple Frame Surveys, enabling us to build estimators that simultaneously adjust for the Multiple Frames situation and for the indirect selection of the sample.

2.3 On the concept of Multiplicity: a unifying tool for Indirect Sampling and Multiple Frame surveys

The concept of Multiplicity has been first introduced by Birnbaum and Sirken (1965) in presenting Network Sampling as a strategy for survey on rare or elusive populations. Also known as Multiplicity Sampling or Snowball Sampling, it constitutes a link-tracing sampling procedure in which the existing links are followed from one respondent to another in order to obtain a sample. Successively that links are taken into account in order to obtain an accurate estimate of the unknown quantity of interest. This sampling methodology applies for instance in estimating the country-prevalence of a rare disease when a frame completely representing the target population is not available. Selection units and target units may either coincide, be related or have no relation according to a one-to-many linkage rule. Thus, multiplicity is defined for every target unit as the number of selection units to which it is linked and a multiplicity-adjusted estimator is suggested. In the field of Indirect Sampling the idea of multiplicity is substantially the same except for the fact that we have now to consider a many-to-many linkage pattern. The generalized weight share method is suggested in order to adjust for possible data duplication at the estimation stage by providing an estimation weight for every target unit in the selected sample which is in fact a multiplicity adjustment. On the other hand, in the context of Multiple Frames surveys the multiplicity is defined as the number of frames from which a unit can be selected.

Thus, the multiplicity can be represented using two different matrices. In the field of IS, as in Network Sampling, the linkage pattern among the units of U_A and those of U_B can be entirely represented through a $M_A \times M_B$ matrix. Thus, the multiplicity is simply defined as the sum over the rows of the linkage matrix.

On the other hand, in the context of MF surveys the frame membership of each unit can be represented through an indicator variable. Thus, the multiplicity is given by the sum over the rows of the matrix reporting the frame membership indicator for the units of the target population.

Table 2.1: Links Matrix for Indirect Sampling.

U_B \ U_A	1...	j...	M_A
1			
.			
.			
.			
k		$1_{k \leftrightarrow j} = \begin{cases} 1 & \text{if } k \in U_B \text{ is linked to } j \in U_A \\ 0 & \text{otherwise} \end{cases}$	
.			
.			
.			
M_B			

Table 2.2: Frame membership indicator for a Multiple Frame survey [2].

$k \in \bigcup A_q$ \ A_q	A_1...	A_q...	A_Q
1			
.			
.			
.			
k		$1_{k \in A_q} = \begin{cases} 1 & \text{if } k \in A_q \\ 0 & \text{otherwise} \end{cases}$	
.			
.			
.			
M_B			

3. Notation

Let U_j be the unknown $j-th$ target population of interest at the current time t, being $j=1$ for rural households, $j=2$ for farms and $j=3$ for land parcels, and let N_j denote the population size in terms of elementary units. These populations are divided into K_j clusters, where K_j is the generic cluster of U_j with N_{k_j} elementary units. For instance, the clusters of population U_1 are households and the members of each household are the elementary units. As far as the farms are concerned the elementary units of each cluster could be defined in different ways: we could consider as elementary units the farm workers and the farm holder or, alternatively, we could refer to land segments that constitute the farms. Let ki_j denote the elementary unit i_j of k_j (being $i_j=1,\dots,N_{k_j}$). With y_{ki_j} we denote the value of the variable of interest y_j, (related to the population U_j), observed on the unit i_j of the cluster k_j. In the case of a quantitative variable directly referred to the cluster (for instance the farm turnover), the value y_{ki_j} is obtained as $y_{ki_j}=y_{k_j}/N_{k_j}$, being y_{k_j} the value of the variable of interest in the cluster k_j. The same expression can be used also when considering qualitative variables, where y_{k_j} is a frequency and $y_{ki_j}=\{0,1\}$. In other case, when a qualitative variable is considered, a possible solution is $y_{ki_j}=y_{k_j}\ \forall\ i_j \in k_j$.

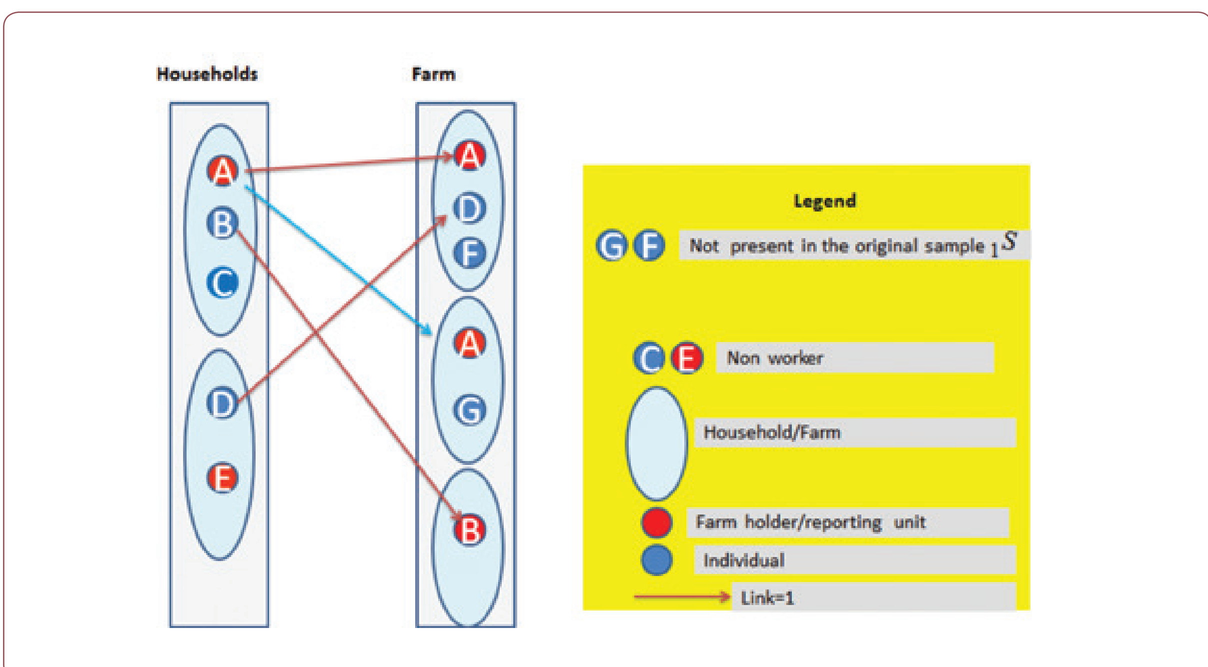
Finally, the parameters of interest considered in this paper are the totals of the variables y_j related to the target populations U_j:

$$Y_j=\sum_{k_j=1}^{K_j}\sum_{i_j=1}^{N_{k_j}} y_{ki_j} \tag{3.1}$$

3.1 Observational strategy

The basic idea here proposed is to jointly observe the different populations in order to obtain estimates $\hat{Y}_j$ of Y_j $(j=1,2,3)$ based on the observation of the common units in the three populations considered. This is obviously crucial for achieving integrated analysis. Essentially, the observation is based on a two-steps schema. The first step consists of directly sampling the units from one out of the three populations. In the second step the units of the remaining populations are reached through indirect sampling using the links with the units in the sample selected in the first step. An example of this process is given in figure below, in which the ovals represents the households or the farms and the circles are the individuals. In the first step we select a sample of two households. Then, all the farms in which the members of the selected family work are surveyed in the second step. For instance, the first sample of two households is linked with three farms.

Figure 3.1: Relationship between households and farms.



In this context we can denote with U_{j^*} the particular target populations (with $j^* = 1$ for the households, $j^* = 2$ for the farms, and $j^* = 3$ for the land parcels) from which the observation starts and suppose that this population can be reached through a collection of Q frames.

Two indicators variables are defined: the first referring to the frame membership of every target unit and the second representing the link between a unit of the population U_{j^*} and a unit of the population U_j (with $j^*, j = 1,2,3$ and $j^* \neq j$). In symbols, the first indicator variable is denoted with $\lambda_{ki_{j^*},q} = 1$ if the elementary unit ki_{j^*} is contained in A_j^q and $\lambda_{ki_{j^*},q} = 0$ otherwise. Furthermore let $l_{ki_{j^*},ki_j}$ denote the linking variable, being $l_{ki_{j^*},ki_j} > 0$ if the elemental unit ki_{j^*} is related to the elemental unit ki_{j^*} of the population U_j and $l_{ki_{j^*},ki_j} = 0$ otherwise (with $j^*, j = 1,2,3$ and $j^* \neq j$). When there is a link between two units ki_{j^*} and, ki_j the choice of $l_{ki_{j^*},ki_j}$ is very important because it has a great influence on the precision of the estimates (Lavalleé, 2009). In most of the observational contexts we are going to consider in this work, the values of $l_{ki_{j^*},ki_j}$ for the linked units are simply set equal to 1. However, as we will see in the following sections, in some situations other choices for $l_{ki_{j^*},ki_j}$ seems to be more adequate.

3.2 On the concept of multiplicity in the observational strategy described

As seen before, the sampling process can be thought as divided in two fundamental steps: one of direct sampling and one of indirect sampling. In each step it is necessary to define the multiplicity factor that adjusts the estimations for the possible duplications of units.
In the first step of the process the concept of multiplicity is only related to the fact that a given unit may be contained in more than one frame (see Table 2). Thus, a simple device for taking into account unit multiplicity is given by the number of frames in which every unit is included, i. e.

$$m_{ki_{j^*}} = \sum_{q=1}^{Q} \lambda_{ki_{j^*},q} \tag{3.2}$$

In the second step the multiplicity factor is computed considering the many-to-many linkage pattern typical of indirect sample (see Table 2). Indeed, if the units of the target population U_j reached through indirect sampling are linked to more than one unit of the population U_{j^*} the probability of being both duplicated and included in the final sample increases. Thus, the multiplicity factor is given by the number of links among a given unit of population U_j and the units of U_{j^*}, i.e.

$$m_{ki_j} = \sum_{k_{j^*}=1}^{K_{j^*}} \sum_{i_{j^*}=1}^{N_{k_{j^*}}} \sum_{i_j=1}^{N_{k_j}} l_{ki_{j^*},ki_j} \tag{3.3}$$

3.3 Reformulation of the parameter of interest taking into account the multiplicity factors

Using the multiplicity factors just defined, a reformulation of the parameter of interest is given below:

$$Y_j = \sum_{q=1}^{Q} \sum_{k_j=1}^{K_j} \sum_{i_j=1}^{N_{k_j}} \alpha_q(ki_j) y_{ki_j} \tag{3.4}$$

where

$$\alpha_q(ki_j) = \begin{cases} \dfrac{\lambda_{ki_{j^*},q}}{m_{ki_{j^*}}} & if\ j = j^* \\ \displaystyle\sum_{k_{j^*}=1}^{K_{j^*}} \sum_{i_{j^*}=1}^{N_{k_{j^*}}} \sum_{i_j=1}^{N_{k_j}} l_{ki_{j^*},ki_j} \lambda_{ki_{j^*},q} / m_{ki_j} m_{ki_{j^*}} & if\ j \neq j \end{cases} \tag{3.5}$$

In Appendix 1 we show that $\sum_{q=1}^{Q} \alpha_q(ki_j) = 1$ both for $j = j^*$ and $j \neq j^*$. Thus, the expressions (3.1) and (3.4) of Y_j are equivalent.

4. Sampling

Alternative sampling schema may be proposed for producing consistent and unbiased inference on the parameters of interest. As already mentioned, each schema may be viewed as an ordered sequence of samples in which the first population U_{j^*} is sampled using a multiple frame approach and the other populations are reached through an indirect mechanism.

Let $S_{j^*}^q$ be the sample selected from the frame A_j^q with a generic sample design, where the specific unit $ki_{j^*} \in A_j^q$ is selected with an inclusion probability denoted with $\pi_{ki_{j^*}^q}$. Starting from the sampled units, $ki_{j^*} \in S_j^q$ the links $l_{ki_{j^*},ki_j}$ between the units of the first sample and the unit ki_j of population U_j (with $j \neq j^*$) are followed in order to find the indirect samples S_j^q for the remaining populations. A unit ki_j of population U_j is selected in the sample S_j^q if and

only if, $ki_{j^*} \in S_j^q$ and $l_{ki_{j^*},ki_j}$. As mentioned before, in this paper we are considering clustered population.

When a unit i_j of the cluster k_j is reached following the existing links with the sampled units of population U_{j^*} all the units belonging to the same cluster as i are surveyed to. Thus, the inclusion probability of unit belonging from the same cluster is constant. Conceptually it is possible to start the selection either from the households or from the farms or from the land parcels. Each choice has pros and cons that must be thoroughly examined in the specific country informative context.

4.1 Example 1: Starting from the populaton of households

Let us consider a first simple example in which the selection starts from the population of households U_1 resorting to a unique frame A_1. Thus, we consider the situation in which $Q = 1$ and the multiplicity factor of each unit of U_1 is constant and equal to 1. In this situation one possible design is the following. (1) Selecting a sample of Census Enumeration Areas (EA_s) adopting a well-known multistage stratified sampling design. (2) Making a census of all existing households in the sampled EA_s. All the people belonging to a sampled household are observed. This schema may be symbolized as follows:

$$A_{1\,di}^{EA_s} \rightarrow S_1$$

(3) The subsequent sample in the chain, named S_2 and finalized at reaching the population of farms, is collected through Indirect Sampling. All the farms having people of S_1 as workers are surveyed. In this way an indirect sample S_2 of the population of the farms U_2 is observed.

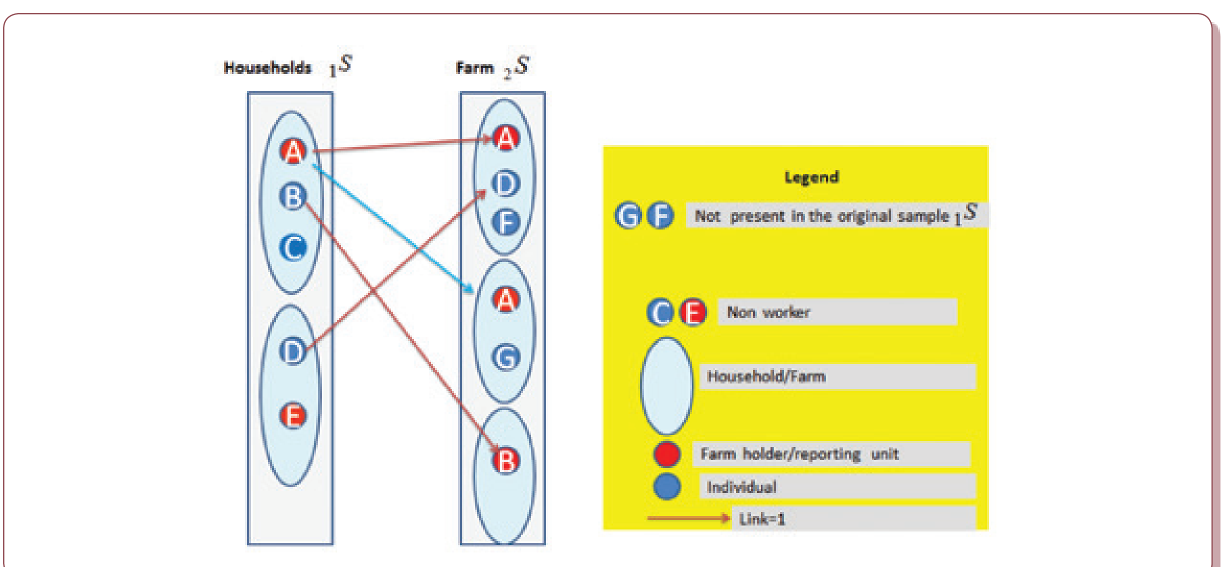
In this IS process we observe the linking variables l_{ki_1,ki_2} in which $l_{ki_1,ki_2} = 1$ if the individual ki_1 is the individual i_2 working in the farm k_2 and $l_{ki_1,ki_2} = 0$ otherwise. In this context, the multiplicity of each unit ki_2 is given by the number of unit ki_1 with which it is linked. In symbols:

$$m_{ki_2} = \sum_{k_1=1}^{K_1} \sum_{i_1=1}^{N_{k_1}} \sum_{i_2=1}^{N_{k_2}} l_{ki_1,ki_2}$$

An example of this process is given in the picture below, in which the ovals represent households or farms and the circles the individuals; the first direct sample S_1 of two households is linked with three farms, where the individual A is the holder of the first and the second farm. Thus, the multiplicity of the unit A is equal 1 in population U_1 and equal 2 in population U_2. In the last sample of the chain, all the land parcels of the farms in S_2 are surveyed. Thus, an indirect sample S_3 of the population of land parcels is observed. Therefore, the whole sequence of samples may be represented as:

$$A_{1\,dir}^{EA_s} \rightarrow S_{1\,indir}^{person} \rightarrow S_2 \rightarrow S_3$$

Figure 4.1: Indirect samples of farms starting from the households.



4.2 Example 2: Starting from the population of farms with multiple frames

When the process of sample selection starts from the population of farms a multiple frames (or a dual frames) approach is often adopted. Let us consider the case in which there are $Q = 2$ frames for the populations of farms. Thus, the multiplicity factor for each unit ki_2 of U_2 is given by:

$$m_{ki_2} = \sum_{q=1}^{2} \lambda_{ki_2,q}$$

A possible sampling chain may be the following: (1) Selecting a sample of farms S_2 by a multiple frame design, (2) All the land of the farms in S_2 is surveyed; (3) Forming a sample of households by considering all the households of the farm workers in S_2.

The entire chain may be symbolized as

$$A^q_{2\ dir} \rightarrow S^{worker}_{2\ indir} \rightarrow S_1;\ \ S_2 \rightarrow S_3 \quad (q = 1, \ldots, Q)$$

Thus, the multiplicity of each unit in U_j is given by

$$m_{ki_1} = \sum_{k_2=1}^{K_2} \sum_{i_2=1}^{N_{k_2}} \sum_{i_1=1}^{N_{k_1}} l_{ki_1,ki_2}$$

4.3 Example 3: Starting from an Area Frame for the land and an outdated farm register

We are now going to consider a more complex situation that faces some critical issues that affect the real survey practices. Let us hypothesize to start the observation from the population of farms U_2 resorting to two different frames which are both not directly related with the units of U_2.

The first frame, named, $A^1_{\tilde{2}}$ is an area frame, the units of which are points in a map. Note that $\tilde{2}$ is used instead of 2 to indicate that the linkage pattern between units of the frame and units of the target population is not one -to- one but many-to-many. We hypothesize that the considered Area frame give a full coverage of the target population U_2 and that each point in the map has an associated area. The union of these areas cover the whole land of reference. The second frame, denoted with, $A^2_{\tilde{2}}$ is a register of farms referred to a period, $t_0 < t$ where t is the current period. Thus, in order to individuate the target units of population U_2 it is necessary to rebuild the longitudinal links among the units of the frame and the units of the population. The farms register give a partial coverage of the target population U_2, i.e. there are some farms included only in the area frame and other units reported in both the area frame and the farms register.

A possible sampling chain in this situation is the following: (1) Selecting a direct sample $S^1_{\tilde{2}}$ of points from the Area Frame and individuating the farms related to the sampled points obtaining an indirect sample S^1_2. Then, starting from S^1_2, the indirect samples S^1_1 and S^1_2 for the households and the land are collected. (2) Selecting a second direct sample from the register $A^2_{\tilde{2}}$, named $S^2_{\tilde{2}}$, containing the farms at the previous time t_0. Following the longitudinal link the current farms referred to the time t are surveyed in a indirect sample S^2_2. The linking variable between the units of $A^2_{\tilde{2}}$ and the units of U_2 can be denoted with $l_{ki_{\tilde{2}},ki_2}$ and can be rebuilt in various alternative ways.

One possible solution is represented in the picture below. The links are identified asking to each worker of the old farms the information about the new farm in which is currently working.

$$A^q_{\tilde{2}\ dir} \rightarrow S^q_{\tilde{2}\ indir} \rightarrow S^q_2 \rightarrow S^q_1; S^q_2 \rightarrow S^q_3 \qquad q = 1{,}2$$

Let introduce the simplifying hypothesis that each farm is linked to only one point in the area frame. Thus, the multiplicity factors $m^{\tilde{1}}_{ki_2}$ for the farm members referred to $A^1_{\tilde{2}}$ are all equal to 1. On the contrary, the multiplicity factors for the units ki_2 referred to the farm registers depends on the number of links between the hold and the new farms, i.e.

$$m^{\tilde{2}}_{ki_2} = \sum_{k_{\tilde{2}}=1}^{K_{\tilde{2}}} \sum_{i_{\tilde{2}}=1}^{N_{k_{\tilde{2}}}} \sum_{i_{\tilde{1}}=1}^{N_{k_{\tilde{1}}}} l^2_{ki_{\tilde{2}},ki_2}$$

In summary, for a generic unit ki_2 in the population of farms U_2 the multiplicity factor is given by:

$$m_{ki_2} = m^{\tilde{1}}_{ki_2} + m^{\tilde{2}}_{ki_2} = 1 + \sum_{k_{\tilde{2}}=1}^{K_{\tilde{2}}} \sum_{i_{\tilde{2}}=1}^{N_{k_{\tilde{2}}}} \sum_{i_{\tilde{1}}=1}^{N_{k_{\tilde{1}}}} l^2_{ki_{\tilde{2}},ki_2}$$

For what concerns the units of U_1 and U_3 we have the same multiplicity factors introduced in Example 2.

5. Estimation

5.1 Basic estimators for multiplicity

Case 1: $Q = 1$; $j = 1,2,3$. As mentioned before, in the context of Indirect Sampling the Generalized Weight Share Method (GWSM) helps in overcoming the difficulty of associating an inclusion probability, or an estimation weight, to the surveyed units of the target population. In fact, GWSM provides an estimation weight for every surveyed unit of the target population U_j reached through IS. Basically, this estimation weight corresponds to a weighted average of the survey weights of the units of the first direct sample. When considering the case of a unique frame, the GWSM is given by

$$\hat{Y}_j = \sum_{k_j=1}^{K_j} \sum_{i_j=1}^{N_{k_j}} w_{ki_j} y_{ki_j} \tag{5.1}$$

where

$$w_{ki_j} = \begin{cases} \delta_{ki_j} / E\left(\delta_{ki_j}\right) & j = j^* \\ \displaystyle\sum_{k_{j^*} \in S_{j^*}} \sum_{i \in k_{j^*}} L_{ki_{j^*},k_j} / \pi_{k_{j^*}} L_{k_j} & j \neq j^* \end{cases} \tag{5.2}$$

being $L_{ki_{j^*},k_j} = \sum_{i \in k_j} l_{ki_{j^*},ki_j}$, $L_{k_j} = \sum_{k_j\ 1}^{K_j} \sum_{i_j=1}^{N_{k_j}} \sum_{i_{j^*}}^{N_{k_{j^*}}} l_{ki_{j^*},ki_j}$ and $\delta_{ki_j} = 1$ if unit ki_j is included in the sample S_j and $\delta_{ki_j} = 0$ otherwise.

Case 2: $Q \geq 2$; $j = j^*$. For what concerns population, U_{j^*} in the context of Multiple Frame surveys an interesting class of estimators are those that exploit the concept of Units Multiplicity (Mecatti, 2007). Resorting to the same notation used for the GWSM estimator, the general form for the Multiplicity Estimator is given by:

$$\hat{Y}_{j^*} = \sum_{q=1}^{Q} \sum_{k_{j^*}=1}^{K_{j^*}} \sum_{i_{j^*}=1}^{N_{k_{j^*}}} w_q\left(ki_{j^*}\right) y_{ki_{j^*}} \tag{5.3}$$

where

$$w_q\left(ki_{j^*}\right) = \frac{\alpha_q\left(ki_{j^*}\right) \delta_{ki_{j^*},q}}{E\left(\delta_{ki_{j^*},q}\right)} \tag{5.4}$$

being $\delta_{ki_{j^*},q} = 1$ if unit ki_j^* is included in the sample $S_{j^*}^q$ and $\delta_{ki_{j^*},q} = 0$ otherwise and $\alpha_q\left(ki_{j^*}\right) = \lambda_{ki_{j^*},q} / m_{ki_{j^*}}$.

5.2 A unified estimator for multiplicity

The estimator proposed in this section can be viewed as a direct generalization of either the GWSM estimator or the Unit Multiplicity estimator. In fact, the weight introduced below adjusts for the multiplicity arising from both the Indirect Sampling process and the use of a set of frames for the first surveyed population.

The estimator presented has the form:

$$\hat{Y}_j = \sum_{q=1}^{Q} \sum_{k_j=1}^{K_j} \sum_{i_j=1}^{N_j} w_q\left(ki_j\right) y_{ki_j} \tag{5.5}$$

Being

$$w_q\left(ki_j\right) = \hat{\alpha}_q\left(ki_j\right) \tag{5.6}$$

where $\hat{\alpha}_q\left(ki_j\right)$ are the sampling estimates for $\alpha_q\left(ki_j\right)$ defined through equation (3.5), i.e. the factor that adjust for unit multiplicity, and are given by:

$$\hat{\alpha}_{\mathrm{q}}\left(\mathrm{ki_j}\right) = \begin{cases} \dfrac{\lambda_{ki_{j^*},q}\, \delta_{ki_{j^*},q}}{m_{ki_{j^*}} E\left(\delta_{ki_{j^*},q}\right)} & \text{if } j = j^* \\ \displaystyle\sum_{k_{j^*}=1}^{K_{j^*}} \sum_{i_{j^*}=1}^{N_{k_{j^*}}} \sum_{i_j=1}^{N_{k_j}} l_{ki_{j^*},ki_j}\, \lambda_{ki_{j^*},q}\, \lambda_{ki_{j^*},q}\, \delta_{ki_{j^*},q} / m_{ki_j} m_{ki_{j^*}} E\left(\lambda_{ki_{j^*},q}\, \delta_{ki_{j^*},q}\right) & \text{if } j \neq j \end{cases} \tag{5.7}$$

Note that the indicator variable $\delta_{ki_{j^*},q}$ is always referred to the first population U_j^* since it allow to exclude the units not included in the first sample (and those of the remaining population related to them) from the computation of the estimators.

Resorting to the weight formulation proposed it is easy to show how the estimator (5.1) with weights given by (5.2) can be viewed as a special case of (5.5) when $Q = 1$.

This estimator can also be expressed as a member of the Generalized Multiplicity-adjusted Horvitz Thompson class (Singh and Mecatti, 2011) which is design-unbiased under slight conditions and clearly analytically simple regardless of the number Q of frames.

The weights expressed by (5.6) allow producing unbiased estimates for the population U_j^* if and only if the union of the Q overlapping frames give a full coverage for the population ($U_j^* = \cup_{q=1}^{Q} A_{j^*}^q$), i. e. if and only if $m_{ki_{j^*}} > 0 \; \forall \; ki_{j^*} \in U_{j^*}$.

Furthermore, using the results given in Lavallée (2007, ch 4) it is possible to show that the estimates for U_j ($j \neq j^*$) are unbiased if the following condition holds.

Condition: Each cluster of units of population U_j ($j \neq j^*$) must have at least one link with a unit in, U_j^* i.e. $L_{k_j} > 0 \; \forall \; k_j \in U_j$.

Remark: In the example 4.3 the weights $w_q(ki_j)$ are given by:

$$w_q(ki_j) = \begin{cases} \dfrac{\lambda_{ki_{\bar{2}},q}\,\delta_{ki_{\bar{2}},q}}{m_{ki_2} E(\delta_{ki_{\bar{2}},q})} & j = 2 \\ \displaystyle\sum_{k_{\bar{2}}=1}^{K_{\bar{2}}} \sum_{i_{\bar{2}}=1}^{N_{\bar{2}}} \sum_{i_j=1}^{N_{k_j}} \frac{\lambda_{ki_{\bar{2}},q}\,\delta_{ki_{\bar{2}},q}\, l^q_{ki_{\bar{2}},ki_j}}{m_{ki_2} E(\delta_{ki_{\bar{2}},q}) m_{ki_j}} & j \neq 2 \end{cases}$$

6. Conclusions

In this paper we have shown as Indirect Sampling and Multiple Frame surveys may be jointly used in a unified approach for assuring the consistency of integrated agricultural statistics, and for dealing with frame imperfections. The approach is general, flexible and may be tailored to the different country contexts. Besides that, it enables us to achieve integration overcoming the necessity of a Master Sampling Frame.

Appendix 1

In this appendix the formal demonstration that $\sum_{q=1}^{Q} \alpha_q(ki_j) = 1$ is given both for $j = j^*$ and $j \neq j^*$.

1) $j = j^*$

$$\sum_{q=1}^{Q} \alpha_q(ki_{j^*}) = \sum_{q=1}^{Q} \frac{\lambda_{ki_{j^*},q}}{m_{ki_{j^*}}} = \frac{m_{ki_{j^*}}}{m_{ki_{j^*}}} = 1$$

2) $j \neq j^*$

$$\sum_{q=1}^{Q} \alpha_q(ki_{j^*}) =$$

$$= \sum_{q=1}^{Q} \sum_{k_{j^*}=1}^{K_{j^*}} \sum_{i_{j^*}=1}^{N_{k_{j^*}}} \sum_{i_j=1}^{N_{k_j}} l_{ki_{j^*},ki_j} \lambda_{ki_{j^*},q} / m_{ki_j} m_{ki_{j^*}} =$$

$$= \sum_{k_{j^*}=1}^{K_{j^*}} \sum_{i_{j^*}=1}^{N_{k_{j^*}}} \sum_{i_j=1}^{N_{k_j}} \Big(\sum_{q=1}^{Q} \lambda_{ki_{j^*},q} \Big) \frac{l_{ki_{j^*},ki_j}}{m_{ki_j} m_{ki_{j^*}}} =$$

$$= \sum_{k_{j^*}=1}^{K_{j^*}} \sum_{i_{j^*}=1}^{N_{k_{j^*}}} \sum_{i_j=1}^{N_{k_j}} \frac{m_{ki_{j^*}} l_{ki_{j^*},ki_j}}{m_{ki_j} m_{ki_{j^*}}} = 1$$

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Endnotes

1 This research has been funded by the partnership of the Global Strategy to improve Agricultural and Rural Statistics: www.fao.org/economic/ess/ess-capacity/ess-strategy/it/#.UlPQNVDilGg .

2 The structure of ***Table 2.1*** and ***Table 2.2*** was suggested by Prof. Fulvia Mecatti.

The Use of a Point Sample as a Master Frame for Agricultural Statistics

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Abstract

Building an Area Sampling Frame for a specific survey has a cost that can be quite high. Resources can be optimised if a common sampling frame is used for several agricultural and environmental surveys. This may mean in particular re-using a multi-purpose stratification and graphical material, such as ortho-photographic documents that may have been produced.

In this paper we present the potential use of the Eurostat LUCAS survey (Land Use and Cover Area Frame Statistical survey) for additional purposes. In particular we assess the possible use for two purposes: sampling farms through points and surveys along the road.

Keywords: Area Sampling Frame; Master Frame; multi-phase sampling.

1. Introduction

Area sampling frames have been used for a long time by agricultural statistical services in a number of countries. The USDA June Agricultural Survey (JAS) of the US Department of Agriculture (USDA) is probably the longest and most important operational experience on area frame surveys (AFS). Several examples of agricultural area frame surveys around the world are reported in a two-volume report published by FAO (1996 1998); examples reported include: TER-UTI, run by the French Ministry of Agriculture, the first operational area frame survey in Europe, running since 1970 and fully operational since 1980, the ESYRCE survey in Spain (Ministerio de Agricultura, 2008), Morocco, the most stable area frame in Africa, and several examples in Latin America. The use of AFS for crop area estimation is well established and has important advantages when list frames (e.g. agricultural censuses) are not properly updated or present a significant amount of missing farms (or households) or overlapping records.

Agricultural area frames may have two types of units: points or patches of land, often named segments. Segments may be delimited by physical boundaries or by a geometric pattern, such as a square grid, on a cartographic projection. The sample design of the USDA JAS is based on the delineation of Primary Sampling Units (PSUs) with physical boundaries that are subdivided into Secondary Sampling Units (SSUs) only if they are selected in the first sampling step (Cotter and Tomczac, 1994). The sampling method is well adapted to the US landscape, but might be too costly in areas with smaller irregular fields. Due to the high cost of setting up a sampling frame with physical boundaries, cheaper solutions have been adopted in the EU, including square sampling units and several types of point sampling methods (Gallego et al., 1994, Gallego and Delincé, 2010).

2. The LUCAS survey (Land Use/Cover Area-frame Survey)

In this paper we mainly focus on LUCAS (Land Use and Cover Area-Frame Survey), conducted by Eurostat, mainly for environmental monitoring. LUCAS was first run in 2001 and 2003 with a systematic non-stratified sample based on clusters of 10 points (Gallego and Bamps, 2008). The sample design changed in 2006, moving from a clustered (two-stage) non-stratified sampling method to a two-phase sampling of unclustered points. The sampling scheme is inspired on the Italian AGRIT survey, with adaptations. The two phases of the sampling procedure are:

- A systematic grid of points is selected. One point every 2 km (around 1,100,000 points in the EU). The points are photo-interpreted with a simplified nomenclature on aerial ortho-photographs or the best available satellite images. This photo-interpretation provides the stratification, incomplete in the sense that not the whole population is stratified but only the grid that is the Master Sampling Frame of LUCAS (Gallego et al., 2010). Figure 1 shows the example of Austria. In this figure we have the visual impression of a complete stratification, but a zoomed image (Figure 2) shows that only one point every 2 km is stratified.

Figure 1: Stratification by point photo-interpretation of Austria.

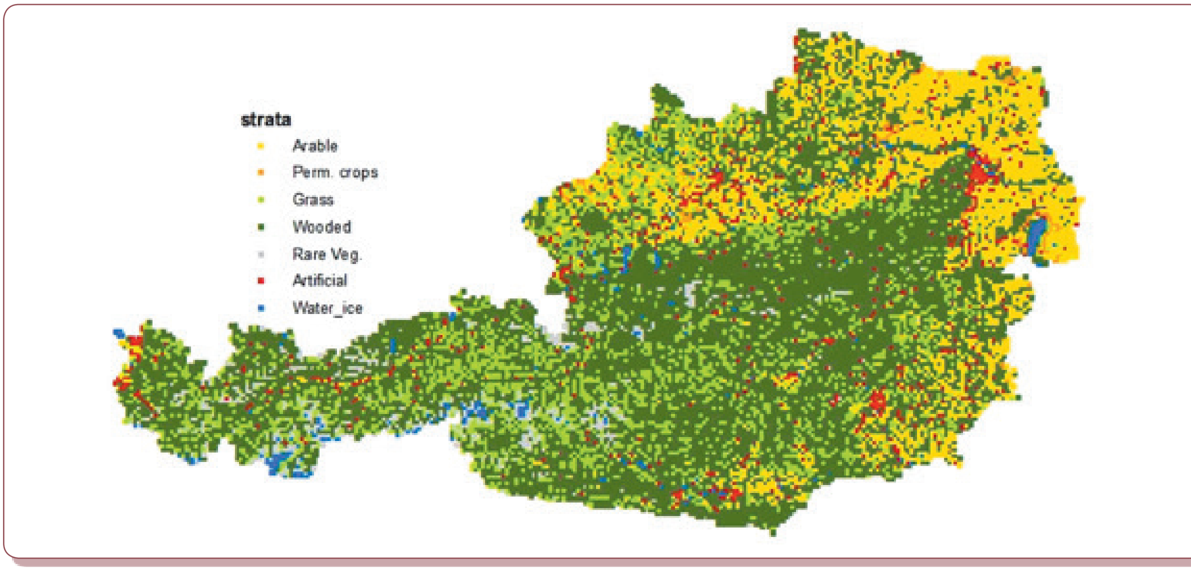
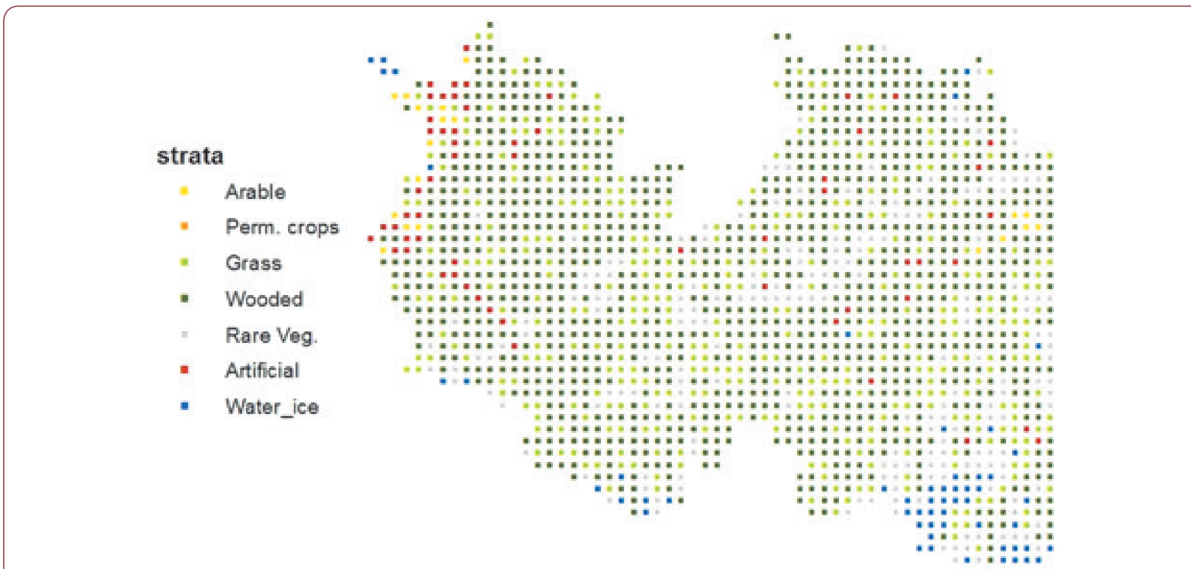


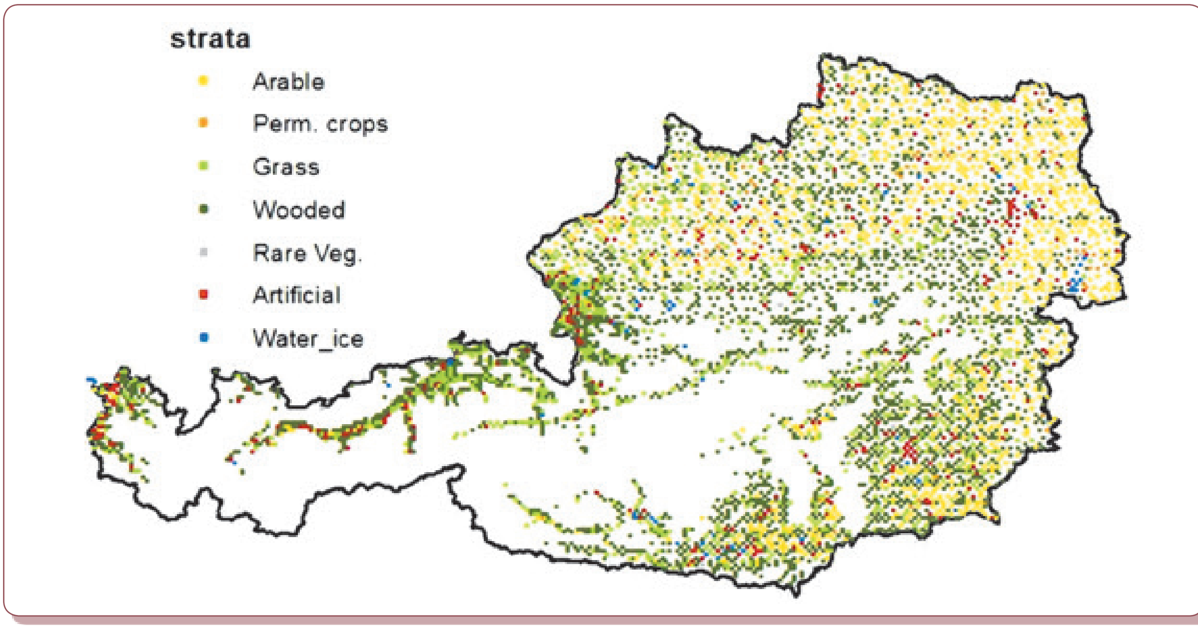
Figure 2: Stratification by point photo-interpretation in Western Austria. Zoomed view.



- Points are subsampled in the second phase. The sampling rate in each stratum is tuned depending on the priority of the survey and the target accuracy for different levels of administrative units. In 2012 the second phase sample has nearly 300,000 points in the whole EU. The subsampling is again systematic with a variable number of replicates in a block of 18 km x 18 km. Figure 3 shows again the example of Austria, that illustrates the different sampling rates in different areas.

The choice of an approach that combines different types of systematic sampling is based on a wide literature showing that systematic sampling with a random starting point is superior to random sampling when the spatial correlation is a decreasing function of the distance (Cochran 1977, Bellhouse, 1988), and in particular for land cover data (Dunn and Harrison, 1993). The good behaviour of systematic sampling is explained because it ensures a good spatial distribution of the sample. Systematic sampling has a drawback that we consider minor: there is no sample-based unbiased estimator for the variance. Usual variance estimators heavily overestimate the variance when applied to systematic sampling. The

Figure 3: Field survey sample in Austria. 2009.



advantages of systematic sampling are hidden if we estimate the variance with the usual estimators (Wolter, 1984).

In LUCAS we use a modified estimator that uses local measures of the variability: If we call y the proportion of area for a given land cover class c, the stratified estimator for the proportion $\bar{y}_{st}$ of a given land cover c is:

$$\bar{y}_{st} = \sum_h w_h \bar{y}_h \tag{1}$$

where w_h is the weight of stratum h estimated from the first phase sample and $\bar{y}_h$ is the proportion of c from the survey in the stratum h:

$$\bar{y}_h = \frac{\sum_{i \in h} w_i y_i}{\sum_{i \in h} w_i} \tag{2}$$

where w_i is the weight of each observation i in stratum h.

Variance estimators for two-phase sampling with stratification in the first phase can be found in classical books. For example Cochran (1977, chapter 12) gives:

$$v(\bar{y}_{st}) = \sum_h w_h s_h^2 \left(\frac{1}{n' v_h} - \frac{1}{N} \right) + \frac{N-n}{(N-1)n'} \sum_h w_h (\bar{y}_h - \bar{y}_{st})^2 \tag{3}$$

where s_h^2 is an estimate of the variance of y. For LUCAS 2006/2012 we have adapted the formula using a local estimate of the variance:

$$s_h^2 = (1 - f_h) \frac{\sum_{i \neq j} w_i w_j \delta_{ij} (y_i - y_j)^2}{2 \sum_{i \neq j} w_i w_j \delta_{ij}} \tag{4}$$

where δ_{ij} is a decreasing function of the distance between i and j:

$$\delta_{ij} = \begin{cases} 1/d(i,j) & \text{if } j \text{ is among the 8 closest points to } i \text{ in the stratum} \\ 0 & otherwise \end{cases} \tag{5}$$

In 2006 a priority on agriculture was decided for LUCAS. Therefore the agricultural strata were subsampled with a probability 5 times higher than the other strata. For the 2009 and 2012 editions the priority was focused on general land cover monitoring and the subsampling rates were more balanced among strata, with some geographic variability depending on the target accuracy per administrative unit. In LUCAS 2006 the same sampling rate was applied in each stratum across the 11 countries covered in that occasion, In 2009 and 2012 the sampling rate per stratum was tuned separately for each "NUTS2" region. There are 272 NUTS2 regions in EU27, with a very variable size (http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction).

3. Sampling farms with an area sampling frame

Area frame surveys are particularly well adapted for land cover area estimation, in particular for crop area estimation, when direct observation of the crop is considered more reliable than reporting by farmers.

Area frames can be also used as an intermediate step to sample farms whose conductors are interviewed to collect information on variables that cannot be directly observed on the field, such as fertilisers, socio-economic information, cropping intentions for next year, etc.

The so-called open, closed and weighted segment estimators are used to make the link between spatial units and farms (Hendricks et al., 1965). The main advantage of an area frame compared to list frames is that completeness of the frame and non-overlapping units are easy to ensure and extrapolation factors are reliable and not difficult to compute.

If a sample of segments is used as a basis to sample farms in a complex landscape with small plots and we select all the farms having a field totally or partially in the segment, the number of farms in the segment may be very large and the sample may become inefficient. To reduce the number of farms per segment, they can be subsampled through points. We can choose for example 5 points per segment. When a point falls on agricultural land, the farm operating the corresponding plot is selected and interviewed (Gallego et al., 1994). When compared to the above mentioned approaches (open, closed and weighted segment), sampling farms through points has the advantage that the "tract" (part of the segment that belongs to a particular farm) does not need to be measured. Some difficulties also appear, for example when the sampling frame is set up for the first time, linking points with farms may be a heavy operation unless a georeferenced data are available for the cadaster or the agricultural census.

The sampling rule is as follows: points that fall on Utilised Agricultural Area (UAA) generate an element of the sample of farms. The definition of UAA may be flexible to some extent, but the concept of UAA used to decide if the point generates or not a sample unit should be the same considered by the farmer when they are asked about the total area of the farm and used for computation. Farm buildings and rough pastures may be included in the UAA if this is considered useful for the completeness of the frame.

If a point of the sample falls on UAA, the farmer managing that field is located and asked to provide global data for the farm, including total area and production of each crop or inputs such as fertilizers or pesticides. No question is asked about the production in each field. If several points fall on fields of the same farm, the farm will have in the computation a weight proportional to the number of points. The area of each crop can be estimated separately from the direct field observations and the farmers survey. This will provide a tool for cross-checking.

Locating the farmer may be a heavy task, depending on the livelihood structure. The task is heavier in regions in which people live in concentrated villages or towns rather than in scattered houses close to the fields. In some cases the owner or the manager of the farm may live in a city that is very far from the fields. However this is an investment to be made the first time the survey is run if the sample of points is kept constant: keeping a database with the link point-farm is much easier, although the amount of work depends on the communications structure or training level of the farmers, in particular whether or not the farmers have a telephone or access to internet.

Assume W_k is an additive variable for farm k, for example the area under a given crop, the production, amount of fertilizer, etc. (yield is not an additive variable). The UAA of the farm will be called A_k. The total area of the region under study is D and the area of each stratum D_h, in which we have selected a sample of n_h points. Farm k is selected with a probability proportional to the area A_k:

$$p_k = \frac{n_h \ A_k}{D_h} \tag{6}$$

The Horwitz-Thompson estimator for unequal probability sampling, also called π-estimator (Särndal et al., 1992), for the total of W in stratum h is

$$\hat{W}_h = \frac{D_h}{n_h} \sum_k \frac{W_k}{A_k} \tag{7}$$

Because the stratification is not perfect, there will be, even in agricultural strata, sample points that do not fall on UAA and therefore do not generate an element in the sample of farms. To deal with such points, we can define a fictitious farm that corresponds to all non-UAA and has a value $W_k=0$.

The computation of the variance of a π-estimator requires the cross-probability of selecting pairs of units, and this is tricky when the sampling plan is systematic, as it happens in LUCAS. The question becomes easier if we introduce an instrumental variable

$$X = W/A \tag{8}$$

This corresponds to the idea of distributing W in a homogeneous way in the whole UAA of the farm. By definition the total of W is identical to the total

of X. The instrumental variable X is now a variable defined in the geographical space and is not anymore sampled with unequal probability. X is also useful to deal with a problem that we have disregarded so far: what to do with farms that are shared by two or more strata in the AFS. If we had considered directly W the estimation of totals per stratum should have taken into account the area of farm k in stratum h. In exchange the variable X is a geographical variable linked to the point and we do not need it anymore. The totals of W and X per stratum do not coincide, but the overall total does. We are still disregarding the cases in which a farm is only partially included in the region or country under consideration.

Using X instead of W as target variable makes the computation of variance easier, but still needs more in-depth work. The sampling approach uses indeed three phases: systematic grid and field survey as carried out in LUCAS are the two first phases. For the third phase there is a stratification of the second-phase sample (LUCAS field sample) into UAA and non-UAA. This stratification is correlated with the stratification used for the second phase sampling (photo-interpretation of a systematic sample), but the concept of "photo-interpreted as agricultural" is not the same as identified as UAA in the field visit. Estimating the variance of a three-phase sample with simple random sample is complicated, but tractable (Fattorini et al., 2006). In our case, combining different types of systematic sampling in the first and second phase with another type of sampling (to be defined) in the third phase, there is certainly no unbiased variance estimator. Variance estimators with a moderate bias still need to be explored.

A major limitation of sampling farms through points is that covering farms that have livestock but no agricultural land becomes problematic. An option to be explored to overcome this issue is considering the subsample of points with artificial land cover and agricultural land use. In the LUCAS sample there are 700 points with such land cover/use combination. There is not enough information to estimate how many of them correspond to livestock farm facilities.

4. Field observations along the road

We have exploited LUCAS data for an empirical assessment of the applicability of a field survey method that is not an ideal solution for unbiased crop area estimates, but may be practical when the available manpower for field observations is very limited or the territory is particularly difficult. To maximize the amount of data that can be collected within a given budget, the area estimation procedure is foreseen to limit the collection of field data with an approach that is called here "survey along the road".

The overall approach is divided into two steps: estimation of cropland based on photo-interpretation, and estimation of the proportion of a given crop compared with the total agricultural land.

$$X = Y \times Z \qquad (9)$$

Where

- X is the proportion of a given crop compared with the total geographical area;
- Y is the proportion of a given crop compared with the total cropland. It would be estimated from a "survey along the road" possibly combined with classified images;
- Z is the proportion of the overall cropland on the total geographical area. It would be estimated by CAPI (Computer Assisted Photo-Interpretation) of a sample of unclustered points, possibly combined with classified images. The finest possible spatial resolution would be used for the photo-interpretation, while classified images of any resolution may be useful.

There are two major underlying assumptions for the validity of this approach:

a) The identification of cropland by photo-interpretation is reliable. The potential bias should be lower than the accuracy requirements of the crop area estimation.

b) While the distance to the closest road is usually correlated with the probability that a sampled point is cropland or not, it should not be strongly correlated with the probability of a particular crop given that the point is cropland. In other words in the above formula, the variable Y should be similar close to the roads and far away.

The concept of "cropland" remains undefined to some extent in this text. For the purpose of this this method cropland is an intermediate step in the estimation procedure. It can correspond to arable land including or excluding temporary fallow, it can correspond to other concepts of agricultural land (including permanent crops or different types of grassland). The more accurately cropland can

be identified by photo-interpretation with a given definition of cropland, the better the concept will be adapted for this purpose.

An empirical test has been run with LUCAS data, considering the EU as simulation region. The results only have an indicative value, since it is not obvious that a particular property the spatial distribution of crops in the EU (assumption "b" above) may be extrapolated to other areas of the world. However the availability of data has determined the choice.

Beside the 234,700 points of the LUCAS 2009 survey, we have used a digital road network with scale 1:250,000 that roughly includes all paved roads and excludes dirt roads. The total length of the roads in this map is 2.6 million km. Bulgaria is still missing in this layer. The road density is not homogeneous, and this should be taken into account in the extrapolation weighting.

The distance from each LUCAS point to the closest road has been computed. Table 1 illustrates the proportion of major land cover classes for points close or far away from roads. For artificial land we check an obvious increase of proportion when we look only close to the roads, while for shrubland it is the opposite. For cropland the difference is not dramatic. If we consider points less than 20m from the road we have 23.9% versus an average of 25.9%, while a distance range until 50 m gives a proportion of 26.7%. This probably means that the bias of a direct "along the road" survey is less dramatic than initially thought. Still this issue needs to be assessed for each specific landscape.

For the purpose of area estimation with surveys along the road, the most meaningful indicator is the proportion of points within a given distance from the road. We should also remember that the field sample in LUCAS is not selected with equal probability. Each point i has a selection probability p_i and a weight for the extrapolation

$$w_i = \frac{1}{p_i} \tag{10}$$

If we take the subsample of points that are "close" (within a given distance) to roads, the new weight is

$$w'_i = \frac{1}{p_i\, q_i} \tag{11}$$

Where q_i is the probability that a sampled point is close to a road, in this case restricted to points with agricultural use.

Table 2 reports a similar table restricted to arable land with major crops considering a distance threshold of 100 m. If we use the weights w_i the differences between the proportions of some crops close and far from the roads appear as non-negligible. For example root crops or sunflower seem to appear much more often close to the roads. However the apparent difference when we use the corrected weights w'_i. appears moderate for major annual crops: within 1.5% for wheat, root crops, sunflower and rapeseed. Somewhat higher for barley and maize. This may be acceptable when we have a strong uncertainty. The situation is more difficult for olive trees and vineyards, with a positive bias, and for fodder and temporary grass, that seems to appear less often close to the roads. A more in-depth geographical analysis needs to be performed to better understand the bias for permanent crops and fodder.

For a hypothetical area frame survey along the roads, a two-stage sampling scheme might be used

Table 1: Proportion of LUCAS points per distance class to roads.

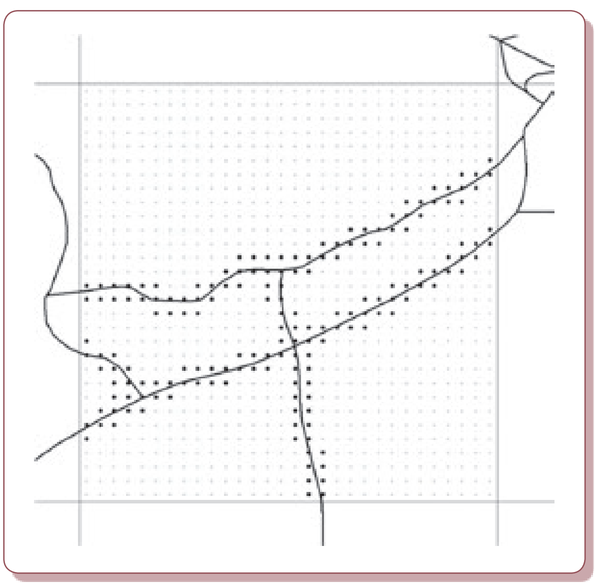
	<10 m	10-20 m	20-50m	50-100m	100-200m	200-500m	500-3000m	>3000 m	Overall
Artificial land	26.7	20.5	14.2	11.0	8.0	4.2	1.5	0.4	4.5
Cropland	22.7	25.1	28.7	31.9	32.9	32.5	22.5	3.2	25.9
Woodland	18.2	21.3	23.1	23.7	25.4	30.7	42.9	43.2	35.3
Shrubland	4.0	3.3	3.9	4.1	4.3	4.8	7.7	19.7	6.8
Grassland	26.0	27.4	27.5	26.8	26.0	23.4	17.6	9.2	20.7
Bare land	1.8	1.6	1.4	1.3	1.4	1.5	1.8	4.7	1.8
Water	0.5	0.7	0.9	1.1	1.5	2.3	4.0	10.2	3.3
Wetland	0.1	0.2	0.3	0.3	0.5	0.7	2.0	9.3	1.7
Total	**3188**	**3160**	**8983**	**14452**	**26389**	**59428**	**104636**	**14473**	**234709**

Table 2: Weighted estimation of the proportion of major crops from all LUCAS points and from LUCAS points within 100 m of a road.

	All LUCAS points	Estimated % 100 m of a road Weight wi	Estimated % 100 m of a road Weight w'i	% bias
Wheat	24.88	24.04	25.24	1.4
Barley	14.63	13.75	14.28	-2.4
Maize	12.31	12.34	11.94	-3.0
Root crops	3.62	9.01	3.65	0.8
Sunflower	2.50	3.73	2.53	1.2
rapeseed	6.18	1.89	6.24	1.0
fodder & temp grass	7.07	5.74	6.70	-5.2
olive trees	5.83	7.73	6.04	3.6
vineyards	3.75	6.29	3.97	5.9

with large cells (for example of 3 km x 3 km) as Primary Sampling Units. The size of the cells can be tuned in function of the road density in the available digital road map. Figure 4 below shows a 3 km segment with the roads that appear in a digital map 1:250,000. Inside the segment a systematic grid with 100 m step appears in grey (900 points). Only the 169 points at a distance < 100 m will be surveyed.

Figure 4: Sample of points along the road in a segment of 3 x 3 km.



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Master Sampling Frames for Agricultural and Rural Statistics in Ethiopia

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1. Introduction

The major duties and responsibilities of Central Statistical Agency of Ethiopia (CSA) are to collect, process, analyze and disseminate statistical data, to provide technical guidance and assistance, and to coordinate the statistical system so as to maintain statistical data quality.

The Central statistical agency of Ethiopia has developed the National Strategy for the Development of Statistics (NSDS) to be implemented for five years. The NSDS has six themes. Theme 1: implementation of the statistics law, theme 2: developing data quality procedures, theme 3: enhance advocacy and use of statistics, theme 4: methodological improvements and statistical modernization, theme 5: capacity development in the NSS. Theme 6: Relationship of NSDS to the monitoring and evaluation of Growth and Transformation Plan (GTP).

Development of master frame is one of the major activities of theme 4 in the NSDS. Activities which help for better integration were also designed and implemented in the NSDS. Some of these are Coordination unit established to facilitate implementation of the NSDS, Standard concepts and definitions and industrial and labor classifications are prepared and disseminated, the data quality assessment frame work has been developed, Statistical activities are supported by GIS and IT, a preparatory activity to develop common data bank is started.

CSA has been collecting agricultural data through annual agricultural survey for more than three decades in integrated approach. The major types of agricultural data collected by CSA are cultivated area and production by crop type, land utilization, crop utilization and agricultural practices. For collecting agricultural data, list frame approach for the ultimate sampling unit is used. The list of enumeration areas (EAs) from population and housing census is used as primary sampling unit (PSU) and list of households prepared during the survey in the sampled enumeration area used as secondary sampling unit (SSU).

Data from sampled households is collected by both objective measurement and interview method. Expert judgment is also used to support the data. The enumeration areas samples for agricultural surveys are also used to collect data for household income and consumption and welfare monitoring survey. Integrating surveys helps to save cost and also to link data for in-depth analysis. But it may create some difficulty since different surveys may need different measure of size and also different sample size. The agricultural data is reported at zone level. Policy makers require data at lower district level. Such data can be obtained by agricultural census. CSA conducted research to implement ratio and model based small area estimation method to get data at lower level.

CSA is conducting different research activities to improve agricultural data quality. This includes research on area frame approach which is expected to result in more timely and accurate data. In the area frame approach, Enumeration areas are used as PSU and segments of size 40 hectare are used as secondary sampling units. The land cover classification is used as a base for the development of area frame. In this approach commercial farms data is collected by using list frame, hence multiple frame is applied.

Community level data was collected during population and housing census and used to develop community data frame. These data was collected at EA level.

2. Developing master frame for integrated agricultural and rural statistics: listing frame approach

Central Statistical Agency of Ethiopia (CSA) has developed a master frame which can be used for sample selection from population and housing census. A listing questionnaire was designed to collect data to be used for master frame development and the data was collected at the beginning of population and housing census. The major variables collected in the questionnaire are agricultural households, non-agricultural households, total households, small and large scale manufacturing, cottage industry, whole sale trade, retail trade and service trade.

The listing frame was scanned. Once the scanning is completed, key correction was also done for the scanned data. Finally the scanned data was exported. The exported data was cross checked with the actual census file. The document for the mismatched EA was

identified from the documentation and rescanned and merged with the original file. The frame compilation, which is exporting the scanned data and cross checking with the census id was done after the census result is released. This creates difficulty in matching.

The frame with total number of households was compiled directly from the census questionnaire and CSA is using that frame now. For large scale farms, commercial frame is compiled. Farms classified as commercial are state farm, private commercial farm, cooperative farm and enterprise farm. This frame is updated every year.

The master frame developed from population and housing census is used to select samples for annual agricultural survey. The primary sampling units which are the enumeration areas are selected by probability proportional to size, size being the number of households from population and housing census. Households are then listed at the beginning of the survey and sample households are selected. Once the sample households are selected, then data on cultivated area and production by crop type, land and crop utilization and agricultural practices are collected. The same sample households are used to collect data for long rainy season, short rainy season, forecast and livestock.

CSA uses integrated approach for data collection. The enumeration areas selected for agriculture survey are also used to collect data for other household surveys such as household income survey and welfare monitoring survey. The rural socio economic survey also uses subsample of the annual agricultural survey EAS. This integration between surveys helps to link the data for in-depth analysis. The master frame developed by CSA is also used by other sector ministries and research institutes to conduct a survey. The procedure here is; the sector ministry submits its request to the CSA and then CSA selects sample and provides the list of sampled EAs with their maps to the sector ministry. This facilitates standardization and minimizes the data discrepancy.

CSA is planning to conduct agricultural census in 2015. The enumeration areas selected for agricultural census will then be used as a frame for annual agricultural survey to be conducted after the agricultural census. The first agricultural census was conducted in 2001. This agricultural census was large sample census which provides data at lower district level. The master frame developed from the previous population and housing census used as a frame for the first agricultural census. Then the agricultural census was used as a master sample frame for annual agricultural survey until the recent population and housing census was conducted.

The list frame facilitates integration between different household surveys, good to collect socio economic data and helps to have diversified representation. This method does not require imagery. The difficulty with list frame is that it is time consuming as the households are distributed in the enumeration area. Some holdings can be missed as their holding is dispersed. It makes supervision difficult. In list frame indirect measure of size, which is number of households is used for agricultural survey. The difficulty to update the master frame due to frequent administrative boundary changes is also a challenge. A simplified mechanism for master frame updating is very important.

To generalize, it is a good practice to collect data to develop master sample during population and housing census. Attention should be given to the quality of frame as it is a base for different surveys to be conducted until next census. Appropriate editing mechanism should be set to improve the quality of frame. It is advisable to do frame compilation in parallel with the census data compilation so as to cross check together. Serious attention should be given for documentation and the capacity to scan, key correction, export and merge the data has to be built well and should be sustainable. More simplified mechanism to update the master frame needs to be developed.

3. Area frame development

3.1 Methodology

In the area frame approach, the observation units are territorial sub divisions instead of list of households/holders/ holdings as in the list frame. The unit of area frame can be points, transects (straight line of certain length) or pieces of territory often named segment. CSA used segment as ultimate unit of area frame. Enumeration areas are used as PSU and segments of size 40 hectare are used as secondary sampling units.

The first step in the area frame survey is frame development. Two inputs, enumeration area maps and land cover map, are used to develop area frame. The EAs which are the PSUs were delineated for the purpose of Population and Housing Census. The criteria to delineate an EA were to have 150 – 200 households in rural areas. Topo-sheet was used as a

base map and the GPS readings for the EA corners (turning points) were plotted on the topo-sheet and then the EA map was traced from the topo-sheet. The enumeration areas are geo referenced.

The land cover classification activity is designed to produce a land cover data base which will provide a standardized, multipurpose product useful for environmental and agricultural purposes. Satellite imagery, appropriate software and predefined legend are required for the land cover classification. CSA Ethiopia used spot-5 satellite imagery, ARC GIS and MADCAT software for land cover classification. Appropriate legend was derived from the standard legend prepared by FAO. The land is stratified in to land cover categories in the land cover classification (LCCS) which is used as a basis for the development of area frame. The LCCS is used to stratify the primary sampling units (enumeration areas) based on their percent cultivated land.

To develop a frame in the area frame, CSA digitized EA map obtained from census cartographic work is overlaid on the land cover map.

Four strata are created for the area frame based on crop intensity:

- Stratum I - crop intensity 75 % or more
- Stratum II - crop intensity 50 to 74 %
- Stratum III - crop intensity 25 to 49 %
- Stratum IV - crop intensity less than 25 %

The primary sampling units (EAs) are selected by PPS, size being number of segments. The sampled EA are divided to segments of size 40 hectare and two segments are selected systematically from each EA for data collection.

Closed segment approach is used for data collection, i.e. all the fields (land use) within the selected segment are listed and questionnaire is filled in for each field. Commercial farms are treated separately and an independent survey is conducted for them. Hence, multiple frame approach which is a combination of area frame and list frame is implemented in the pilot survey.

3.2 Pilot survey conducted in area frame approach

The west shoa pilot survey

- Area frame methodology was started in one zone, west shoa zone of oromiya region
- 40 enumeration areas and 40 segments (1 segment per EA) were sampled
- This survey helped just to check the practicality of area frame. It served like pre-test
- Segment map preparation, delineation, listing of fields and filling the questionnaire was tested

The 2010 pilot survey in oromiya region

- In 2010 E.C pilot survey conducted in all zones of oromiya region
- By incorporating the recommendations in the west shoa pilot, the 2010 pilot covered all zones of oromiya region
- 215 EAs and 430 segments selected (2 segment per EA)
- The sample allocated to all zones proportionally
- In this pilot improvements in implementing the area frame approach was observed
- Looking at the results of the survey, significant differences in the estimate of area b/n the list frame and area frame occurred
- Identification of possible sources of the differences was done by international consultants and recommendations made for the 2011 pilot survey

The 2011 pilot survey in oromiya region

- The recommendation in the 2010 pilot survey implemented
- To clearly measure part of field only with in the segment boundary, when the boundary dissects the field
- To prepare the clear manual and give intensive training
- Allocate enough time for data collection
- Prepare clear segment map with clear boundary as much as possible
- To avoid segments of less than 2 % crop land in stratum 4 in nomadic areas
- To identify and exclude commercial farm
- 239 EAs and 478 segments sampled
- Estimate of major crops are found to be comparable for list and area frame except sorghum, coffee and chat
- Stratum 1 and 2 (high crop land area) working well but stratum 3 and 4 (less crop land area) creates high variability

- CV's compared and area frame CV are high
- Most of the discrepancies in the estimate of the area and CV occurred due to stratum 4 (less than 25 % crop land stratum)
- It is recommended to further stratify stratum 4 and also to review the issue of some crops

The 2012 pilot survey in four regions in the country

- As recommended in the previous pilot, stratum 4 is sub stratified in to two
- In the 2012 pilot, three additional regions are covered by area frame pilot survey
- The regions covered by this pilot are Tigray, Amhara, Oromiya, SNNP
- The pilot data collection is now finalized in Tigray, Amhara, oromiya and SNNP region
- A final summery for area frame pilot survey is expected from this pilot survey

Area frame survey saves time as the holdings are near to each other. On the other hand identifying the owner of the field may take some time. It also avoids missing fields. The data can also be cross checked with the total area of the segment. In the area frame approach selecting the appropriate approach for area, production and other socio economic survey should also be thought well. Area frame approach uses appropriate measure of size, which is area. Area frame approach also facilitates Supervision. One of the disadvantage of area frame is it requires satellite imagery and land cover classification which requires large budget.

Sample EAs for area frame in one zone

Ea Code	Agri Area %	Total Area (M.Sq)	Total Area (Ha)	No. Seg	Stratum
07020501401	100	1450944	145	4	St-1
07020501802	99	2323661	232	6	
07020602003	98	2232635	223	6	
07020701603	96	1869735	187	5	
07021000502	95	3360209	336	8	
07020601802	94	2754419	275	7	
07020102302	93	1651078	165	4	
07020603005	92	2185661	219	5	
07020501801	91	2645485	265	7	
07020200705	90	2140646	214	5	
07020102204	89	3002179	300	8	
07021001701	87	2907523	291	7	
07020402403	86	2848395	285	7	
07020300304	85	1971227	197	5	
07020200406	83	3566411	357	9	
07020901701	82	4047000	405	10	
07020600403	80	3401578	340	9	
07020600901	78	3802385	380	10	
07020300401	75	2594965	259	6	
		19			
07021000703	73	4764353	476	12	st-2
07020500204	68	4919645	492	12	
07020801903	64	3701123	370	9	
07020200301	58	7501270	750	19	
		4			
07020401001	47	4117062	412	10	st-3
07020201102	30	13341625	1334	33	
		2			
07020200501	22	20329972	2033	51	st-4
07020602803	17	16351628	1635	41	
		2			
07021001101	11	60656134	6066	152	st-5
07021000801	9	36712839	3671	92	
		2			

In 2012, CSA and World Bank conducted research in afar region using multiple frame approach to get livestock estimates in the region. The method used combination of area frame and list frame. This method can be further tested and implemented in the future surveys for nomadic areas.

4. Development of Community frame

The community questionnaire was designed to collect data on agricultural and health related issues such as agro ecology, types of crops grown in meher (long rain season) and belg (short rain season) season, culture of growing rare crops, irrigation and types of major diseases in the enumeration area. The data was collected only from rural areas during population and housing census. The respondents in the community questionnaire were representatives in the enumeration area which are from 3 to 5 peoples composed of elders, officials and development agents.

After the data is collected, the identification part of the community frame was edited. This facilitated the frame compilation very highly. For the community questionnaire, the data was captured by data entry instead of scanning. The data entry was done after editing and this minimizes the mismatch. The community frame compilation is a good start.

The community questionnaire is basically useful for stratification purposes for surveys. The information collected in community questionnaire is based on respondent's opinion; and this may create discrepancy with the data collected on scientific basis.

Table 1: Region * Agro ecological zone Cross tabulation.

% within Region	Agro ecological zone				
Region	**Dega (High land)**	**Woina Dega (Midland)**	**Kola (Low land)**	**Bereha (Desert)**	**Total**
Tigray	16.5%	45.0%	37.9%	.6%	100.0%
Affar	.7%	7.4%	24.0%	67.9%	100.0%
Amhara	16.0%	53.9%	28.0%	2.1%	100.0%
Oromiya	16.1%	57.2%	23.9%	2.8%	100.0%
Somali	.8%	6.2%	30.0%	63.1%	100.0%
Benshangul-Gumuz	4.3%	23.7%	58.7%	13.4%	100.0%
SNNP	20.5%	57.9%	20.7%	.9%	100.0%
Gambella		22.3%	60.7%	17.0%	100.0%
Harari	2.1%	81.1%	16.8%		100.0%
Total	**16.3%**	**53.3%**	**25.9%**	**4.5%**	**100.0%**

Table 2: Region * Cereals growing in meher season Cross tabulation.
% within Region

Region	Cereals growing in meher season		Total
Tigray	74.3%	25.7%	100.0%
Affar	31.5%	68.5%	100.0%
Amhara	91.5%	8.5%	100.0%
Oromiya	88.0%	12.0%	100.0%
Somali	30.8%	69.2%	100.0%
Benshangul-Gumuz	80.3%	19.7%	100.0%
SNNP	80.8%	19.2%	100.0%
Gambella	73.8%	26.2%	100.0%
Harari	80.0%	20.0%	100.0%
Total	**84.3%**	**15.7%**	**100.0%**

Table 3: Region * Irrigation Cross tabulation.

% within Region

Region	Irrigation	No	Total
Tigray	49.7%	50.3%	100.0%
Affar	29.5%	70.5%	100.0%
Amhara	45.0%	55.0%	100.0%
Oromiya	27.9%	72.1%	100.0%
Somali	9.4%	90.6%	100.0%
Benshangul-Gumuz	30.0%	70.0%	100.0%
SNNP	12.2%	87.8%	100.0%
Gambella	14.6%	85.4%	100.0%
Harari	42.1%	57.9%	100.0%
Total	**30.2%**	**69.8%**	**100.0%**

5. Conclusion and recommendation

- Master sampling frame is a basis for all socio economic surveys including agriculture.
- As the master frame is basically developed from data collected during census, very serious attention should be given for master frame development for agricultural survey during census. Appropriate variables needs to be collected during census to develop good master sample frame for agriculture and rural statistics.
- Appropriate frame; that is list, area or multiple needs to be implemented accordingly.
- It will be good to collect community frame to further verify and validate the master frame and also to get appropriate stratifying variable.
- Developing master sample frame from agricultural census should also be considered.
- Simplified frame updating mechanism should be studied.

Master Sampling Frames for Agricultural and Rural Statistics – experience of Lesotho

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Abstract

Agricultural Production Survey (APS) is an annual survey, which is undertaken by Lesotho Bureau of Statistics. The survey runs throughout the agricultural year; from the 1st of August of the current year to 31st July of the following year. In every ten years, the Bureau carries out the agricultural census to generate data on variables that do not change much overtime and also serve as an indispensible base for assessing reliability of current agricultural statistics. Both APS and agricultural census concentrate on the production of both livestock and crops in the rural parts of the country.

This paper presents Lesotho Agricultural Production Survey design and sample selection methodology. For both annual agricultural survey and/or agricultural census, Stratified multi-stage cluster sampling design is adopted for the selection of the sample. Two or three enumeration areas are combined to form a Primary Sampling Unit (PSU). A Probability Proportional to Size (PPS) is used for the selection of PSU's where households are taken as a measure of size. Individual farming households constitute Secondary Sampling Units (SSU's) and systematic sampling technique is adopted for selection of SSU's. For the estimation of crop yield, fields for each of the main crops per PSU are selected following systematic sampling technique and these fields constitute third stage sample units. Another sample of fields for crop forecasting is done from the sample of selected field for crop production.

Keywords: Agricultural Production Survey (APS); Agricultural Census (AC); Stratified multi-stage Cluster sampling design; Primary Sampling Units (PSUs); Secondary Sampling Units (SSUs); Probability Proportional to Size (PPS); systematic sampling.

1. Introduction

Lesotho is situated in the southern part of Africa and is land locked by the Republic of South Africa. According to the 2006 Population and Housing Census, total population stood at 1,872,721, of which about 51.4 percent was females. The country's total area is 3,035,500 hectares, of which 325,000 hectares is arable.

The mandate of Lesotho Bureau of Statistics (BOS) is to collect, process, analyse and disseminate statistical data. BOS has been collecting agricultural data through annual agricultural production surveys (APS) and Agricultural Sample Censuses every 10 years from as far back as 1973. The difference between the annual surveys and Agricultural Censuses is that for the census, the sample size is increased to give a better coverage and hence increase precision of the estimates. For the most recent Agricultural Census, the 2009/10, the sample was increased by 10 percent from the 2008/09 annual APS.

The major types of agricultural data collected by BOS are crops and livestock for both rural and urban setting. Rural crop statistics covers area planted, production by crop, yield per hacter, land utilization per season and cereal availability and utilization per year. Livestock Statistics gives livestock inventory and stock changes within a survey period.

The urban Statistics report covers vegetables planted and livestock reared in urban households. The type of agriculture practiced in Lesotho is mainly subsistence with minimal commercial farming. Farming households are identified after stratification of households into farming and non-farming following listing operation in the selected Primary Sampling Units (PSU's) of the master sample.

2. Development of the Master Sampling Frame for agriculture and the household surveys

Like in other developing countries, Master Sampling Frame in Lesotho is designed as a basis for selection of different samples for various surveys or different rounds of a single survey. The sample for annual agricultural production survey has been selected from the Lesotho Master Sampling Frame that is designed for all surveys that are likely to be conducted within the same period.

During the developing Master Sampling Frame, quality of data should be the priority from the surveys selected for the frame. The completeness of the sampling frame pays a very important role to avoid under-coverage (Statistics Canada, 2010). The most important source of quality data is population census. The current master sampling frame was constructed from the 2006 Population and Housing Census.

According to Pettersson, it is desirable for the basic frame units to be small areas that will allow for a grouping of the units into larger sampling units to meet survey's cost considerations. In Lesotho, the enumeration areas (EAs) are the best frame units as they are well demarcated and documented. The average measure of size is attached to each EA. Samples can be drawn from master sampling frame by sampling EAs or by grouping EAs to form larger PSUs. List of Households form second stage sampling units. The Agricultural Census uses frame of institutions. BOS had developed the first frame of community when conducting of 2009/10 Agricultural Census. For each unit of the master frame, the information is distributed by rural/ urban, district, zones, Community Council and Constituencies.

2.1 Area Frame

The 2006 Housing and Population census enumeration areas are regarded as the basic unit of BOS Master Frame. The Enumeration areas are well defined and cover the totality of Lesotho territory, so there is no problem of completeness or duplication of units. All the EAs and PSUs are geo referenced. In the first stage, probability proportional to size was used to select the enumeration areas to be included in the sample.

For administrative purposes, Lesotho is divided into ten districts. Within the districts there are four agro- ecological zones. These zones experience different climatic conditions; they are therefore regarded as strata. The lowland zone is most densely populated and an intensively cultivated zone with relatively high chances of rainfall. The foothill zone, as compared to lowland is less populated with less rainfall. The mountain zone is the largest zone of the country that is characterized by very cold winter. Senqu River Valley is the smallest zone which runs from the east to the west across some districts. Stratification is also done by rural and urban dichotomy. The districts are regarded as Domains of study for all BOS surveys. Table1 illustrates the strata used for BOS Master Frame across districts.

2.2 The List Frame

Households form second stage sampling units. The list of households comprises the total number of households within a PSU. Apart from giving sample selection, number of households is used to determine the allocation of sample PSU to strata, to form sampling units of a desirable size and to form strata of units classified by size. Within the rural area, an EA is delineated to have about 100 to 150 households while in the urban, the range is between 80 and 100 households on average.

2.3 The Institution Frame

The institution frame is composed of schools, prisons and projects. All the institutions engaged in agricultural activities within the selected PSU are secondary sampling units. This frame is used during the Agricultural Census not with annual APS data collection.

2.4 The Community Frame

Both community level data and agricultural Census data collection were done concurrently as part of World Census of Agriculture 2010. However, the community level data covered agricultural, social and economic related data not collected from holdings.

The community questionnaire was designed to give community profile from the village level, community council up to the district level. Data collected from the community profile was of interest in an agricultural census especially for decentralized planning, identification of poor villages, planning of targeted area development programmes and targeting communities for relief operations in case of natural disasters. The respondents for community information were either village chiefs or councilors or both parties.

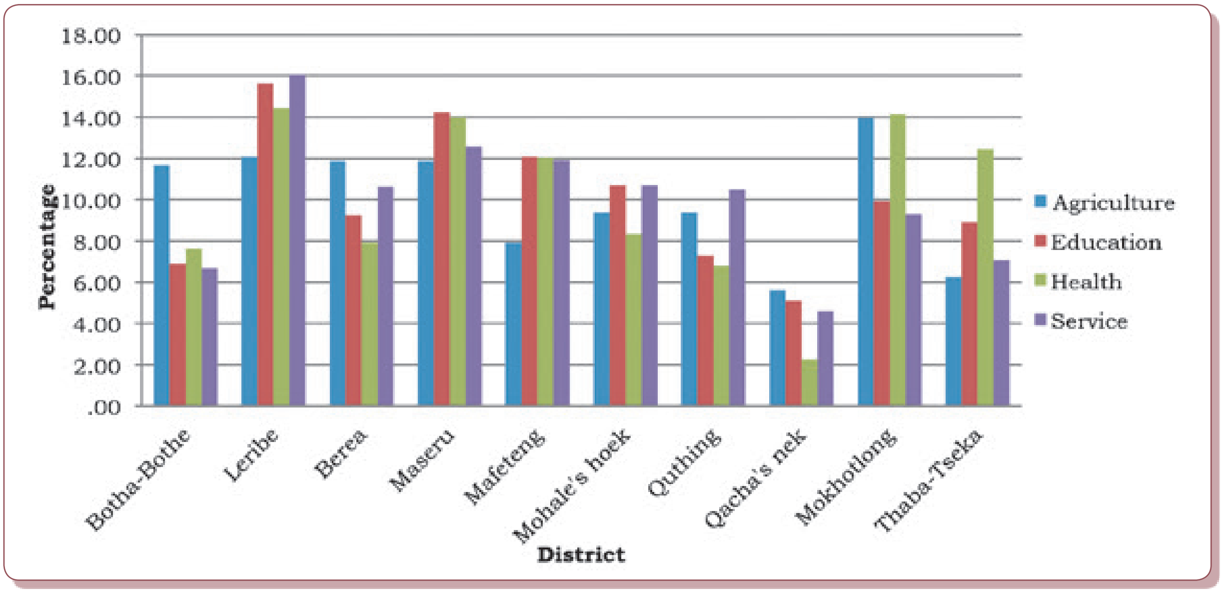
In addition, the main purpose of community profile was to provide frame for agricultural, social and economic surveys. The 2009/10 community level data gives list of agricultural, social and economic establishments such as agricultural input dealers, wool sheds, sheep studs, facilities such as education, health and agricultural and village programmes like water provision and infrastructure. This information is useful for stratification of villages with or without facilities.

Table 1: Distribution of Strata by District and Region, 2006 Cartographical Zone.

District	Rural Lowlands	Rural Foothills	Rural Mountain	Rural Senqu River Valley	Urban Strata
Botha- Bothe	√	√	√		√
Leribe	√	√	√		√
Berea	√	√			√
Maseru	√	√	√		√
Mafeteng	√	√			√
Mohale's Hoek	√	√	√	√	√
Quthing			√	√	√
Qacha's Nek			√	√	√
Mokhotlong			√		√
Thaba Tseka			√		√

Source: Household Budget Survey, Volume1, 2006.

Figure1: Percentage Distribution of Villages with Facilities by District.



Source: Community Level Data Volume V, 2012.

3. The BOS Master Sampling Frame

The development of a master sampling frame and a master sample for the surveys is often an important part of an integrated system of household surveys (ISHS). Master sample frame becomes basis for sample selection required for data collection of all surveys conducted by the Bureau. This enables correlation of information from those surveys at the area level. It enables certain linkages, such as sharing of survey personnel, using same definitions and concepts, sharing of facilities like transport, etc, for different surveys. These result in effective and efficient coordination between surveys. It is also effective in that once permission from regional and local authorities has been secured when the first survey is conducted, time is saved to conduct subsequent surveys as there is no need to ask for permission again. It is easy to locate households by interviewer residing within the area.

There is need to periodically up-date the master sample to properly account for post-censal growth on a large scale such as that which occurs in high-rise residential construction and expansion of squatter areas in urban areas. The list frame is also updated to reflect migration, births and deaths.

3.1 Using BOS Master Sampling Frame

Stratified multi-stage cluster sampling design is adopted for the selection of the survey sample. In the rural areas, in the first stage, PSUs are constructed with combination of 2 to 3 adjacent enumeration areas from population and housing census. The PSUs are selected with probability proportional to size (PPS). In the urban areas, the enumeration areas are used as PSUs. All households in the selected PSU's are listed, for APS the households are classified into the following four classes:

Rural Agricultural Production Survey:

- Households operating at least one field;
- Households raising at least one cow, sheep and or goat and improved pigs;
- Households operating both fields and livestock;
- Households without fields and livestock.

Urbanl Agricultural Production Survey:

- Households operating kitchen garden and /or vegetable field;
- Household raising at least one /sheep/ goat/ improved pig/ 50 improved poultry;
- Households operating both fields and livestock;
- Households without fields and livestock.

These stratifications for both rural and urban agricultural surveys justify the need to update list frame every two to three years since the ownership or operation of livestock and or fields do not last for a long time. None farming households are excluded from the agricultural frame. A sample of farming households is then selected by systematic sampling from each selected PSU.

Finally, for estimation of crop yield in each sample PSU, a maximum of fifteen fields under each principal crop are selected with equal probability for each crop.

The selected PSUs (group of EAs or single EAs) for APS, UAPS and or AC are also selected for Continuous Multi-purpose Household Survey (CMS). The two parallel surveys are maintained as their data collection is done within the same areas. Since the agricultural sector is composed largely of small farming households, partial integration of rural household and agricultural survey is observed. The demographic variables are the same for both surveys. This eases the comparison of findings hence assurance of quality and reliable statistics produced by BOS.

Most developing countries use list frame approach for data collection of agriculture because of an availability of good land records (United Nations, 1986). Use of list frames is time consuming, as mentioned earlier, there is a need to update list of household prior to every data collection of APS. It has been established that list frame as it uses the indirect measure of field size, gives different area planted as compared to area frame. To some crops, list approach gives large area planted while to others area planted is smaller than area approach (Central Statistics Agency, 2011).

4. Documentation of Master Sampling Frame

Master Sampling Frame is well kept and easily accessible for selection of Master Sample and maintenance thereof. BOS has computerized data base containing all the enumeration areas identified with codes. It is therefore easy to execute sorting and filtering during sampling.

5. Conclusion

The purpose of the global strategy to improve agricultural statistics is to provide the vision for national and international statistical systems to produce the basic data and information to guide the decision making required for the 21st century. The draft global strategic plan puts emphasis on the integration of agriculture into the national statistical system which is built on the concept that all census and survey data collections for agriculture be based on sample units selected from a Master Sample Frame for agriculture as a single source (World Bank, 2010). As indicated earlier, the BOS has developed its master sample frame basically from its Population censuses. A master sample frame has been used for selection of primary sampling units (PSUs) for agriculture and household surveys.

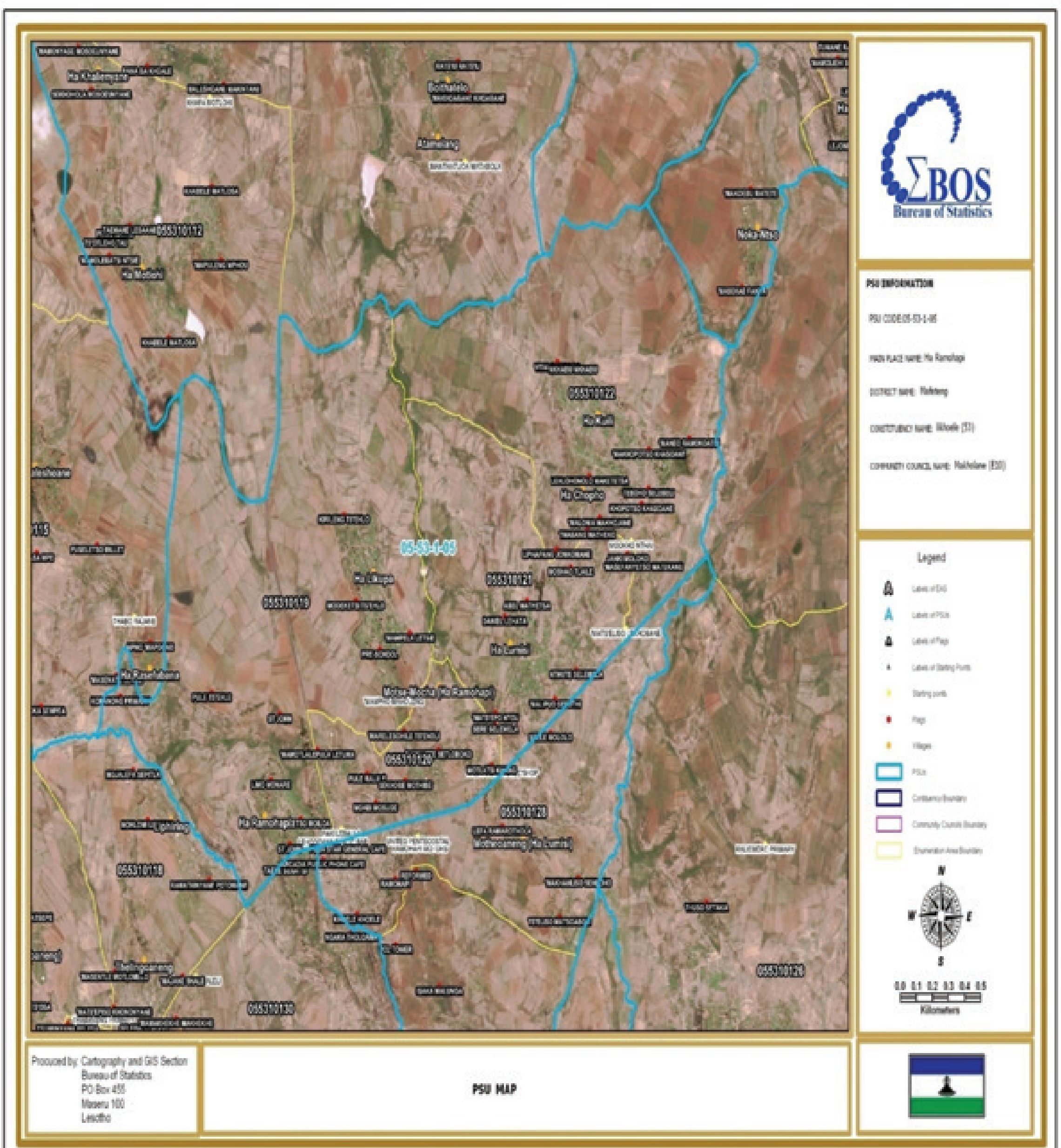
The second stage sampling units for both CMS and APS are households. BOS is cautious so as to avoid risks of biases resulting from conditioning effects and from increased non response caused by the cumulative response burden hence PSUs are selected every two years.

With efforts being made to produce accurate, timely and reliable data for evidence-based planning, decision making, research, policy, program formulation and monitoring and evaluation to satisfy the needs of users and producers, the

division of Agriculture and Food Security produce Crop Forecasts by end of May. This information is needed to inform Government planners and other private sectors with forecasted crops production so as to make effective decision concerning availability of food in the country and to make necessary preparations if there is a shortage of food. The actual crop production estimates are reported by October. However, for more timely and accurate data, advanced methodological changes and technology such as portable computers for data collection need to be employed. BOS together with Ministry of Agriculture and Food Security have to work towards construction of area frame approach where the observation units are territorial sub divisions and weigh the advantages of using multiple frame i.e. list frame and area frame to improve area under crop.

Annex 1: PSU no.05-53-1-05.

EA no.055310119, 0553100120, 055310121 and 55310122



Annex 2: APS and CMS Listing Form.

THE KINGDOM OF LESOTHO

Form..1...of......3

Agricultural Production Survey Listing Form

IDENTIFICATION INFORMATION

District		Population	
Constituency		Male	
Community		Female	
Zone		Total	
EA Code		Households	

NB: R – Residential, N – Non-Residential, B – Both Residential and Business

Form..2....of.........3

ST no.	HH no.	Type of Use: R, N and B	Name of Household Head	Sex 1.Male 2.Female	No of Persons		Do you own fields? 1.Yes 2.No	Do you operate field? 1. Yes 2. No	No. of cattle
					F	M			
(A)	(B)	(1)	(2)	(3)	(4a)	(4b)	(5)	(6)	(7)

NB: R – Residential, N – Non-Residential, B – Both Residential and Business

Form..2....of.........3

ST no.	HH no.	No. of Sheep	No. of Goats	No. of improved pigs	No .of improv Chicken	No. of other chicken	No. of doves	No. of Turkeys	Other poultry not stated (specify)	Do you own forestry 1.Yes 2.No	OFFICE USE ONLY
(A)	(B)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)

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SPP 2
Survey Design and Sampling Strategies for Agricultural Surveys

Organizers: Renee Picanso, USDA/NASS and Zelia Bianchini, IBGE
Chair: Zelia Bianchini, IBGE
Discussant: Michael Steiner, USDA

As a way to ensure consistency in agricultural statistics, the Global Strategy (GS) advocates the use of a single frame of reference, a master sample frame and the establishment of an integrated system of surveys.

The GS admits some alternatives to master frame - list register (from population or agriculture census); area register (from images classified according to use, from agriculture census enumeration areas, or making use of grids or points). It discusses alternatives with direct sampling or different stages.

On the other hand, it defines a set of key indicators, and provides guidance on attendance requirements and geographical detail. It also proposes criteria and methods to discuss the relative importance of different agricultural activities, aimed at setting the national statistical program.

More appropriate solutions for survey methods, sampling design and strategy will depend crucially on the availability of information and particular characteristics of agriculture and other country-specific circumstances.

This session is intended to highlight new survey methodology and improved sampling and strategies for successful agricultural surveys and censuses. Topics include: 1) Integrated survey methods and sampling (including integrating agriculture and household surveys); 2) Conducting follow-on surveys from an agricultural census; 3) Reporting on successful research and/or experience in survey design and sampling areas.

Papers:

- Denis Santos, Marcos Freitas, Maurício Lila, et al. (Brazil), “Brazilian Agricultural Survey System - a description of sampling methods”
- Carlos Alberto Rossi (Argentina), “Redesign of the National Agricultural Survey in Argentina: changes in the sampling frame and data collection”
- Mónica Madrid Arroyo (Colombia), “Statistical Methodologies for the Development of Colombian Agricultural Statistical System”

Brazilian Agricultural Survey System - a description of sampling methods

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Abstract

The aim of this work is to present the development of strategies and sampling techniques that might be adopted in the Brazilian Agricultural Survey System (in Portuguese, Sistema Nacional de Pesquisas Agropecuárias - SNPA). First, a brief description of the sampling frame is presented. The sample design adopted in this study is a stratified and clustered sampling design. Strata are defined by an administrative criteria that defines contiguous geographic areas and according the size of the establishment. The cluster selection is performed in two stages. First, areas are selected then in the second moment establishments are selected. The selection of areas is done using probability proportional to a measure of size. There are two measures of size considered in this study, the production, which provides better precision for the parameter of interest, and the number of establishments in the area. The quantity of interest to be estimated in this survey is the total production in all establishments. Some relative precision is defined in association to the coefficient of variation of the total estimator in order to define the sample size. It is desired to publish results for different domains corresponding to administrative divisions of the Brazilian territory. The smallest domains of interest are the Federative Units (FU), e.g. states and the Brazilian capital city. The preliminary studies are performed using results from the Agricultural Census taken in 2006.

Keywords: sample design; enumeration areas; stratification; sampling frame.

1. Introduction

The Brazilian Agricultural Survey System (in Portuguese, Sistema Nacional de Pesquisas Agropecuárias – SNPA) of the Brazilian Institute of Geography and Statistics aims to improve the way which agricultural establishments are monitored. The basic idea is to start with a review of the current surveys and implementation of other sources of investigation.

The Census of Agriculture is conducted every decade. In between decades, agricultural information are obtained from different sources, for instance, agribusinesses and administrative records from municipalities. The SNPA aims to obtain the information directly from the farmers, avoiding error propagation caused by external information.

The population of interest are the agricultural establishments. According to the 2006 Census (IBGE, 2012) there are 5,175,636 agricultural establishments in Brazil. These establishments should be represented by SNPA.

2. The Sampling frame

The Sampling frame in this surveys system corresponds to a set of agricultural establishments distributed in both area and list frames. Establishments where the production is higher when compared to others are likely to be selected in the list frame while small establishments are going to be selected using the area frame. In the list frame there is stratification by economic activity and the magnitude of the establishment. In some cases there are units selected with probability one. Others are selected using simple random sampling without replacement. The main concern in the area frame rises from the quantity of establishments in the enumeration areas. The spatial distribution of small establishments can be sparse, thus it is reasonable to consider levels of aggregation of enumeration areas. In the area frame part, the sample is obtained through the selection of primary sampling units (PSU) and subsequently agricultural establishments, so-called secondary sampling units (SSU). In the list part, the primary sampling units are the agricultural establishments. Both samples will be obtained from the 2006 Agricultural Census.

2.1 The List Frame

In order to define which establishments are parts of the list frame, cutoff points are set taking into account the participation of the establishments in the national production. The idea is that large establishments are easily accessed (e.g., using telephone). Table 1 shows the criteria used and the number of establishment per product.

The establishments in the list frame are stratified according their total production value, taking into account the Federative Unit and the economic activity.

Table 1: Classification rule and number of establishment per product.

	Rule	Establishments
Eggs	10,000 egg-laying hens	1.310
Poultry	420,000 chicken sold	426
Pork	40 sows or 880 swines sold	10.090
Milk	50 dairy cows	22.459
Cattle	Number of animals larger than 1000	20.365
Coffee	1000000 coffee plants	214
Orange	300,000 trees or 200 ha harvested	425
Storage	1200000 Tons	2.636
Cotton	300 ha harvested	313
Tobacco	100 ha harvested	376
Rice	100 ha harvested	3.593
Corn	300 ha harvested	1.633
Wheat	300 ha harvested	64
Soy	300 ha harvested	10.245
Beans	100 ha harvested	3.147
Cas s ava	25 ha harvested	8.861
Wood	1000 ha of forest	213
Sugar Cane	500 ha harvested or CNPJ	5.329

The strata were obtained using the method proposed by Lavallée and Hidiroglou (1988). The method aims to determine the "optimum" stratification limits setting the number of strata and the level of precision required to estimate the total production such that the total sample size is minimal. The largest units in the population have probability of being selected equals to one. Therefore, these units are aggregated to a separated stratum. In the remaining strata, units are selected by simple random sample without replacement. The method of stratification is implemented as follows. Consider Y the total of the variable of interest in the population; H denotes the number of strata in the population U, such that the population can be partitioned like $U_1 \cup U_2 \cup \ldots \cup U_H = U$; let a_h be the sample selected from; U_h; N is the number of units in the population; n is the number of units in the sample; N_h is the number of units in the stratum h, $h \in \{1, \ldots, H\}$; n_h is the number of units in in the sample for a given stratum h, $h \in \{1, \ldots, H\}$.

The problem consists in how to find H-1 cutoff points, $b_1 < b_2 < \ldots < b_{H-1}$ which define a partition with H strata, such that the sample size n is minimized and related to the precision of the total estimator Y, considering power allocation (Bankier, 1988) for the distribution of the total sample size over the strata. The cutoff points must satisfy the constraints: $n_h < N_h$, $\in \{1, \ldots, H\}$ and $n_h = N_h$. Another constraint is that the units in the strata H have probability one to be selected.

In this case an unbiased estimator of the total is given as

$$\hat{Y} = \sum_{h=1}^{H-1} N_h \bar{y}_h + N_H \bar{Y}_H,$$

Where

$\bar{y}_h = \frac{1}{n_h} \sum_{i \in a_h} y_i$ is an unbiased estimator of $\bar{Y}_h = \frac{1}{N_h} \sum_{i \in U_h} y_i$ based on the sample selected from the strata $h = 1, \ldots, H-1$.

The variance of $\hat{Y}$ is given as $V(\hat{Y}) = \sum_{h=1}^{H-1} N_h (N_h - n_h) \frac{S_h^2}{n_h}$,

Where $S_h^2 = \frac{1}{N_h - 1} \sum_{i \in U_h} (y_i - \bar{Y}_h)^2$

The coefficient of variation of $\hat{Y}$ is

$$CV(\hat{Y}) = \frac{\sqrt{V(\hat{Y})}}{Y}$$

According to Bankier (1988), the number of units in each stratum when power allocation is used is

$$n_h = (n - N_H) \frac{Y_h^p}{\sum_{k=1}^{H-1} Y_k^p} \quad (1)$$

Where $0 < p < \infty$ and, $Y_h^p = (\sum_{i \in U_h} Y_i)^p$, considering p as 1/2 or 1/3 in order to provide estimates with similar coefficients of variation in the different strata without the reduction of the precision of the estimator of the total.

Denoting $n^* = n - N_H$, $Z_h = \frac{Y_h^p}{\sum_{k=1}^{H-1} Y_k^p}$, it follows that $\sum_{k=1}^{H-1} Z_h = 1$ e $n_h = n * Z_h$.

For a fixed coefficient of variation

$$CV(\hat{Y})^2 Y^2 = \sum_{h=1}^{H-1} \frac{N_h S_h^2}{n * Z_h} - \sum_{h=1}^{H-1} N_h S_h^2.$$

Solving this equation for n *

$$n^* = \frac{\sum_{h=1}^{H-1} \frac{N_h S_h^2}{Z_h}}{CV(\hat{Y})^2 Y^2 + \sum_{h=1}^{H-1} N_h S_h^2},$$

this results in

$$n = N_H + \frac{\sum_{h=1}^{H-1} \frac{N_h S_h^2}{Z_h}}{CV(\hat{Y})^2 N^2 \bar{Y}^2 + \sum_{h=1}^{H-1} N_h S_h^2}. \quad (2)$$

Equivalently,

$$n = NW_H + \frac{N[\sum_{h=1}^{H-1}(W_h \bar{Y}_h)^p][\sum_{h=1}^{H-1}(W_h S_h)^2 (W_h \bar{Y}_h)^{-p}]}{NCV(\hat{Y})^2 \bar{Y}^2 + \sum_{h=1}^{H-1} W_h S_h^2}, (3)$$

Where

$W_h = \frac{N_h}{N}$, for $h = 1, \ldots, H$

Hence, the objective is to minimize (3) with respect to $b_1, b_2, \ldots, b_{H-1}$ for fixed coefficients of variation and number of strata. Therefore, is taken the derivative of (3) with respect to b_h and set equals to zero. Thus, the boundaries $b_h, h = 1, \ldots, H-1$ are given as

$$b_h = \frac{-\beta_h + \sqrt{\beta_h^2 - 4\alpha_h \gamma_h}}{2\alpha_h} \quad (4)$$

for $h = 1, \ldots, H-2$,

$\alpha_h = FT_h - FT_{h+1}$,

$\beta_h = F(K_h - K_{h+1} - 2\bar{Y}_h T_h + 2\bar{Y}_{h+1} T_{h+1}) + 2AB(\bar{Y}_h - \bar{Y}_{h+1})$

$\gamma_h = FT_h(\bar{Y}_h^2 + S_h^2) - FT_{h+1}(\bar{Y}_{h+1}^2 + S_{h+1}^2) - ABF(\bar{Y}_h^2 - Y_{h+1}^2)$

For $h = H-1$,

$\alpha_{H-1} = FT_{H-1} - AB$,

$\beta_{H-1} = F(K_{H-1} - 2\bar{Y}_{H-1} T_{H-1}) + 2AB\bar{Y}_{H-1}$

$\gamma_{H-1} = FT_{H-1}(\bar{Y}_{H-1}^2 + S_{H-1}^2) - AB\bar{Y}_{H-1}^2 - F^2$,

Where A, B, F are given as,

$$A = \sum_{h=1}^{H\ 1} (W_h \bar{Y}_h)^p$$

$$B = \sum_{h=1}^{H-1} (W_h S_h)^2 (W_h \bar{Y}_h)^{-p}$$

$$F = NCV^2 \bar{Y}^2 + \sum_{h=1}^{H-1} W_h S_h^2$$

And K_h, T_h given as

$$K_h = Bp(W_h \bar{Y}_h)^{p-1} - Ap(W_h S_h)^2 (W_h \bar{Y}_h)^{-p-1}$$

$$T_h = AW_h (W_h \bar{Y}_h)^{-p}$$

Hence, the algorithm to obtain the boundaries is given as follows:

Step 0 – the variable of interest is ordered in ascending way; let $b_0 = x_1$ and $b_H = x_N$

Step 1 – Define values for $b'_1 < \ldots < b'_{H\ 1}$ such that $b_0 < b'_1 < \ldots < b'_{H\ 1} < b_H$

Step 2 – Calculate W_h, $\overline{Y_h}$ e S_h considering $b'_1 < \ldots < b'_H$

Step 3 – Calculate new boundaries $b''_1 < \ldots < b''_{H\ 1}$ from equation (10)

Step 4 – Repeat steps 2 and 3 until $\max_{h=1}^{H-1} |b''_h - b'_h| < \varepsilon$, where $0 < \varepsilon < 1$

2.2 The Area Frame

The Area Frame is composed by primary sampling units with two or more agricultural establishments which are not considered large enough to be part of the List Frame. The sample selection in this frame is a stratified two stage clustered sample. In the first stage, PSUs are selected with probability proportional to size (PPS) with the size measure being the total production value. In the second stage, establishments are selected with equal probability, i.e., simple random sampling without replacement. The number of PSU with at least two agricultural establishments in the area frame is 53,334. The sample size of interest is the number of PSUs because the second stage the sample size of establishments was set to 10. The number of PSUs with less than 10 establishments is 638. Initially there were many enumeration areas with only one establishment. These enumeration areas were grouped forming new PSUs.

The number of PSUs with two or more agricultural establishments in each Federative Unit is in Table 2.

In order to define the sample size of PSUs a number of establishments in each area is fixed. The idea is to derive the number of PSUs as a function of the coefficient of variation of the total production value. The levels of accuracy are calculated for some products of interest such as rice, corn, wheat, sugarcane, soy, beans, cassava, tobacco, cotton, orange, coffee, cattle, milk, pork, poultry, eggs, wood for paper and wood for other purposes. These products are represented by their production value.

The basic setup is given as

Y is the total of the variable of interest in the population;

M is the total number of PSUs in the population;

N the total number of establishments in the population;

N_i is the number of establishments in the i-th PSU i, $i \in \{1, \ldots, M\}$;

Table 2: Number of PSUs with two or more agricultural establishments by Federative Units.

FU	M	FU	M	FU	M
Rondônia	784	Ceará	3.583	Rio de Janeiro	893
Acre	235	Rio Grande do Norte	784	São Paulo	3.394
Amazonas	850	Paraíba	1.549	Paraná	4.124
Roraima	104	Pernambuco	2.888	Santa Catarina	2.172
Pará	1.928	Alagoas	920	Rio Grande do Sul	5.015
Amapá	52	Sergipe	932	Mato Grosso do Sul	870
Tocantins	650	Bahia	6.657	Mato Grosso	1.111
Maranhão	2.862	Minas Gerais	6.168	Goiás	1.699
Piauí	2.124	Espiríto Santo	927	Distrito Federal	69

Y_i is the total of the variable of interest in the i-th PSU, $i \in \{1, \ldots, M\}$;
$\bar{Y}_i = \frac{Y_i}{N_i}$ is the mean of the variable of interest in the i-th PSU;
y_{ij} is the value of the variable of interest in the j-th SSU given the i-th PSU, $j \in \{1, \ldots, N_i\}, i \in \{1, \ldots, M\}$;
m is the number of PSUs chosen in the first stage;
n_i is the number of selected establishments in the i-th PSU;
X_i is the total production value or number of establishments in the i-th PSU

$$p_i = \frac{X_i}{X}$$

$$S_i^2 = \frac{1}{N_i - 1} \sum_{j=1}^{N_i} (y_{ij} - \bar{Y}_i)^2$$

$$\hat{Y} = \frac{1}{m} \sum_{i \in s} \frac{\hat{Y}_i}{p_i}$$

where

$$\hat{Y}_i = \frac{N_i}{n_i} \sum_{j=1}^{n_i} y_{ij}$$

Thus, the variance is given by:

$$V[\hat{Y}] = \frac{1}{m} \sum_{i=1}^{M} \left(\frac{Y_i}{p_i} - Y\right)^2 p_i + \frac{1}{m} \sum_{i=1}^{M} \frac{1}{p_i} N_i^2 \left(\frac{1}{n_i} - \frac{1}{N_i}\right) S_i^2$$

$$V[\hat{Y}] = \frac{1}{m} \left[\underbrace{\sum_{i=1}^{M} \left(\frac{Y_i}{p_i} - Y\right)^2 p_i}_{A} + \underbrace{\sum_{i=1}^{M} \frac{1}{p_i} N_i^2 \left(\frac{1}{n_i} - \frac{1}{N_i}\right) S_i^2}_{B} \right] \qquad (5)$$

The coefficient of variation for each variable can be calculated as follows:

$$CV(\hat{Y}) = \frac{\sqrt{V[\hat{Y}]}}{E(\hat{Y})} = \frac{\sqrt{V[\hat{Y}]}}{Y}$$

because population values are known.
To calculate the sample size at a given level of coefficient of variation: Consider $n_i = 10$ in the formula in Part B of the expression of the variance:

From the variance equation in (5) we obtain

$$m.V[\hat{Y}] = A + B, m = \frac{A+B}{V[\hat{Y}]}$$

As

$$V[\hat{Y}] = CV(\hat{Y})^2 Y^2$$

$$m = \frac{A+B}{CV(\hat{Y})^2 Y^2} \qquad (6)$$

From expression (6) we can find the coefficient of variation for the variables of interest:

$$CV = \sqrt{\frac{A+B}{mY^2}} \qquad (7)$$

2.2.1 Stratification

The set of equations derived previously aimed to estimate sample sizes for each Federative Unit. An alternative scenario is to consider for each Federative Units the same the stratification adopted by the Integrated System of Household Surveys. It ensures the spreading of the sample over the Brazilian territory. Based on that, it is adopted the stratification with proportional allocation in the municipalities strata, being h the considered stratum, h=1, 2,...,138 (H=138);
The expression of the total estimator variance is given by:

$$V[\hat{Y}] = \sum_{h=1}^{H} \frac{1}{m_h} \left[\sum_{i=1}^{M_h} \left(\frac{Y_{hi}}{p_{hi}} - Y_h\right)^2 p_{hi} + \sum_{i=1}^{M_h} \frac{1}{p_{hi}} N_{hi}^2 \left(\frac{1}{n_{hi}} - \frac{1}{N_{hi}}\right) S_{hi}^2 \right], h \in \{1, \ldots, H\} \qquad (8)$$

Where

$$m_h = m \frac{N_h}{N} \qquad (9)$$

To find the m, from (8) and (9):

$$V[\hat{Y}] = \frac{1}{m} \sum_{h=1}^{H} \frac{N}{N_h} \left[\sum_{i=1}^{M_h} \left(\frac{Y_{hi}}{p_{hi}} - Y_h\right)^2 p_{hi} + \sum_{i=1}^{M_h} \frac{1}{p_{hi}} N_{hi}^2 \left(\frac{1}{n_{hi}} - \frac{1}{N_{hi}}\right) S_{hi}^2 \right]$$

$$V[\hat{Y}] = \frac{1}{m} \left[\underbrace{\sum_{h=1}^{H} \frac{N}{N_h} \sum_{i=1}^{M_h} \left(\frac{Y_{hi}}{p_{hi}} - Y_h\right)^2 p_{hi}}_{C} + \underbrace{\sum_{h=1}^{H} \frac{N}{N_h} \sum_{i=1}^{M_h} \frac{1}{p_{hi}} N_{hi}^2 \left(\frac{1}{n_{hi}} - \frac{1}{N_{hi}}\right) S_{hi}^2}_{D} \right] \qquad (10)$$

$$V[\hat{Y}] = \frac{(C+D)}{m} \rightarrow m = \frac{(C+D)}{V[\hat{Y}]} \qquad (11)$$

As

$$V[\hat{Y}] = CV(\hat{Y})^2 Y^2 \text{and } m = \frac{C+D}{CV(\hat{Y})^2 Y^2} \rightarrow CV(\hat{Y}) \;\; = \sqrt{\frac{C+D}{mY^2}}$$

Steps to obtain the CVs of the variables considering the stratification:

1) Find m using (11) considering Y as main variable and with fixed precision.
2) Distribute m in the strata m_h, if $m_h < 2$ Then $m_h = 2$
3) CVs of other variables considering m_h using (10).

3. Results

3.1 Estimated sample sizes for the list frame

Initially, it was obtained the number of establishments in each group, which is defined by combining FU and economic activity. In those groups whose number was less than 10, all units are considered part of the sample with probability one. In the other groups, the method Hidiroglou and Lavallée (1988) was applied.

In these tests were made with H = 2 strata and H = 3 strata. It was adopted a CV for total production value set to 5% and the frame containing 8.859 establishments.

Table 3 presents the sample size resulting from the method Hidiroglou and Lavallée (1988). It is noteworthy that the groups were aggregated by FU for easy viewing and, in some combinations of FU and activity, it was chosen only two strata (units with probability of being selected equals to one and sampled) due to the small number of establishments (less than two in any of strata) involved in the result with three strata.

Table 3: Distribution of the sample size for the registration list of strata formed by combining Federative Units and Economic Activity, aggregated by Federative Units.

Federation Unit	Number of establishments	Strata							Total
		1	2	P =1	Total	1	P= 1	Total	
Rondônia	2.399	45	60	73	178	8	22	30	208
Acre	349	13	27	38	78	4	13	17	95
Amazonas	1.572	48	63	48	159	5	9	14	173
Roraima	94	-	-	-	-	9	35	44	44
Pará	6.696	107	142	177	426	9	25	34	460
Amapá	53	-	-	-	-	9	26	35	35
Tocantins	1.534	39	56	79	174	8	9	17	191
Maranhão	3.881	70	88	117	275	5	18	23	298
Piauí	476	24	45	57	126	2	8	10	136
Ceará	2.310	50	76	139	265	6	19	25	290
Rio Grande do Norte	801	19	24	50	93	20	52	72	165
Paraíba	1.058	35	45	77	157	9	27	36	193
Pernambuco	2.851	53	63	143	259	13	18	31	290
Alagoas	1.714	28	39	74	141	5	5	10	151
Sergipe	638	23	29	36	88	19	19	38	126
Bahia	6.006	129	153	263	545	22	68	90	635
Minas Gerais	14.469	237	263	366	866	12	34	46	912
Espírito Santo	1.297	34	47	90	171	12	30	42	213
Rio de Janeiro	1.928	53	65	70	188	6	15	21	209
São Paulo	12.216	184	249	378	811	20	32	52	863
Paraná	6.189	144	158	258	560	9	26	35	595
Santa Catarina	3.842	83	85	162	330	18	42	60	390
Rio Grande do Sul	8.043	157	179	304	640	25	27	52	692
Mato Grosso do Sul	6.723	107	134	125	366	13	30	43	409
Mato Grosso	7.060	106	137	147	390	45	68	113	503
Goiás	8.165	111	136	206	453	6	25	31	484
Distrito Federal	311	15	19	23	57	16	26	42	99
Total	**102.675**	**1.914**	**2.382**	**3.500**	**7.796**	**335**	**728**	**1.063**	**8.859**

3.2 Estimated sample sizes for the area frame

The sample size with stratification of the Federative Units resulted on a sample size of 9.313 PSUs distributed as follows

Table 4: Sample sizes of PSUs stratified only by Federative Units.

FU	m	FU	m	FU	m
Rondônia	201	Ceará	236	Rio de Janeiro	252
Acre	326	Rio Grande do Norte	282	São Paulo	621
Amazonas	237	Paraíba	623	Paraná	279
Roraima	254	Pernambuco	323	Santa Catarina	212
Pará	297	Alagoas	839	Rio Grande do Sul	206
Amapá	129	Sergipe	1.143	Mato Grosso do Sul	159
Tocantins	248	Bahia	416	Mato Grosso	443
Maranhão	243	Minas Gerais	495	Goiás	253
Piauí	225	Espírito Santo	177	Distrito Federal	194

The larger sample sizes were observed in Sergipe (1.143), Alagoas (839) and Paraíba (623). The sample size of Sergipe is greater than the number of PSUs Sergipe.

Considering the stratification of municipalities, the sample size is 11438 PSUs, setting the CV value of production to 5% for FU. The sample size in this stratification resulted in a sample size larger than the sample size stratified only by Federative Units. In table 5 sample sizes of FUs Alagoas and Sergipe, for example, exceed the number of PSUs in these FUs.

Table 5: Sample sizes of PSUs with complete stratification of 138 geographic areas.

FU	m	FU	m	FU	m
Rondônia	203	Ceará	241	Rio de Janeiro	245
Acre	324	Rio Grande do Norte	280	São Paulo	754
Amazonas	323	Paraíba	696	Paraná	294
Roraima	255	Pernambuco	435	Santa Catarina	220
Pará	303	Alagoas	1.779	Rio Grande do Sul	210
Amapá	130	Sergipe	1.291	Mato Grosso do Sul	166
Tocantins	249	Bahia	474	Mato Grosso	580
Maranhão	292	Minas Gerais	775	Goiás	304
Piauí	235	Espiríto Santo	194	Distrito Federal	194

Table 6: Ratio of sizes by FUs.

FU	m%	FU	m%	FU	m%
Rondônia	0,26	Ceará	0,07	Rio de Janeiro	0,27
Acre	1,38	Rio Grande do Norte	0,36	São Paulo	0,22
Amazonas	0,38	Paraíba	0,45	Paraná	0,07
Roraima	2,45	Pernambuco	0,15	Santa C.atarina	0,10
Pará	0,16	Alagoas	1,93	Rio Grande do Sul	0,04
Amapá	2,50	Sergipe	1,39	Mato Grosso do Sul	0,19
Tocantins	0,38	Bahia	0,07	Mato Grosso	0,52
Maranhão	0,10	Minas Gerais	0,13	Goiás	0,18
Piauí	0,11	Espiríto Santo	0,21	Distrito Federal	2,81

In order to solve this problem, in some units of the Federative the coefficient of variation is increased. For the state whose sample sizes exceeded the number of PSUs was decided to calculate a sample size with CV of 10%. The sample sizes are presented in Table 7:

Table 7: Sizes of PSUs stratified sample of 138 geographic strata.

FU	m	FU	m	FU	m
Rondônia	203	Ceará	241	Rio de Janeiro	245
Acre	81	Rio Grande do Norte	280	São Paulo	754
Amazonas	323	Paraíba	696	Paraná	294
Roraima	64	Pernambuco	435	Santa Catarina	220
Pará	303	Alagoas	446	Rio Grande do Sul	210
Amapá	33	Sergipe	325	Mato Gros s o do Sul	166
Tocantins	249	Bahia	474	Mato Gros s o	580
Maranhão	292	Minas Gerais	775	Goiás	304
Piauí	235	Es piríto Santo	194	Dis trito Federal	49

* To Acre, Roraima, Amapá, Alagoas, Sergipe and the Distrito Federal was considered CV = 10% for value of production.

The sample size becomes 8471 PSUs.

3.3 Total sample size for the combined frame

The final sample sized estimated from the two different sources is 8471 x 10 + 8859 = 93569 establishments.

Table 8: Estimated sample size by Federative Units.

Federation Unit	List Frame	Area Frame	Final
Rondônia (11)	208	2030	2238
Acre (12)	95	810	905
Amazonas (13)	173	3230	3403
Roraima (14)	44	640	684
Pará (15)	460	3030	3490
Amapá (16)	35	330	365
Tocantins (17)	191	2490	2681
Maranhão (21)	298	2920	3218
Piauí (22)	136	2350	2486
Ceará (23)	290	2410	2700
Rio Grande do Norte (24)	165	2800	2965
Paraíba (25)	193	6960	7153
Pernambuco (26)	290	4350	4640
Alagoas (27)	151	4460	4611
Sergipe (28)	126	3250	3376
Bahia (29)	635	4740	5375
Minas Gerais (31)	912	7750	8662
Espírito Santo (32)	213	1940	2153
Rio de Janeiro (33)	209	2450	2659
São Paulo (35)	863	7540	8403
Paraná (41)	595	2940	3535
Santa Catarina (42)	390	2200	2590
Rio Grande do Sul (43)	692	2100	2792
Mato Grosso do Sul (50)	409	1660	2069
Mato Grosso (51)	503	5800	6303
Goiás (52)	484	3040	3524
Distrito Federal (53)	99	490	589
Sum	**8859**	**84710**	**93569**

4. Assessment of the expected precision

The next step after the estimation of the sample size is to perform an assessment of the expected precision of the total production value for a set of 18 items cited previously.

The results indicate that it is necessary to define the relative importance of each item in the geographic area. It is due to the diversity and dimension of the Brazilian territory.

Table 9: Estimated coefficient of variation by Federative Units and activities.

Variable	Brasil	Federation Unit																									
		11	12	13	14	15	16	17	21	22	23	24	25	26	27	28	29	31	32	33	35	41	42	43	50	51	52	53
Total value (in BR$)	1	3	8	3	3	3	3	3	3	3	3	2	3	2	4	6	2	3	3	3	2	3	3	3	2	2	2	4
Rice	4	16	27	17	5	12	8	7	12	33	16	16	27	13	16	40	22	40	41	31	39	20	6	23	22	24	32	
Corn	3	17	21	17	12	15	30	19	10	12	10	15	6	10	15	12	9	6	21	28	8	6	8	10	8	9	9	13
Wheat	8	-	-	-	-	-	-	-	-	-	61	60	127	-	-	-	-	31	-	-	18	12	21	13	34	321	52	18
Sugar Cane	3	119	99	7	56	5	138	3	4	6	30	6	10	10	6	17	15	10	11	11	5	11	29	48	7	8	6	55
Soy beans	2	7	13	36	2	13	18	6	14	5	214	57	28	43	27	22	5	7	16	270	8	6	14	7	4	5	5	7
Beans	4	15	23	28	33	23	39	21	18	11	13	12	8	12	10	17	14	12	22	28	19	14	19	25	38	52	19	11
Cassava	4	21	14	6	14	7	22	46	7	19	31	23	22	18	25	13	12	29	103	20	22	19	30	15	18	15	34	29
Tobacco	15	-	70	30	-	20	-	57	703	30	105	36	21	41	46	43	38	28	-	-	20	48	16	12	-	279	45	-
Cotton	5	31	122	31	-	40	-	0	0	1	77	60	28	72	60	100	7	11	-	33	11	43	83	88	10	9	12	5
Orange	6	56	125	37	36	28	25	133	84	54	74	43	19	45	139	39	45	31	70	50	6	36	216	35	36	45	32	3
Coffee	4	10	78	28	39	47	79	43	62	74	49	41	14	30	150	-	11	6	6	12	9	24	64	140	37	18	20	47
Cattle	2	5	13	10	19	14	28	11	8	12	13	5	6	3	12	11	7	6	11	7	6	9	9	9	5	6	6	18
Milk	2	5	19	13	11	9	36	9	14	14	10	7	5	8	9	10	8	4	10	7	7	8	7	8	14	7	5	15
Pork	6	11	19	15	17	11	43	13	14	11	15	8	9	8	17	16	8	17	24	21	27	15	14	17	25	10	25	13
Poultry	23	41	18	8	13	46	63	48	59	38	43	34	21	60	38	41	33	25	32	80	106	26	17	26	22	32	47	34
Eggs	6	55	57	9	18	23	93	14	40	14	15	13	12	10	44	13	22	9	11	24	15	15	19	24	27	16	15	15
Wood 1	7	57	78	19	-	38	-	57	105	-	62	42	32	27	38	-	6	32	2	23	12	23	31	26	2	26	44	-
Wood 2	10	76	114	22	63	19	0	72	43	-	36	28	21	59	42	20	27	11	62	28	20	20	28	61	5	40	28	112

5. Concluding remarks

There is a great variability between enumeration areas with respect to the number of establishments and the variables of interest. This lead to a inflated sample size when the units are selected from the area frame. Thus, other studies were implemented in order to investigate the intra- class correlation and obtain further details about how to avoid the oversampling and keeping a reliable precision level. Another study of interest is based on the relative importance of products according the geographic domain. In addition to the sample design described in this document, other designs are being planned, especially for the area frame.

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Redesign of the National Agricultural Survey in Argentina: changes in the sampling frame and data collection

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Abstract

The National Agricultural Survey (also known as ENA, in its Spanish acronym) constituted a regular program of data collection for the agricultural and livestock sector that the National Institute of Statistics and Censuses (INDEC) of Argentina started in 1993, on an annual basis with provincial and national representation. The ENA applied a probabilistic design method for the collection of data used to estimate stock composition, by categories of cattle and ship, sown field and grain and oilseed production, area planted with annual and perennial forage, the production of forage reserves, and a set of data on cultural practices, the use of input and other relevant information. This program continued until 2007, prior to the completion of the 2008 National Agricultural Census. INDEC[1] aims to restart the development of the ENA introducing changes to the definition of the sampling frame, the sample design and the data collection method, without changing the probabilistic survey nature.

Until 2007 the ENA was designed on a list frame elaborated from complete records of farms (EAP, in its Spanish acronym) surveyed in the 1988 and 2002 National Agricultural Censuses (CAN'88 and CAN'02). However, a redesign of the ENA becomes necessary, thus incorporating a conceptual and methodological approach which would allow to obtain a sampling frame that guarantees a complete coverage of the population and a long useful life, and that allows more accurate estimates. In order to achieve this, a multiple frame sample design, which combines an area frame with a list frame, will be adopted. On the one hand, this involves a strong use of satellite images, combined with information collected from other sources (censuses, subjective surveys, administrative records, etc.). On the other hand, this also involves the identification of the EAP that will be part of the list frame (records of the CNA'08, National Register of Agricultural Producers and other national and provincial sources).

Another change will be introduced in the data collection method. Until 2007 the ENA used paper questionnaires administered by interviewers. The new ENA will use an electronic collection method with a questionnaire that will speed up responses and with a program that will provide the results in real time. The new ENA will constitute an agricultural surveys program with general and specific objectives, according to activities, regions and provinces.

In 2014, the INDEC plans to conduct a new National Agricultural Census with the aim, among others, to obtain a current listing of farmers and farms. These lists will be used for the preparation of samples of the new ENA.

Keywords: probabilistic survey; multiple frame sample design; satellite images.

1. Background

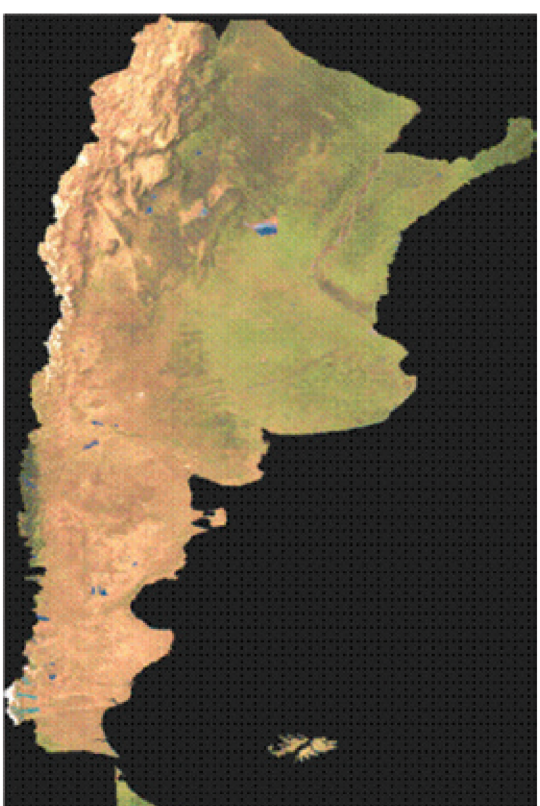
First of all, this paper presents a work project that is simultaneously being elaborated and conducted, this is why it is subject to changes until it reaches a defined profile before the first operation of the new ENA takes place; and still, it will continue incorporating changes in the following waves. Therefore, it should be noted that certain statements and clauses set forth herein may undergo changes which will be reflected in future documents.

The Argentine Republic is a federal State constituted by 23 Provinces and an Autonomous District, the City of Buenos Aires, which is also the Country's Federal Capital. In a territory of almost 2.8 million km2, there are over 180 million hectares of land for agricultural, farming, and forest use. About 50 million of these hectares are used to cultivate annual and perennial crops, fodder plants, and forest trees. It is estimated that there are over 300 000 farms (INDEC, 2007). Almost 70 % of the territory of Argentina corresponds to arid and semi-arid zones (UNESCO, 2010), and humid and sub-humid zones are located in the central-east area of the country. In the following satellite map you can see humid and sub-humid zones in green, in contrast to the arid and semiarid areas in beige and brown (Figure 1).

The National Agricultural Survey (ENA) was a regular program of the National Institute of Statistics and Censuses (INDEC), which remained in force between 1993 and 2007. The main objective of the ENA was to collect, on an annual basis, data of Argentina's agricultural sector, comprising agriculture and livestock activities. Annex 1 provides a summary table containing the data gathered in surveys over those years. Selection variables used for the preparation of the samples were the areas sown to cereals, oilseeds, fodder and occasionally other groups of crops, if they were included in the year in which the survey was conducted, and stocks of cattle, sheep, goats and pigs.

During the period 1993/2001 the ENA sampling design combined a list, from the census of farms and ranches (EAP) registered in the National Agricultural Census 1988 (CNA'88), except in the province of Buenos Aires where a framework sample by area was used according to a design developed by the former Secretariat of Agriculture, Livestock, Fisheries and Food (SAGPyA, in its Spanish acronym). List frame samples were prepared by experts from the Division of Primary Sector Statistics (DESP, in its Spanish acronym), with the collaboration of experts from the Provincial Offices of Statistics (DPE, in its Spanish acronym). After the completion of the National Agricultural Census 2002 (CNA'02), ENA samples for 2004, 2005 and 2007 were redesigned using the EAP list of the Census, and the design alternative for areas applied in the province of Buenos Aires was set aside.

Figure 1: Satellite map of Argentina.



Source: Secretariat of Environment and Sustainable Development.

While it remained in force, the ENA provided estimates of the agricultural sector, multi-variables, using probability samples. In contrast, subjective estimates provided by the Ministry of Agriculture, Livestock and Fisheries (MAGyP) were made in consultation with qualified informants, conducted by a body of regional delegates residing in various locations across the country[2]. MAGyP has recently implemented a new methodology for estimating the area under crops, mainly cereals and oilseeds, called "Method of Random Segments", which at present is being carried out in some Districts of Provinces in the Pampa region and in the Northeast region of Argentina, and is complemented by the work done by regional representatives. This method seeks to improve subjective estimates of areas sown, introducing an objective estimation of the areas which is performed in two annual waves, one for "thin harvest" crops (winter-spring wheat, oats, rye, barley, linen, etc.) and another one for "thick harvest" crops (spring-summer, corn, grain sorghum, soybean, sunflower, peanut, etc.). At the moment, the method of "random segments" can only provide estimates of sown areas and an appreciation of the crop when the observers visit the field, since no interviews are conducted with the producers. Production estimates continue to be made with the usual subjective procedure.

2. Need to redesign the National Agricultural Survey

There are several reasons why it is necessary to develop between-censuses agricultural statistics in order to provide annual data concerning the structure and the situation of the agricultural sector in Argentina.

On the one hand, current legal rules and regulations establish INDEC's direct responsibility, shared with the MAGyP, to develop between-censuses agricultural statistics of the main variables and statistics of the major agricultural products in regional economies, in coordination with the

Provinces. In addition, it is necessary to give continuity to the estimates of land use, agricultural production and livestock totals, among others, made by the ENA since 1993.The ENA has been the only source of objective and continuous estimates of some variables not collected by any other survey, providing useful information for the national and provincial public sector, and the System of National Accounts (SCN, in its Spanish acronym). In this context, the aim is to coordinate with the MAGyP the strengthening of an integrated system of surveys, records, and statistics sources that would cover all requests for information on the agricultural sector.

On the other hand, these developments will facilitate the inclusion of Argentina in the Implementation Plan of the Global Strategy to Improve Agricultural and Rural Statistics, approved by the Statistical Commission of the United Nations in February 2010, and participate in plans for technical assistance and training to enable the execution of that strategy.

In 2014, the INDEC plans to conduct a new National Agricultural Census with the aim, among others, to obtain a current listing of farmers and farms. These lists will be used for the preparation of samples of the new ENA.

3. Agricultural Censuses and ENA, from the list frame to the multiple frame

EAP lists obtained from CNA'88 and CNA'02 constituted the sampling frame of the successive waves of ENA, except for the Province of Buenos Aires (as mentioned in section 1.). Since ENA'01 a frame list has been used throughout the country. The National Agricultural Census conducted in 2008 (CNA'08) had an incomplete national coverage due to various reasons; therefore, the list of farms is also incomplete, especially in several provinces of great agricultural importance.

This is only one of the reasons that motivated the study of a change in the sample design methodology applied in between-censuses surveys conducted until 2007. Another reason is the need to incorporate a sample design methodology reflecting the progress made in the field of remote sensing using satellite images of high spatial and temporal resolution, useful for the stratification of land uses. Until a few years ago, the implementation of a design based on an areas framework was limited by the experience concentrated in the list frame design of INDEC and the emerging development of protocols tested in the use of satellite images. The tests have been successfully passed, the availability of images has become more affordable, new software and methodologies have been developed, and therefore the conditions are given to incorporate a methodology that, if properly applied and executed in field operations, will allow to obtain reliable data with an objective measure of error estimates (Galmés, 2005). Additionally, another proposal is to amend the method of data collection, this is to change the traditional paper forms for an electronic medium.

These are deep and extensive changes: On the one hand, the change of the sample design and the introduction of the use of satellite images, not only in the steps of determining the land use, but also as equipment for the fieldwork; on the other hand, the previous scheme of the interview with the producer or informant, made in paper questionnaires and discontinuous chapters has change to another form mounted on an electronic medium, which follows a logical sequence oriented to exhaust all topics of interest about an activity or a crop in each portion of the statistical unit to be surveyed, with a set of guidelines for real-time consistency that will minimize office tasks and will facilitate an immediate reception of data to the survey database.

The redesign of the ENA, then, includes a change in the sampling frame design using multiple frames (MM) instead of model list frames (ML) based on agricultural censuses, which combine the use of area frames (MA) with list frames made of special holdings that complement the area. In the first stage of the new ENA, this option includes the use of lists of the CNA'08 in some provinces or areas in which an ML may be applicable, depending on the type of survey to be made (for instance, this applies in the provinces where it is decided to conduct only a survey of livestock EAP). MM design is implemented in the provinces in the Pampas region, where there is more than 75% of the country's agricultural production, and in several Northeastern provinces and some of the Northwest provinces.

The areas framework development requires cartography and satellite imagery. Experienced personnel are required for the interpretation of the images, but especially for the stratification of the territory, in the design of the framework and appropriate estimation methods. For the latter task INDEC has expert staff that needs to be strengthened. To process and to interpret satellite images, INDEC has requested the collaboration of the Laboratory of Regional Analysis and Remote Sensing (LART) School

of Agriculture of the University of Buenos Aires (FA-UBA) which, together with the National Institute of Agricultural Technology (INTA, in its Spanish acronym), has developed a protocol for estimating the areas cultivated by the main crops of Argentina from remote sensing and field information (LART, 2010).

In principle, an ML has a lower cost in design and implementation, if based on the results of a successful census, that is, with a statistically satisfactory coverage and a good response from the informants on a large number of variables that identify and characterize the information units that constitute the target population of the survey, and especially if, as happens in some countries, a real register of farms and producers is created, this is a continuously updated list. This way, the frame construction would be simplified and less expensive. But this is an ideal situation not usually verified nor in regard to CNA'08, as noted above.

As stated by FAO (FAO, 1998), in theory, area frames would provide complete coverage of the population if the set of geographic areas or the segments that constitute the selection frame covered the entire population. One advantage of sampling is that the population is clearly defined and it is possible to identify all farms. Moreover, an MA has a more durable representation of the population of interest, compared to an ML that may become outdated rapidly.

However, an MA requires critical supplies and personnel with experience in the design of the framework and in appropriate estimation methods. This means that "at the beginning of the survey program" (FAO, 1996) the costs are higher "for the selection of a sample of segments with recognizable physical boundaries than for a sample list." The advantage is that the MA does not require frequent updating; it provides a complete coverage of the target population, lower coverage errors and therefore no bias. If enumeration procedures are properly implemented, it is also possible to obtain more accurate estimates of agricultural land in a sample list because, by definition, in an MA, selection probabilities and expansion factors of the sample are proportional to the agricultural land (FAO, 1996).

To obtain the MM, the MA is combined with a complete list of EAP during the collection of field data or by a sample of that list. This supplementary list is constituted by units that have special features: its size and productive type significantly contribute to the estimation of crop areas, or to the estimation of numbers of livestock or other animals, those which perform certain crops that could not be adequately represented in the sample areas, or those which have the largest number of workers, etc. These listings are taken from the lists of EAPs of recent censuses and also from previous ENAs, or from other sources such as administrative records, irrigation consortia, etc., which are confirmed in the selection process of the sample.

As ENAs conducted with list frames, the representativeness of the probabilistic survey of MM will have coverage at a provincial level, but reasonable coefficients of variation may be achieved for some variables in homogeneous agro-ecological zones in each Province or in homogeneous interprovincial areas. Representativeness at the level of Districts or Departments[3] would require very large sample sizes, more survey effort and would increase costs considerably.

Of course, when talking about the MM, a design methodology in general is defined, but when it comes to objectives and variations, on the basis of the aforementioned provincial representativeness, there is a set of provincial surveys with their respective sampling frames that share common modules (for instance, many of those that composed the traditional ENA) and differ in specific aspects according to the production profile of each Province. In addition to the National Survey, there is a need to conduct specific surveys during different periods of time in one or more regions or Provinces. This is an issue that shall be considered according to the priorities and the resources availability.

4. Stratification and segmentation for the areas framework

The stratification of the territory is a critical input for the sample design of an areas framework. The objective of stratification is to achieve a relative homogeneity of geographic spaces that would reduce sampling variance and the size of the sample, increasing the accuracy of the estimates of the main variables. All of the strata are then subdivided into segments, of appropriate size for each one, from which a sample is taken and used as a statistical unit for the survey.

The ideal stratification is different for each variable investigated (FAO, 1996), but for a survey with broad purposes and covering various agricultural activities, such as the ENA, the main stratification criterion is to take into account the proportion of cultivated land. Given the nature of the

agriculture of Argentina in rainfed areas, basically the Pampas region and surrounding areas of similar productive type, combining agricultural and livestock activities in the same rural areas and depending on soil conditions, topography and climatic features, the presence and the diversity of land coverage with agricultural crops and forage harvesting relate to most of the variables to be estimated. For this reason, the strata were defined according to the percentage of cultivated land in the following progression:

a) No crops

b) Up to 25% of cultivated area

c) From 25.1% to 50% of cultivated area

d) From 50.1% to 75% of cultivated area

e) More than 75.1% of cultivated area

The surface area to be stratified in each province where the MA will be implemented, shall be defined after excluding all land for non-agricultural uses, urban centers, major roads and highways, lakes and permanent lagoons, national parks with intangible areas, mountain areas without farming and livestock, etc. This way, the framework will contain almost exclusively the land under agricultural use. "Almost exclusively" means that what will be included in the area to stratify is land with rural schools, scattered industries, storage facilities for agricultural products, rural roads, railways and other spaces which cannot be excluded prior to the formation of the strata. Obviously, a perfect setting would be one that contained only the units belonging to the target population of the survey, but it is extremely difficult to achieve that. The non-agricultural strata are identified according to their use or features.

Most of the uncultivated lands that fall within the surfaces to be stratified are intended to livestock and correspond to natural pastures, either in herbaceous or shrub formations, savannahs, mountains and natural forests. They constitute part of the farm lands of the country and cover a very significant percentage of the whole territory.

Since the objective is to build an MM, it is necessary to exclude the area of those EAPs that are on the list to avoid being included in the MA, which would lead to a serious error if a segment coincident with an EAP frame from the list is selected in the areas sample.

Stratification according to the proportion of cultivated land may contain, in any of the layers ranging from b. to c., different crop compositions according to the productive type of the different areas that have the same proportion of cultivated land. In other words, in layer c., for example, there may be an area where a perennial crop like sugar cane prevails while in another area of the same Province an annual crop like soybeans prevails. In these same cases or in other strata, there may be areas in which there are small EAPs and other areas of larger EAPs. In both examples, which may include other cases, substrata may be created with the same main objective of stratification, i.e. to delimit land surfaces used as uniformly as possible in order to maximize the accuracy of the estimates and minimize the size of the sample necessary to achieve this. Stated briefly, as noted by FAO, land use strata are generally defined from the proportion of cultivated land, the predominance of certain crops, particular agricultural practices, and the average size of the fields or other land-use characteristics (FAO 1996).

The stratification procedure by LART begins from the use of satellite images provided by the MODIS sensor to perform an unsupervised classification of the areas under agricultural use in 5 classes. A coverage and use of land map will serve as a basis. It will be conducted by the National Program of Ecological Regions (PNECO, in its Spanish acronym) developed by INTA from remote sensors (INTA, 2009). This map identifies the areas corresponding to the classes of land use or occupation of interest for the project. In these areas, an unsupervised classification of 50 classes will be conducted based on an image mosaic of MODIS, product 13Q1 of the agricultural season 2012/13. The spectral signatures of each class will be extracted and grouped together according to a hierarchical analysis and a visual interpretation. The group of the 50 classes will lead to the creation of 6 new classes (Summer Crops, Winter Crops, Double Cropping, Forage Resources, Multiannual Crops, and Miscellaneous). These classes, together with the remaining classes of the PNECO map (Crop tree and shrub species, Natural and semi-natural areas of predominantly terrestrial vegetation, Natural or semi-natural vegetation of flooded areas or bodies of water, Artificial surfaces and associated areas, Isolated natural areas and water bodies, and Snow or artificial or natural ice) will establish 13 new classes of land use. Next, a grid of hexagonal cells is drawn up and applied over the entire area of a surface in order to minimize the edge effect. For each hexagon, proportions of each kind on its surface are calculated and the classes according to the agricultural

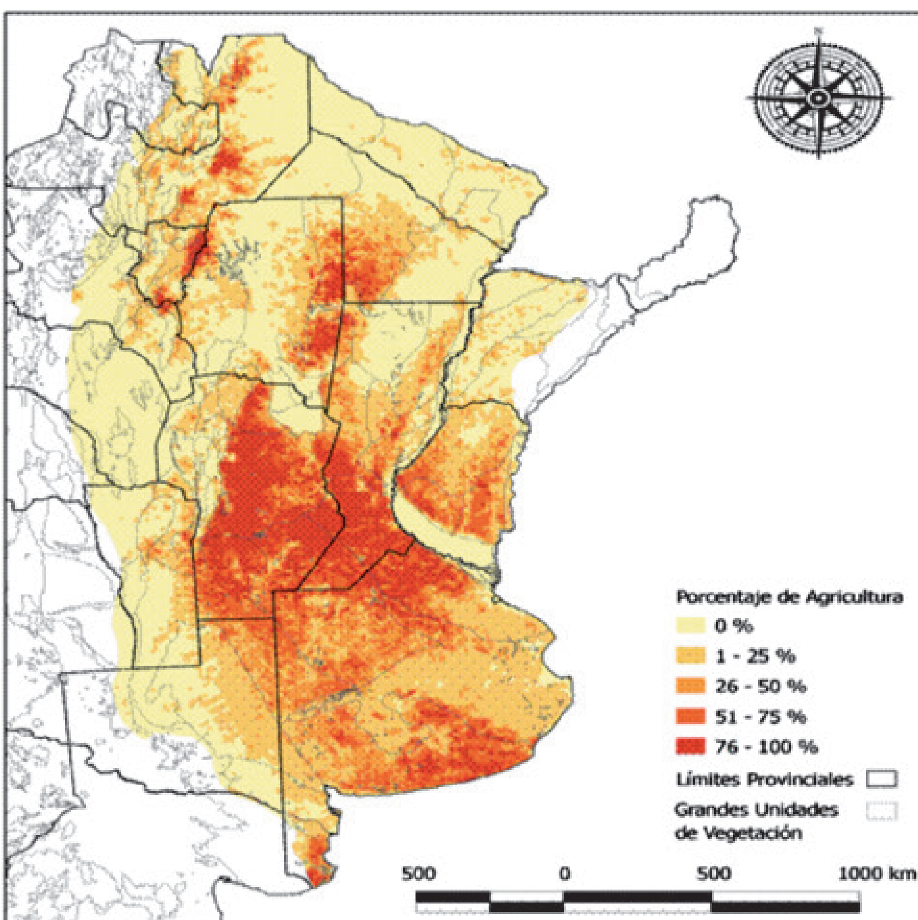
landscape present within each cell are then defined. Over the images and the grid with their respective classifications, cadastral vector layers may be used, as well as, radios and census divisions, roads, railways, urban areas, water bodies, etc.

Over the same hexagonal grid, landscape indicators will be calculated as average patch area, number of patches, perimeter-area relations, etc., to characterize the hexagons according to fragmentation and configuration of the landscape. The hexagons may be classified in different quality levels as high, medium and low level of fragmentation according to the needs arising from the analysis of INDEC sample designers. The two characterizations may be combined creating a stratification involving the proportion of the agriculture and the configuration of the agricultural landscape. In addition, over the stratification a vector of major biogeographic units will be superimposed thus generating a group that would incorporate climatic, soil and vegetation characteristics that are presented as the main biophysical controls of land use.

The boundaries of the strata and substrata will be established within estimation domains, e.g. Homogeneous Agro-Economic Areas (INTA, 2007), bounded areas of land with readily identifiable boundaries (which define fractions or census radius, for example). The strata and substrata already located in the estimation domains are subdivided into primary sampling units (PSUs), with recognizable physical boundaries in the field, bringing together a number of segments. This procedure is conducted to facilitate the design of the sample frame, the selection of the sample and to count the total number of frame segments and of each stratum. PSUs will be organized within each stratum and then, they will be classified according to the prevailing productive orientation in each one.

Finally, we will select samples applying the statistical procedures used for the analysis done to establish the size and number of segments that will define the samples. Then, we will apply a selection of replicate samples in order to obtain independent samples with different objectives.

Figure 2: Intensity of land cultivation.



Source: Laboratory of Regional Analysis and Remote Sensing (LART, 2010).

5. List Frames Selection

In the Provinces where an MM will be applied, we will select the EAPs that will be part of the ML, complementary to the MA, from some specific listings. The first listing will be the list of EAP from CNA'08 and a subsequent registry created to fix any failure in coverage. This list will be compared with CNA'02 data to complete any information missing. Second, we will use data from the National Health Registry of Agricultural Producers (RENSPA, in its Spanish acronym), which is a continuous and obligatory system to register all producers throughout the country and it is administered by the National Service for Agrifood Health and Quality (SENASA, in its Spanish acronym). In particular, this registration requirement has a very broad coverage of livestock producers, although the unit of information is defined differently from the EAP definition used by the INDEC. It also provides information on fruit farms of great interest for the development of lists for units specialized in this type of production. Another available source is the Grain Operators Registry (ROG, in its Spanish acronym) which is a tax system of obligatory registration for all individuals or enterprises operating on the market of cereals and oilseeds. It is necessary to select the list of those operators who are registered in their capacity as agricultural producers due to the fact that in this Registry there are different kinds of operators registered (collectors, exporters, brokers and direct producers).

In general, the main objective of the list sample is to define a fraction of the EAPs that makes a significant contribution to some of the main variables of the sample selection, specifically the surface sown or planted with crops that cover most of the agricultural area, on the one hand, and stocks of cattle for each of the species to be surveyed, on the other. To that end, an algorithm will be used to determine a cutting line above which the EAPs being part of the ML will be defined.

Other possible lists shall be the ones aimed at collecting data about some specialized productions that will integrate the first wave of the ENA or subsequent waves. In this case, the size of the EAP, regarding the variables of interest, will be one of the elements to be considered for its inclusion in the list, but it will be probably necessary to take into account other lists in order to improve the accuracy of the estimates.

After defining the list of EAPs comprising the ML, it will be necessary to determine the exact location from the information of census mapping (CNA data) or from the available geo-referencing (SENASA records) to debug the MA and prevent data duplication. It is necessary to study variations of procedure in case there are difficulties in establishing the exact location of the EAPs of the ML. In principle, the list frame will be of complete enumeration, but it could also be developed a sample of that list where, due to its size and the complexity of operation, results inconvenient to consider it in a complete manner.

At the beginning, an ML will be applied only in some provinces, basically for three reasons. The first reason is that in those jurisdictions, the ENA will only focus on the collection of data related to livestock or, depending on the circumstances, some specific and localized agricultural activity, also by means of an ML. The second reason is that there are lists available from the sources cited at the beginning of this chapter that will achieve a coverage equivalent to the one of previous waves of the ENA. Finally, the third reason is that the requirements for the construction of the MA in those provinces require a task beyond schedule to perform the first operation of a new wave of surveys.

The MLs will present some improvements compared with those used on the 1993-2007 ENA series because while the previous ML included only the EAPs which had replied in the censuses, now there are EAP strata not surveyed for some reason (absence, rejection, incomplete data, etc.) and which will be supplemented with information from RENSPA.

6. The multiple frame

The MM will be built in the Provinces to be applied, combining the MA with the ML. While in the MA the estimates will arise from the expansion of the data obtained from a probabilistic sample of segments of farm lands and, therefore, with a certain error estimate (CV, coefficient of variation), ML estimates shall be constituted with the total of the data resulting from the complete enumeration of the EAPs comprising it. The estimated data of the MA plus the estimated data of the ML will result in the MM estimate. In this case the MM sample variance will only be the one corresponding to the MA. It is possible that in some cases the ML could be relatively extensive and could require the development of a sample of the list. In that case only the EAP of the selected sample of the ML will be surveyed, and the

variance of the sample of the MM will be the result of adding the variances of both samples. In either case, the MM guarantees that the total population of statistical and information units will be covered and that a measure of the error of the calculated estimates will be obtained.

7. Data Collection and Processing

Data collection between 1993 and 2007 by the ENA was conducted on paper forms and administered by specially selected interviewers trained for this task through the DPE. The design of the forms considered different thematic chapters that connected specific activities (crops, livestock, etc.) with management practices and techniques (use of agrochemicals, seed type, type of tillage, contracting, livestock feeding and health, etc.). The provision of questions required the interviewer to carry out a "return" to verify the presence of the crop or livestock activity related to that question. The resolution of inconsistencies during the interview was very weak. The forms had to be moved to a central office, entered into a database, analyzed by the team of analysts to resolve inconsistencies, missing data was assigned, and finally the data was expanded to generate the estimates. For field work, the interviewers had the allocated EAP listings, along with the sketch from the previous survey.

The new ENA, by contrast, intends to completely change the way the survey is conducted. The data collection instrument will move from the traditional paper form to an electronic medium (probably with a Tablet, to be confirmed) that will contain a questionnaire that follows a logical path oriented to exhaust all topics of interest about an activity or a crop in each portion of the statistical unit to be surveyed (either a segment of the MA or an EAP of the ML) avoiding the "jumps" of the previous form. The new instrument will carry all the information necessary to guide the work of the interviewer, as well as images of the segment and mapping that will facilitate the interaction with the informant. The data entry program will be connected simultaneously with an inconsistencies resolution procedure that would allow expanded results in a short period of time.

Furthermore, the design of the program to be loaded into the electronic instrument will define a true GIS (geographic Information System), in which the questionnaire, the images and the data will be integral parts of an interrelated whole.

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Endnotes

1 With the participation of the Ministry of Agriculture, Livestock and Fisheries, decentralized offices and Provincial Bureaus of Statistics and Census.

2 This type of survey, unlike the ENA, enables two basic objectives to be attained, in despite of its lack of error estimators: 1) to obtain monthly results over the entire crop cycle surveyed; and 2) to obtain level estimates of Districts or Departments.

3 Administrative divisions of the Provinces. There are 512 and are called "Districts" ("Partidos" in Spanish) in the Province of Buenos Aires and "Departments" in the rest of the Provinces. Source: National Geographic Institute (IGN) www.ign.gob.ar/AreaProfesional/Geografia/DatosArgentina/Departamentos.

4 It corresponds to a partial classification of the territory in rainfed areas. It doesn't include the Province of Misiones, the north-eastern part of the Province of Corrientes, and irrigated areas located in arid regions.

Annex 1

Table 1. Synthetic Scheme of the data released by the National Agricultural Survey (ENA) between 1993 and 2007

1. Identification data of the farm and the producer
2. Total area of the farm and number of plots
3. Legal type of the producer
4. Form of land tenure
5. Land use:

Agricultural activities	Crop detail	Cultivated area (ha)	Harvested area (ha)	Production (ton)	No tillage	Use of transgenic seeds	Grain consumption on the farm	Use of fertilizers and pesticides	Use of seeds and sowing density	Rotations	Rotaciones	Cultivated pasture management	Use of farm machinery	Hiring of agricultural machinery
Grain cereals	√	√	√	√	√	√	√	√	√	√	√		√	√
Oilseeds	√	√	√	√	√	√	√	√	√	√	√		√	√
Industrial crops 1/	√	√	√	√	√	√								
Seed crops		√												
Vegetables 1/		√												
Fruit trees 1/	√	√	√	√										
Annual forage	√	√		√ (reserves)	√			√	√	√	√	√	√	√
Perennial forage	√	√		√ (reserves)	√			√	√	√	√	√	√	√
Complementary surfaces														

Livestock activities	Area devoted to livestock and grazed	Stocks by category	Type of rodeo	Dairy cows	Cows in service	Calves births	Mortality	Slaughtering on the farm	Cattle movements	Productive orientations	Types of management and health	Sales	Production of wool and hair	Milk production
Bovines	√	√	√	√	√	√	√	√	√		√	√		√
Pigs	√	√								√	√	√		
Sheep	√	√							√	√	√	√	√	√
Goats	√	√							√	√	√		√	√
Camelids	√	√												

Population and labor	Number of persons by sex, age and occupational category
Resident population in the farms	√
Permanent and temporary labor	√

1/ Only were included in some surveys.
Source: Based on data from ENA 1993-2007

Statistical Methodologies for the Development of Colombian Agricultural Statistical System

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1. Introduction

Agricultural sector is essential in the socio-economic development of Colombia, as it represents the economic sustenance of 24% of Colombian population. The statistics that are produced for such sector provide an objective basis for studying its problems and establishing effective policies for addressing them. The implementation of statistical investigations that observe the behavior of agricultural sector`s variables are produced in benefit of life conditions of rural population, dealing with as economic as political, social and cultural aspects. Most of actors involved in this sector require the analysis of agricultural sector statistical information that both defines an objective evaluation basis and achieves the desired accuracy levels, the appropriated designs, the absence of errors, wide validity ranges and the possibility to calculate levels of uncertainty in terms of the quality of results.

It implies to have a set of statistical methods applicable for agricultural, livestock, and forestry sub- sectors that enable to plan their short, medium and long term development. This document was created with the purpose of studying the statistical methodologies suitable for the development of the Sistema Estadístico Agropecuario SEA (Agricultural Statistical System) in Colombia, bearing in mind the investigations that are currently carried out by The Departamento Administrativo Nacional de Estadística (National Administrative Department of Statistics) DANE.

This paper is divided as follows: the first part in which this primary introduction is presented, the second part i.e. the background - where the behavior of agricultural sector in the last years is briefly analyzed, the Agricultural Statistical System and its characteristics (in the framework of the National Statistical System – SEN) are defined, and a brief description of the different sector's investigations carried out by DANE are presented-. In the third section, the most important investigations concerning the agricultural sector are analyzed, the needs for strengthening the statistical operations carried out by this entity are pointed out, as well as are identified the potential investigations which DANE may apply, with the purpose of generating a relation between these demands and the statistical methodologies that permit the design of statistics that meet such demands. Finally, a conclusion is set out.

2. Background

2.1 Information on the agricultural and livestock sectors in Colombia

The starting point to define the scope of agricultural statistics in Colombia corresponds to the System of National Accounts – SNA, which establishes the international regulations, concepts, definitions and classifications of economic activities[1]. The DANE`s Direction of Synthesis and National Accounts – DSNA, is the division in charge of calculating the annual, quarterly, departmental and satellite accounts on culture, environment, tourism amongst other. Regarding SNA, agricultural sector is measured taking into account the Agricultural and Livestock activities.

The first agricultural activity is made up of two major groups of products: Coffee and other agricultural products[2]. In Colombia - In accordance with DANE (2013a) - the agricultural Gross Domestic Product GDP "… is calculated in a quarterly basis taking into account a sample of 22 products, which in 2005 represented the 98, 6% of the sector`s total production. Estimations are produced either from constants and current prices, depending on the available indicators that may correspond to annual, monthly or quarterly production, by the demand components; or from indirect methods…" (p. 58).

In order to calculate the agricultural–GDP-, estimations are produced bearing in mind the annual production which is obtained from the information that is quarterly organized through planting schedules, for so defining the temporary distribution

of crops. Estimations can be also produced from the half-yearly production of transition and permanent products, with six monthly indicators that are quarterly organized taking account of agricultural schedules. Likewise, for products such as cocoa and sugar cane, estimations are obtained from monthly data, whereas for the production of parchment coffee, flowers and banana, estimations are produced from the demand.

Regarding livestock activity, this is made up of three groups of products: Cattle and sub-products, poultry and sub-products, pigs and other livestock. For estimating the production, “The production of cattle, pigs, milk, poultry and eggs is calculated in a quarterly basis. In 2005, such products represented the 96, 1% of the total livestock production (...) (DANE, 2013a:p.58).

Activities such as: forestry, wood extraction and similars are comprised of five groups of products: wood logs, firewood, forests planted with commercial and protection purposes, as well as services related with such activity. In the calculation of forestry`s production excluding wood-, an indicator is produced by means of the index of real production of wood from the Monthly Manufacturing Survey (MMM as its acronym in Spanish), and the index of paper pulp`s production obtained based on the figures from The Asociación Nacional de Empresarios de Colombia (National Business Association of Colombia) ANDI. For the case of wood, the total rural population taken from the Great Integrated Household Survey (GEIH as its acronym in Spanish) is used as indicator. Finally, fishery products and aquaculture activities are made up of three groups: live fishes, fresh or chilled fishes, crustaceans, clams and other invertebrate animals (DANE, 2013a).

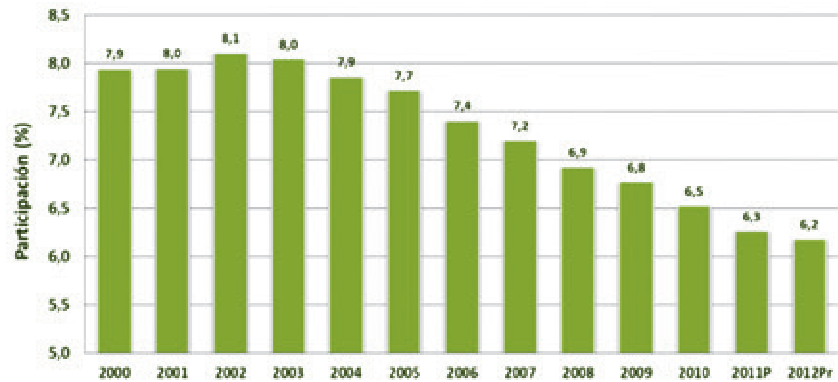
In this regard, the scope of basic agricultural statistics – which are relevant for the agricultural GDP calculation-, is given by the conceptual framework provided by the Food and Agriculture Organization of the United Nations [FAO] (2007). Such frame includes aspects concerning forestry, fishing, and land/water use (irrigation, irrigated lands, irrigation methods and resulting production). Recently, the FAO (2012) and its Agricultural Statistics’ Division designed the Global Strategy to Improve Agricultural and Rural Statistics, where FAO recognizes that agricultural statistics – in a conceptual framework- are considered as the starting point for the SNA. Its scope should be defined concerning three dimensions: the economic, social and environmental dimension.

Likewise, this strategy has defined three pillars: (i) the definition of basic data for satisfying minimum requests, as well as the frequency and the methodology for achieving it; (ii) the integration of rural statistics to the Sistema Estadístico Nacional (National Statistical System) SEN “considered as an important element to produce statistics in coordination with Ministries and statistics institutes, to avoid double-counting or the non-coverage of statistical facts; and (iii) the creation of a sustainable statistical system which should be integrated to a public-financial plan that supports such system and also contributes with the governability and the development of an integrated work between statistics institutes and the corresponding ministries. Finally, FAO (2012) suggests that the existence of a legal framework, that regulates the Agricultural Statistical System in Colombia (SEA as its acronym in Spanish) and supports the infrastructure required for its sustainability, should be revised at the country level.

Given that the need for updating information is an important aspect in terms of agricultural statistics, Colombia has statistics and figures that supports facts such as: in the 2012p[3], the agricultural sector`s GDP was increased 2,6% in comparison with the total Colombian GDP which was of 4, 0%, (DANE,2013b). In regards of participation, this sector has lost contribution in the total GDP considering that in 2000, this sector contributed with the 7, 9% and participated with the 6, 2%[4] in 2012, having the sixth place within the national GDP, with a 7, 0% of average participation in the period between the years 2000-2012. Although the sector has lost participation during such period, it remains as one important sector due to its relevance in the provision of rural employment (with a contribution of 16, 3% of the total national population engaged – according with the GEIH, 2013).

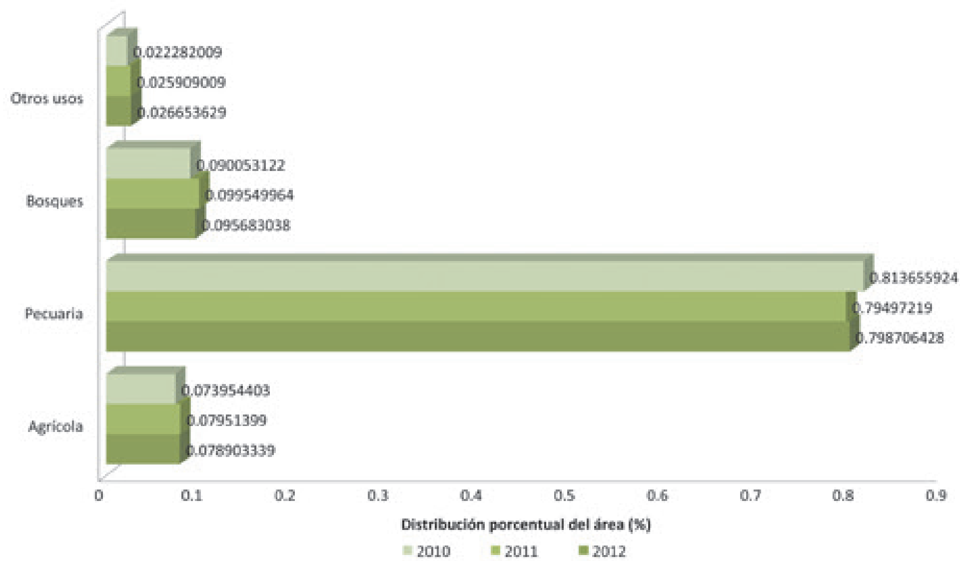
In Colombia, the agricultural production is linked to the soil use and management. In accordance with the National Agricultural and Livestock Survey – ENA (DANE, 2013c)[5], whose sample covers 22 departments of the country[6], soil is mainly used for livestock activities, forestry and agricultural purposes. In 2012, 62% of soil used for agricultural activities was mainly intended for permanent crops, 25% for transition crops, 12% for fallow lands, and the remaining 3% corresponded to soils at rest[7].

Figure 1: Participation of Agricultural Value Added in the GDP* 2.000 - 2.011 Pr.



Source: DANE- Direction of Synthesis and National Accounts (2013).

Figure 2: Land use in 22 Colombian departments for the period 2010-2012.



Source: DANE- National Agricultural and Livestock Survey (2012).

Additionally, the most representative permanent crops in the country correspond to: coffee[8], cocoa, panela cane, plantain and banana. In accordance with ENA, such products occupied an area planted of 1, 2 million hectares in 2012. Likewise, fruit crops had an area planted of 179.774 hectares.

On the other hand, transition crops include: tubercles, vegetables and cereals. Taking into account the first category, products such as potatoes and cassavas are highlighted. In the group of vegetables, onion crops, peas and tomatoes are the most important. In the third group i.e. cereals, the most important products correspond to white and yellow corn, barley, beans and wheat. In Colombia, the areas planted with white and yellow corn, potatoes and cassavas are the most relevant transition crops.

In terms of livestock, the land use is intended for three purposes: pasture and fodder, weeds and stubbles and special vegetations[9]. 65% from the 30 million of hectares used for livestock purposes correspond to pastures and fodders, 21% for weeds and stubbles and the remaining 13% for special vegetations.

The Livestock Slaughtering Survey (*Encuesta de Sacrificio de Ganado ESAG*) (DANE, 2013e), enables to have a record on the number of the most relevant heads of large and small species in the country. For instance, in 2012, the record of cattle slaughtered was 4, 1 million heads - figure that grew in 8% in relation with last figure reported in 2009.

Other investigations such as the Sistema de Información de Precios y Abastecimiento del Sector Agropecuario (*Agricultural Sector´s Supplying and*

Price Information System) SIPSA, presents the wholesale prices of agricultural products which are traded nationwide, informs on the food supplying volume in the main cities, and provides information about the behavior of retail prices of inputs and factors associated with the agricultural production.

Within DANE, other investigations are carried out serving as complement of the agricultural sector´s statistical surveys, enabling the sector´s data integration and this way providing demographic information, foreign trade statistics (imports, exports), producer and consumer's price indices, as well as the socioeconomic information regarding the rural areas of Colombia.

2.2 Background on the provision of agricultural statistics in Colombia

Nationwide, statistics on the agricultural sector arise since 1915. In this year, a compilation of statistics on production and prices for producers was carried out with 12 agricultural goods and a livestock inventory (Gutierrez, 2009). Then, in 1943, the Agricultural Census´ Preparation Office was created – an activity which was granted to the Office of The Comptroller General of the Republic on May 1951 and failed due to technical and public security issues. One year later, FAO contributed with the design of an agricultural investigation, which enabled to have information in the period between 1954 and 1956. Also, Gutierrez (2009) points out that the committee of agricultural statistics was created in 1959, whose functions concerned the centralization of statistical data produced by the different sector´s entities, as well as analyzing the information and finally authorize its dissemination.

Acosta and Perez (2011) points out that DANE carried out the first National Agricultural Census in 1960, which was continued with surveys on topics of interests since 1964 to 1969. Subsequently, in 1970, DANE applied the second National Agricultural Census. Then in 1982, the application of the third National Agricultural Census – that was supposedly to be carried out in 1986- was approved; however, such project could not be engaged; as a result, the country adopted the methodology of agricultural area sampling, given by FAO.

Acosta and Perez (2011) points out that the methodology for the area sampling was tested in various regions of the country during the three following years, with successful results. At the end of 1988, such action allowed the creation of the First Agricultural Survey PENAGRO. In the same way, in 1993, the authors summarizes that both the Ministry of Agriculture and Livestock and DANE proposed general regulations for carrying out the National Agricultural and Fishing Statistical System in Colombia, and the Colombian Agricultural Sector´s information System – SISAC- was created, whose main purpose was to develop of a system of inter-census surveys as from the framework given by the Second Agricultural Census. In the subsequently 10 years, the DANE and the Ministry of Agriculture and Rural Development (MADR as its acronym in Spanish) carried out the Encuesta Nacional Agropecuaria (*National Agricultural and Livestock Survey*) ENA in an annual basis, and the unions of production independently, carried out their investigations for the development of surveys and the production of their statistics[10].

In the same way, a relevant effort for attaching the General Census on Population and Housing with the Agricultural sector was done by DANE in 2005, when the population census was carried out, integrating agricultural economic units and whose results contributed with the creation of an approximated statistical framework of rural households. On the other hand, as from 2006, the MADR delegated to the Corporación Colombia Internacional [CCI] the development of ENA; however, such survey was once again applied by DANE in 2010.

In addition, in 2001, DANE started the development of the conceptual and methodological design of the Third National Agricultural Census – 3er CNA. The census` objective of is to provide strategic, geo-referenced and updated statistical information regarding the agricultural, aquaculture, fishery, forestry and environmental sectors, for so creating the SEA. The third CEN will be carried out in 2014; as a result, during the years 2012 and 2013, DANE has focused on the construction of a data collection instrument and the definition of pre-census procedures. Likewise, such entity has been designing the data capture and processing system as well as other technological developments in order to make easy the monitoring, control and the communications along the census application; has configurated the quality assurance system and prepared the cartographic materials, and finally has carried out both pilot tests as well as experimental censuses.

Finally, in 2012, the SIPSA – a research that has been developing in the CCI since 1994- was granted to

DANE. With the integration of this system to the group of continuous and inter-census statistics, DANE has strengthened SIPSA's provision of agricultural statistics having the challenge of consolidating the SEA within the National Statistical System –SEN[11].

2.3 The Agricultural Statistical System in Colombia - SEA

"The process to improve agricultural statistics should start with the integration of agriculture in the National Statistical System (...)" (FAO, 2012, p: 23). The integrated systems of statistics are important as they avoid the duplication of efforts, taking a better advantage of resources. In addition, such systems require the use of concepts, definitions and classifications, fact that in a long term allows having reliable and comparable data.

Therefore, the SEA (*Agricultural Statistical System*) - understood as a reliable and a long term system that provides quality information for the agricultural sector in Colombia - is based on the Plan Estadístico Sectorial (*Sectoral Statistical Plan*) of Agriculture, Livestock, Forestry and Fishing 2012-2015. PES is defined as "... a technical and permanent instrument for planning purposes which identifies and analyzes supply and demand of statistical information on the sector, in order to define strategies for filling the gaps of information, for putting together the inter-institutional statistical activities of the sector and for strengthening the production of the existent statistics...", (DANE, 2013:p.11).

According with Acosta and Perez (2011), among the SEA objectives, it includes the improvement of communication between producers and users of agricultural statistics, the identification of needs for statistical information in order to adopt decisions in agri-food, socio economic and rural development, gender, production and environmental matters; the formulation and application of statistical programs that fulfill such needs, the coordination of sectoral data collection, validating and consistency, the improvement of statistics dissemination and the contextualization of statistical data which is produced.

All the above can be achieved through the development of an agricultural framework which can be used to design both survey investigations and samples. This is why an agricultural census is important in the production of databases that provide reference frameworks for decision-making. In the future, it is necessary to make the information from the third National Agricultural Census compatible with the results of surveys that contribute with information on the sector, and connect them with the rest of activities from SNA, with the purpose of making compatible the census frameworks with the frameworks taken from other censuses and enabling the derivation of sample surveys through different methods. Given the importance of having a systemic vision that works in coordination with the system of statistics of the country, the development of the third CAN represents a fundamental part for the integration of all this system.

2.4 Public and private offer of statistical investigations on the agricultural sector

According with the PES (DANE, 2013f)[12], in Colombia are carried out 22 statistical operations are which implemented by 7 entities from the public sector attached to Agriculture. Moreover, the Instituto Colombiano Agropecuario (*Colombian Agriculture Institute*) ICA[13] produces 9 administrative records containing the information on the development of agricultural and livestock activities. In addition, as explained, unions of the main agricultural products carry out statistical operations. This way, information related with sugar cane, panela cane, cotton, coffee, cocoa and palm oil is obtained. In the livestock part, information on cattle, pigs and poultry is produced.

The PES (DANE, 2013f) indicates that the MADR highly contributes to the national statistics, especially with the Evaluaciones Agropecuarias Municipales (*Municipal Agricultural Evaluations*) – EVAS, whose strength is to provide data with levels of municipal desegregation. EVAS are carried out since 1972 and covers information on area and production of transition crops in a year, semi permanent and permanent basis. These also provide data on livestock, fishing and aquaculture sector. In terms of data collection, the sources of information for EVAS correspond to the local authorities and the technicians from the Secretarías de Agricultura Departamentales y las Unidades Municipales de Asistencia Técnica Agropecuaria (*Departmental Agriculture Secretariat and the Municipal Units of Agricultural Technical Assistance*) – UMATAS, which by consensus inform to MADR about the evolution of the agricultural and livestock activities in their municipalities. Even though the MADR strengthens EVAS by means of the use of systems of geographic and participating mapping, the lack of statistical compliance and the use of subjective techniques make difficult data comparability, given

Table 1: The counting of statistical operations on the agricultural sector, by each production entity.

Entity	Agriculture	Livestock	Forestry	Fishing / Aquaculture	Agriculture / Livestock
Departamento Administrativo Nacional de Estadística – *(National Administrative Department of Statistics)* - DANE	-	1	-	-	4
Ministerio de Agricultura y Desarrollo Rural – *(Ministry of Agriculture and Rural Development)* MADR	-	1	1	1	1
Autoridad Nacional de Acuicultura y Pesca – *(National Authority on Aquaculture and Fishing)* Aunap	-	-	-	1	-
Instituto Colombiano Agropecuario – *(Colombian Agricultural Institute)* ICA	4	5	-	-	-
Bolsa Mercantil de Colombia *(Colombian Mercantile Exchange)* - BMC	-	-	-	-	1
Confederación Colombiana de Algodón – (*Colombian Confederation of Cotton*) Conalgodón y MADR (*)	1	-	-	-	-
Federación Nacional de Arroceros – Fedearroz y DANE (*) (*National Federation of Rice Growers*)	1	-	-	-	-
Total	**6**	**7**	**1**	**2**	**6**

Source: DANE (2013) (*) Statistical operations carried out together with public entities and unions.

the methodological differences in respect with the other surveys carried out by entities and unions.

In the same way, PES (DANE, 2013f) points out that the MADR in association with the Autoridad Nacional de Acuicultura y Pesca (*National Authority on Aquaculture and Fishing*) – Aunap, provides the fishing and the aquaculture information of the country. Nowadays, the measurements of general aquaculture activities and the fishing volumes landed are available. It is important to clarify that the thematic and geographical coverage, the improvement in the quality of the information and the creation of historic series are topics to be treated in future plans for the improvement of such statistics.

Likewise, MADR provides the forestry information from different sources. In this case, it is supported by the information from the Ministry of Environment and Sustainable Development – MADR and the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM). This entity provides data on forest plantations and their production, as well as for forest reserves; however, the geographic coverage, the continuity and the compliance are aspects to be strengthened. In relation with data on forest plantations with commercial purposes, the MADR deals with the record of the Certificado de Incentivo Forestal (*Forestry Incentive Certificate*) – CIF and the Ventanilla Única Forestal - VUF (*Forestry One-stop Service*), enabling the interaction of forestry information in the country (DANE, 2013f).

On the other hand, livestock information is provided by different sources. In accordance with the PES (2013), unions concerning cattle and pigs carry out data production exercises in an independent basis, with no coordination with the census of species of animals developed by ICA, neither with the livestock modules for the ENA and the ESAG carried out by DANE. In this sense, differences can be seen in the figures presented by such sources.

Meanwhile, information obtained from statistical operations carried out by unions is produced in response of their objectives and occasionally may help to fill the lack of information in the sector; and even though such information is considered as of good quality, it only covers the union producers. Although data with departmental and municipal disaggregation is produced, databases are private; therefore the use of information is limited. In any case, the results of these investigations are used by official entities for carrying out consistency and coherence analysis, as well as of sectoral context (DANE, 2013f).

In conclusion, public and private organizations in charge of the statistical information on agricultural sector share the responsibility of producing agricultural statistics in Colombia. In this case, the sector`s lead entity is the MADR and the statistical

entity is the DANE. The MADR receives the support of related bodies in terms of issues such as: health care, land and fishing; likewise, such lead entity is supported by production unions.

2.5 The strengthening of agricultural sector´s continuous statistical operations carried out by DANE

In Colombia, DANE carries out the most important surveys investigations on this sector. Some aspects to be strengthened in each one of the operations leaded by such entity are mentioned as follows:

a) National Agricultural Survey – ENA[14]. The main aspect to improve is the updating of the sampling framework, with which it is expected to improve the coverage of some products' results which are disseminated provides for calculating the agricultural GDP.

b) Survey of Livestock Slaughtering –ESAG[15]. Among the factors that contribute to the ESAG´s strengthening we have the permanent updating of the sampling framework and the sample expansion, in order to provide disaggregated information at departmental level. Moreover, this survey aims to include questions enabling the establishment of the age range of slaughtered cattle in the country.

c) National Survey of Mechanized Rice – ENAM[16]. This survey needs a modernization of mobile capture devices in which the information is collected; this way facilitating the data quality verification and the monitoring, tracking and control applications of the survey.

d) Agricultural sector`s Supplying and Price Information System – SIPSA[17]: Due to its recent transfer to DANE, the strengthening of methodological and consistency aspects of information have been possible. The aspects to be improved correspond to the sample extension concerning the module of prices for dairy raw milk, the coverage expansion regarding the food supplying module, the perfection of the data capture device concerning the module: Inputs and Factors Associated to Production, the consolidation of the System`s Information dissemination by means of computer tools, and the reconstruction of prices` historical series.

With the above mentioned list of investigations, it is possible to understand the agricultural sector`s importance and the need for consolidating the Agricultural Statistical System through the framework produced by the Third National Agricultural Census CNA. This fact would enable to strengthen and improve the existing operations, to optimize resources, to complement efforts and also to design and implement new investigations in order to fulfill the needs of information which are not covered yet.

In view of the above, the PES (DANE, 2013f) studied in detail the unsatisfied needs of the sector`s information, concluding that DANE should apply the Third CAN in a short term and also propose, design and implement a survey on the costs of production, so enabling the identification of values per agricultural product in their unproductive and productive stages, the operational costs (inputs, materials, services, fuel, infrastructure maintenance, transport, animal and plant health, organic and inorganic fertilizer, interests, taxes and workforce) and finally fixed costs such as land, infrastructure and equipment.

Finally, PES (DANE, 2013f) identified that DANE should produce, in a medium and long term, information on the employment state in the rural sector, the workforce`s productivity, as well as on the state of environmental resources within the agricultural activity; for understanding phenomena such as: climate variation and its effects in the agricultural production and food security; similarly, the use of water resources, soil degradation, deforestation and the use of fertilizers and agro-chemical products.

3. Analysis of the statistical methodologies for the development of SEA (Agricultural Statistical System) in Colombia

The World Programme for the Agricultural Census (FAO 2007) suggests the planning of an integrated system of agricultural statistics in which the main module corresponds to the Agricultural Census, whereas the supplementary module is the program of agricultural surveys that are formulated from such census. This last module should be developed through the use of sampling methods or with a combination of them.

In accordance with Nusser y House (2011), the production of statistics for the agricultural sector represents challenges in term of complexity, diverse nature of target population and the type of information that this sector requests. Such challenges are related with: (i) the use of adequate methodologies for the different sampling units (ii) the selection or updating of an efficient and complete

sampling frame, (iii) the handling of changes in the observation units whose trend can be consolidated as big agricultural units that can be divided into smaller units, taking into account the corresponding changes in the limits of land use both cases, (iv) the handling of low response rate in the surveys, (v) the production of efficient and consistent estimators, compatible with the administrative records and other supplementary sources of information (vi) the optimal identification of all population units through geo-referential methods (viii) production of information on farmers who are located in small geographical areas and work at the production of specialized goods, (viii) the provision and analysis of information which is required due to the growing demand of specialized investigators and users, so allowing the full access to data bases and their use by means of technological tools, and (ix) the assurance of confidentiality of information and sources[18].

In view of the above, sampling methods in agricultural investigations can be directly or indirectly attached to the land use. In a direct manner because such investigations contributes to know the state of variables such as: amount of production within the area; whereas in an indirect manner because these makes easy the understanding of auxiliary variables such as: the implementation of conservation practices, or the behavior of environmental factors, inter alia.

3.1 Sampling of area frames

According to Nusser y House (2011), the sampling of area frames[19] have been widely used in agricultural surveys. Such technique enables to directly sample land units through multiple-staged and stratified designs. The major advantage of using area frames is that they provide a complete coverage of the area under study, being more efficient in the sampling design, and therefore in data collection. The measurements obtained as from their use, as consequence, are directly correlated with the area of observed units. However, area frames usually have extensive sampling errors, in special when rare phenomena are being measured.

In Colombia, the ENA is the only survey which was designed by taking into account area frames. This survey is carried out each six months through probability sampling and data are disseminated in an annual basis. Bearing in mind the advantages that could be taken by having an area frame, ENA could be strengthened by updating the frame -task which has be partially carried out with the support of both the geographical computerized systems from the Geographical Institute Agustín Codazzi (IGAC as its acronym in Spanish), and field trips carried out by the ENA staff. However, the need for applying the third National Agricultural Census CNA is clearly evidenced; due to this represent the central component of the integrated system of agricultural surveys and an important input for updating the frame with which ENA is carried out. In this regard, from the results obtained from CNA, the National Agricultural and Livestock Survey ENA would have to optimize its sampling design, to extend both its coverage for the estimation of products and its scope concerning aquaculture, livestock and forestry sub- sectors, to overcome its geographical coverage limitations and to construct continuous series of information.

A second use of area frame`s sampling in the Agricultural Statistical System, could be identified as the design of a survey that permits the monitoring of land conditions and of the inventory of natural resources. Such exercise, apart of coverage and land use, would enable to collect data regarding the soil erosion, the diversity of habitats, the conservation practices and other natural resources` attributes. The Natural Resources Inventory of United States –proposed by Goebel and Baker (1982)- referenced in Dayton, Herrick, Pierson, Pellant, Pyke (2003), is a clear example of the design of area frames' sampling (stratified at two levels); in which the primary frame was obtained as from the use of remote sensing and is periodically updated with sub-samples that are visited on field. In terms of levels, the first one is selected from the political-administrative division of the country, whereas the second level is selected in function of either the variables of interest of each state (department) or the diversity of geographical domains. In this type of sampling, the segments are square-shaped – 1, 6 km each side-; however these could be smaller or bigger depending on the land characteristics. Furthermore, the sampling ranges between strata and the randomness are restricted for so assuring a better geographical coverage and obtaining in detail, information on the survey`s variables of interests.

Another potential application of the area frame's sampling methodology in the Agricultural Statistical System corresponds to the development of the Inventory of commercial forestry holdings. According to Bechtold, McRoberts, Patterson, Reams, y Scott (2005),- who were investigators from U.S Department

of Agriculture Forest Service-, forestry inventories should be periodically carried out for evaluating the factors related with the change of soil use, trees growing and mortality, and the absorption among inventories. In terms of sampling, such investigation is carried out by stages for stratifying the land surface under study, using auxiliary data such as satellite images or aerial photographs and intensifying the accuracy of measurements regarding the crops` health state, the existent biological diversity ant the environmental wealth.

It should be also added that the use of technological tools supports the sampling methodology by area frames. The availability of aerial photographs, remote sensing and satellite images complement the information of sampling units and permit the sample selection in a specific basis. In Colombia, progress has been made in terms of the conversion of actual area frame`s sampling segments to digital analogue formats. Specific points have been geo- referenced within primary sampling units, and the updating of stratification of such units by means of satellite images have been carried out.

3.2 Sampling of list frames

The sampling of list frames is also considered as relevant for the SEA[20] consolidation. Although the area frame`s sampling methodology has been used for measuring the performance of small and medium producers (who comprises the relevant population in the country`s rural area), the list frame`s sampling can be focused on evaluating the agricultural holdings with business purposes. The use of list frames allows the application of well-recognized sampling methodologies, including the simple random sampling, systematic sampling, stratified sampling, probability proportional to size, multivariate probability proportional to size and permanent random number[21].

In the country, producers` unions and associations count with lists of business producers which can be used as list frames, provided that these have detailed information in order to increase the accuracy of estimations as from the stratification of such lists. Likewise, administrative records managed and systematized by public entities or unions, as well as the lists of users of projects on agricultural and social development may be useful for creating list frames.

In accordance with Nusser y House (2011) major producers should have a bigger representation in the samples created from list frames in comparison with small farmers, given that major producers have a most important participation in the production. Nevertheless, conglomerations in the sample shall be avoided for ensuring the production of estimations of all products under study. In these cases, stratified sampling should be defined, primarily by the product of interest and then by the size of agricultural holdings. In the case that agricultural units have different crops, each unit should be included in more than one stratum, giving more priority to those products which are less common. This is an effective system, when a minimum amount of products are evaluated; however, when lots of crops are obtained, stratification becomes more complex. Here, the Poisson`s sampling method developed by Kott and Bailey in 1997 is recommended, which is based on the creation of multiple list frames that are partially overlapped.

Given the data collection methods, it is known that these may vary in function of the observation unit, the type of complexity of the information to be collected, the available time for data collection and the budget considerations. In the case of business agricultural producers, surveys applied via internet – on the website- are considered as an excellent alternative for capturing information, provided that awareness-raising and training processes are previously carried put, this way making easy the understanding of the survey`s questionnaire.

On the other hand, in relation with the operations which are currently carried out by DANE, the SIPSA`s module of dairy raw milk prices requires an updating and a complementation of the current list frame, which is stratified by the size of the dairy herd, the milk production volumes and milk production regions. In addition, such frame should be unified with the list of milk producers which is managed by the livestock union – FEDEGAN, for restoring the sampling design and unify the estimation of volume of milk produced nationwide. This same frame can be fed with auxiliary information from the processing industries or cooperatives that buy milk in the country.

Recently, the Survey of Livestock Slaughtering (ESAG) updated the frames of the centers intended to livestock slaughtering in the country, in finding the coverage expansion that enables to provide information at departmental level, facilitating the analysis of this sub-sector. It is important to remember that ESAG collects information by means of a web-questionnaire; as a result, the coverage expansion was efficient in terms of costs and results.

Likewise, list frames that update products relevant for unions such as flowers, potatoes, palm oil, corn, cocoa, plantain, panela cane, rubber inter alia are analyzed by DANE for defining sampling designs that facilitate or improve the statistical data production of such institutions. In this sense, the fact of replicating the exercise carried out together with FEDEARROZ - in which DANE provides support to the ENAM`s statistical and conceptual design, and to the information processing; whereas FEDEARROZ carries out the field operation-, would represent an important step forward in the SEA, by ensuring the application of statistical methodologies that encourage comparability and also assure data quality. In the same way, this approach can be adjusted and serve as complement to the future research that DANE will carry out i.e. the survey on Costs of Agricultural Production[22].

3.3 Sampling of mixed frames

The use of combined sampling frames – list and area frames- in a statistical investigation or survey corresponds to the methodology of mixed sampling frames, which is considered as a manner for taking advantage of the strengths of both frames. In accordance with Holland (2011), by means of this methodology, sample is selected by a listing exercise and by areas; then, data are collected from the units selected in both frames, this way determining if agricultural holdings in the sample by areas are also included in the list. As a result, data in the sample by list and the information on agricultural holdings of the sample by area that are not included in the list can be expanded, by using selection probabilities.

In accordance with FAO (2007), the sampling of mixed or dual frames is highly used in agricultural survey, especially for household sector. "… Its main advantage is the easy and cheap creation of lists of agricultural holdings only in the selected areas, instead of making it in the entire country. Data collection is also cheap because sample units are conglomerated in the selected areas, instead of being spread in all the country´s territory…" (p.68). Moreover, another advantage consist in the jointly way in which frames cover the target population. Given that it is a sampling method, variability can be controlled; in addition, such methodology enables the study of special or rare products.

However, this methodology has weaknesses. For instance, it can be difficult to identify overlapping in the frames, producing bias in the estimation if such overlapping is incorrect. Therefore, lists and areas frames should keep updated in an independent manner.

Nusser y House (2011) points out that the frames combination is effective bearing in mind two aspects: A complete and well developed list of agricultural enterprises supported by auxiliary information can provide an effective sample; even though it sometimes may provide incomplete data. For its part, an area frame may be ineffective for specific data collection, but it contributes to have a more complete coverage. In this way, by using dual frames estimations from the domains´ overlapping are weighted by the inverse of the standard error of each frame. In other words, standard errors provided by an area frame are considerably bigger than in a list frame. Consequently, with the domains´ overlapping, the error is estimated almost in exclusive way since the list frame.

In Colombia, progress should be made in the use of sampling of dual frames for producing information on employment in the rural sector (and other variables), using a household sampling framework. This can be achieved through the design of a particular survey that inquires on the workforce occupation in the rural area, or by the extension of the employment modules in the Great Integrated Household Survey (GEIH) which are applied in rural households. Some inquiries have been brought up on the contribution of woman, youth and elderly workforce, child work or the non agricultural workforce. Food security in the rural context is another survey option which can be designed as from the use of this methodology. In any of both cases, it is expected that the third CAN provides the framework of households and agricultural holdings in the country.

In addition, the methodology of mixed frames can be useful concerning the improvement of measurements of bovine inventory which are carried out in the country. One approximation to the sampling design can be consulted in the World Programme of Agricultural Census 2010 (FAO, 2007: p.69).

3.4 Statistical estimations for the agricultural sector

Statistical estimations comprise the processing of information, imputation, weighting and the estimation of parameters and variances. As in a common survey, estimation methods depends on the objectives previously defined. The most common estimations for the agricultural sector has to do with production forecasts which are complex due to these

require the integration of information from surveys and administrative records – data usually obtained by using different methodologies in different periods of time.

Bearing in mind the high dependency of agriculture to factors impossible to anticipate and control such as climate or diseases; uncertainty can be handled by using production forecasts. This information is useful for producers, traders and other agents involved in this sector. For instance, producers should use forecasts for planning their harvest strategies, storage and distribution. Likewise, traders as well as agro-industries require forecast information for making logistics decisions. In this sense, records of meteorological seasons are relevant for carrying out reliable and timely forecast exercises.

In Colombia, further work on the use of statistical methods that go beyond production predictions[23] is needed i.e. microdata and administrative records´ assembling techniques which by engaging a simple analysis, these generate statistical routines and analyze the products` behavior in terms of exports, imports, needs for storage, raw material availability for agro-industry and market purposes, balance sheets´ calculations, among other type of analysis.

Finally, for the case of ENA, regarding the use of SIPSA´s food supplying database, estimations of the marketing margins along the agri-food chain have been undertaken in Colombia. In the same way, SIPSA has the challenge of recovering the historical series of wholesale prices by using estimations that combine the current price information, with the historical consumer and producer price indices – PPI/CPI, the ENA´s information of production and the analysis carried out by the DANE´s Direction of Synthesis and National Accounts.

4. Conclusions

The need for high quality information for the agricultural sector is fundamental to engage the sector´s development in all its contexts. Best analysis should come from the combined use of information derived from the implementation of surveys with adequate statistical methodologies. The planning of an integrated system of agricultural statistics -in which its main module correspond to the Agricultural Census, and the supplementary module is the program of agricultural surveys- is the strategy followed by Colombia for strengthening its Agricultural Statistical System (SEA), understood as a long term stable system that produces quality information for the agricultural sector in Colombia.

The DANE is the major sector´s statistics supplier which is currently preparing the Third National Agricultural Census -3rd CNA-, and is also planning both the strengthening of its continuous statistical operations and the design and implementation in a short, medium and long term of new investigations. As from the use of all sampling methodologies previously analyzed (area, list and mixed frames, and statistical estimations), DANE has identified the methodological alternatives which can be applied for the SEN`s configuration.

Table 2: Summary of statistical methodologies useful for the Agricultural Statistical System (SEA).

Methodology	Definition	Main advantage	Main disadvantage	Current use in Colombia	Use in the Agricultural Statistical System (SEA) in Colombia
Area frames sampling	Set of land segments which are divided by means of physical limits, enabling the identification of exploitations, crops and animals within each segment.	It enables to have a total coverage, less non sampling errors and contributes to the estimation of products which are regularly generated.	High costs, (ii) it is difficult to estimate the behavior of special products, they are sensitive to data which is out of range, which means that such frames need of clearly-defined physical limits.	National Agriculture/ Livestock Survey – ENA.	Strengthening of the National Agriculture-Livestock Survey – ENA- Design of the Land Conditions Survey and the natural resources` inventory. Design of the Commercial Forestry Operations` inventory
List frames sampling	It`s a base containing data that identify, locate and contact the producers and agricultural enterprises.	It enables: data expansion by using the selection probabilities, the use of low-cost collection methods, the analysis of specific or rare products and the reduction of variability generated due to the sampling exercise.	Such frames become rapidly outdated; it increases the non sampling errors and therefore needs of permanent maintenance.	SIPSA`s module of prices for dairy raw milk. Livestock Slaughtering Survey–ESAG. Surveys and investigations from unions and associations of producers	Updating and complementing the list frame used in the SIPSA`s module of prices for dairy raw milk. Updating of the frame of centers involved in livestock slaughtering –ESAG. Strengthening of surveys on products such as: flowers, potatoes, oil palms, corn, cocoa, plantain, panela cane, rubber.
Mixed frames sampling	The use of combined sampling frames – list and area frames- in a statistical investigation or survey.	1. Provides an efficient sample, allowing a more complete coverage. 2. Data in the sample by list and the information of the sample by area that is not included in the list can be expanded, by using selection probabilities. 3. Its `creation and application is easy and cheap. 4. Cubren mejor la población objetivo, al ser un muestreo que puede controlar la variabilidad. 5. Such frames cover in a better way the target population, given that it is a sampling method where variability can be controlled. 6. It enables the study of special or rare products.	It can be difficult to identify overlapping in the frames, producing bias in the estimation. Ineffective to be applied in the collection of very specific data.	National Survey of Mechanized Rice – ENAM.	Design and implementation of surveys on both employment in rural areas and food security. Improvement of the conditions of bovine inventory.
Statistical estimations	Consists on the processing of information, imputation, weighting and the estimation of parameters as well as variances.	It`s application is cheap.	These require the integration of information from surveys and administrative records – data usually obtained by using different methodologies in different periods of time.	Estimation of the production of some transitory crops in order to calculate the quarterly GDP. In the ENA`s research, estimations of the marketing margins have been undertaken regarding the use of SIPSA´s food supplying database.	1. The analysis of the products` behavior in terms of exports, imports, needs for storage, raw material availability for agro-industry and market purposes, balance sheets´ calculations, amongst other.

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Endnotes

1 The SNA 2008 "is a statistical framework that provides a complete, coherent and flexible set of macroeconomic accounts, for the formulation of policies, the analysis and investigation`s objectives (...) it shows the changing needs of users, the new developments in the economic context and the progresses in the methodological research..", (ECLAC, 2009: p.1).

2 This group includes cereals, legumes, edible roots and tubercles, fruits and nuts, seeds and oleaginous fruits, live plants; flowers and flower blossoms cut, flowers and fruits seeds, vegetable seeds, other crops of spices or drinkable plants, tobacco, cane crops, vegetable raw material previously non classified, plants used for perfumery, pharmacy or as pesticides of fungicides, trees and crops permanently planted, inter alia. (DANE, 2013a).

3 Preliminary data.

4 This decrease in the participation of the Agricultural GDP in the national total can be also explained by the growing of other economic sectors, such as mining.

5 In Colombia, agricultural investigations are mainly developed by DANE, which carries out the main surveys and investigations on this sector i.e. The National Agricultural Survey – ENA as its acronym in Spanish- The National Survey of Mechanized Rice –ENAM-, The Survey of Livestock Slaughtering –ESAG- and Agricultural Sector`s supplying and Price Information System –SIPSA- are just an example of the important and recognized agricultural sector`s investigations. These provide information on the medium and small producers. Fort the case of business producers, associated to products such as sugar cane, palm and banana for exportation, the production of statistical information is carried out by its related associations or trade unions.

6 From a total of 32 departments in the country, ENA approximately covers 37.941.476 inhabitants in 22 departments; excluding, Arauca, Amazonas, Caquetá, Chocó, Guainía, Guaviare, Putumayo, San Andrés, Vaupés and Vichada. Neither forests, rural-urban areas, zones with no agricultural use, palm oil domains, banana for exportation, nor sugar cane.

7 Fallow lands are those which are in temporary rest, before being once again used for planting purposes; whereas soils at rest are those that do not have any type of crop, and bearing in mind that such lands were previously cultivated, are not longer used for cultivation in a continuous basis during a period between 1 and 3 years, waiting for such land recovers its fertility, (DANE, 2013d).

8 The statistical information on coffee crops is produced by the Federación Nacional de Cafeteros de Colombia (*National Federation of Coffee Growers of Colombia*), using the Sistema de Información Cafetero (*Coffee Information System*) SICA.

9 In accordance with DANE (2013), the concept: special vegetations consider lands with savannah, xerophile and paramo vegetations.

10 It is known that many efforts for having information on the agricultural sector in Colombia started from both the interests of unions; and the concern for attending their own needs. Nowadays, producers ´unions have consolidated information systems, for instance: the Sistema de Información Cafetero (Coffee Information System) SICA, the Sistema de Información de la Caña de Azúcar (Sugar cane's Information System), managed by the Sugar cane´s Research Center [CENICAÑA] and the Sistema de Información Estadístico del Sector Palmero (Palm Sector's Statistical Information Center.

11 In accordance with DANE (2013f), "…the main source of statistical information is represented by the National Statistical System –NSS - an articulated set of components that ensure the production and dissemination of official statistics in Colombia-. This is made up by producers, sources of information, principles, standards, human and technical infrastructure, policies and technical processes. The NSS is coordinated by DANE, and integrates the statistics that are produced by ministries, administrative departments, decentralized entities, autonomous organizations, and private entities inter alia. Bearing in mind the regulations that govern the NSS, according to the Decree 262 of 2004, DANE will be in charge of -apart from the functions established in the 59 of Law 489 of 1998- coordinating and advising the execution of the National Statistical Plan as well as the sectoral and the territorial plans; likewise, to monitor, evaluate and disseminate them. The DANE is the organization that should coordinate the planning and the standardization of statistics, as well as ensuring the fulfillment of good practices in the processes of statistical production carried out in the entities that comprise the national public administration …" (p.5).

12 This plan was developed by the Direction of Regulation, Planning, Standardization, and Normalization – DIRPEN, in the framework of the Project of Statistical Planning and Harmonization, where its objective is to strengthen and consolidate the National Statistical System. "… Sectoral statistical plans analyze and consolidate the statistical production of a specific sector, involving a formulation process similar to PEN. These are based on specific objectives for the sector and provide answer to their punctual needs of information, which in some cases, are of national interest. Such plans also enable the design, formulation, monitoring and evaluation of sectoral public policies. (…) Sectoral statistical plans correspond to an important element for the Sectoral statistical plans correspond to an important element for the NSS´s strengthening, as far as its development and formulation require the interaction and constant participation of entities and institution involved…", (DANE, 2013f: p.8).

13 ICA is the entity attached to MADR that works for the agricultural health and the safety in the primary production of businesses regarding the Colombian agriculture.

14 ENA produces estimations on the use of soil, sowing areas of transition and permanent crops, cultivated areas, production and performance of transition and permanent crops, areas sowed with pastures, fodder and forestry, amount of total plants and productive age of scattered trees, carries out an inventory of bovine animals and swine regarding productive purposes, sex and age at national and departmental levels, and the amount of heads of other livestock species by sex, volume and the destination of bovine milk production the day before the interview. Finally such survey inquires and carries out the estimations of other study variables such as (irrigation, fertilization and commercialization).

15 Its objective is to provide information disaggregated by sex, standing and carcass weights of slaughtered cattle as domestic as foreign destination. Likewise, it measures the production of livestock activity in terms of meat extraction by sex, origin and destination of slaughtered cattle as well as it contributes to establish the main destinations of the meat consumed in the country.

16 The purpose of this survey is to estimate the sowing areas as well as the production and performance of mechanized rice crops (irrigated and upland rice) each six months in Colombia. ENAM is carried out together with DANE and the union FEDEARROZ, where the first entity provides support in the survey`s statistical and conceptual design, as well as the information processing; whereas the union is in charge of the field operations.

17 SIPSA provides information on the wholesale prices` behavior, the food supplying and information of retail prices of inputs and factors associated to agricultural production; through the data collection in the country`s main wholesale centers, the cities 'entrances and in stores specialized on the selling of inputs. Such system reports on the wholesale prices of food and their variations concerning the preceding period (daily, weekly and monthly) for the 61 country`s wholesale centers, panela prices in 9 regional markets, information of the dairy milk`s Price in 189 milk producer`s municipalities, rice prices at mills for 27 municipalities and meat in 7 slaughterhouses. Likewise, the food volume that enters to 13 wholesale centers the loads go through 23 vehicle traffic controls.

18 In addition, the production of agricultural statistics in Colombia have to confront current challenges such as: the implementation of Income Generation Policies in Rural Population, the Increase of Agricultural Competitivity, The Extension and Diversification of Domestic and Foreign Markets, the Equity in the Regional Development, The Management of Agricultural Risks, The Integral Policy OF Lands, as well as the factors associated to the internal armed conflict inter alia.

19 Holland (2011) points out that area frames correspond to a set of land segments which are divided by means of physical limits, enabling the identification of exploitations, crops and animals within each segment. Such frames are created by using digital maps, aerial photographs or satellite images, in which the surface is divided in strata regarding the land use and the aptitude for agricultural production, and a sample for each stratum is selected. Area frames are used by selecting a sample of segments which are usually kept for a period of 5 years, and then are rotated in a 20% of the sample each year. This tool permits to have information on all exploitations with a surface within segments; moreover, the results of this can e expanded by using the probabilities of selection based on the land surface. Furthermore, areas include and cover all segments. Each area should be provided with available cartographic material and permanent limits between the updating moment and the field work should be also defined. The cartographic aspect of each area is the primary factor concerning this type of sampling. The application of this technique is useful due to it enables to have a total coverage, less non sampling errors and contributes to the estimation of products which are regularly generated. This is a versatile tool with a wide useful life; however this frame has disadvantages such as: (i) their construction and utilization may be expensive, (ii) it is difficult to estimate the behavior of special products, (iii) they are sensitive to data which is out of range, which means that such frames need of clearly-defined physical limits.

20 Holland (2011) defines list frames as a base containing data that identify, locate and contact the producers and agricultural enterprises. Such frame is created by

contacting the organizations and unions of farmers, by consulting lists of agricultural programs, through compulsory records at departmental and municipal level, by means of lists of other government or private entities, by updating the information of surveys or through the application of the Agricultural Census. This frame is used through the lists classification for identifying producers and/or agricultural enterprises that may provide relevant information. Subsequently, a stratification or grouping of similar units regarding the size or the amount of variables to be measured is carried out; then, the sample selected i.e. the units within each group are selected and the survey is carried out. Among the advantages involved in this type of frame, we have: data reporting by using the selection probabilities, the use of low-cost collection methods, the analysis of specific or rare products and the reduction of variability generated due to the sampling exercise. However, regarding the frame`s disadvantages, the following are highlighted: list frames do not cover the total population, become rapidly outdated; it increases the non sampling errors because of the data collection methods and therefore needs of permanent maintenance.

21 In order to know more on these sampling techniques by means of list frames, it is required to develop a more deep and punctual investigation for each case.

22 Bearing in mind the design of statistics on costs of production, alternatives such as the implementation of longitudinal surveys should be evaluated. This technique would help to define how changes in cultural practices of certain groups of producers contribute to improve their results in specific periods of time. With such type of studies, a monitoring of costs of production during each of the stages of a given crop could be performed.

23 Nowadays, only the production of some transitory crops is predicted in order to calculate the quarterly GDP.

SPP 3
New Technologies for Data Collection for Agricultural Surveys and Statistics

Organizer: Mark Harris, USDA/NASS

Chair: Andrea Lamas, USDA/NASS

This session will focus on technology utilization in data collection, frames development, and other survey process. This includes:

- Thin client data collection utilizing cellular technology and devices;
- Frames development utilizing new methodology or technology and new technology utilized in the collection of data from these frames; and
- All other unique technology assisting in efficiency of survey and data collection processes.

Utilization of remote sensing technology should be limited to assisting in frame development or data collection or other uses in traditional agricultural surveys and census.

Papers:

- Fenghua Wei (China), "The Applications of High-Technology Measures in China Agricultural Surveys"
- Jaki S. McCarthy, Michael Gerling, Eric Wilson (USA), "Field Data Collection for an Area Frame Survey Using iPads, the USDA's June Area Survey"
- Sarah Nusser, Andrew Vardeman, Alan W. Dotts (USA), "Geospatial Data Collection in the US National Resources Inventory"
- Susana Pérez Cadena (Mexico), "2012 National Agricultural Survey"

The Applications of High Technology Measures in China Agricultural Surveys

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Abstract

With the continuous development of science and technology, the applications of high-tech means in agricultural surveys become increasingly in-depth and wide-ranging. Such applications enhance the capacity of agricultural statistical survey, thereby improving the survey data quality continuously. In recent years, National Bureau of Statistics of China conducted constructions of statistical information modernization, a series of applications of high-tech means in China agricultural statistical survey come into fruition. This article will introduces the application of high-tech means in China agricultural statistical surveys in details, such as unmanned aerial vehicle (UAV), personal digital assistant (PDA), agronomic parameters collector and so on. This article will also introduce an up-coming project named Fast Agricultural Survey Platform which is an integration of this high technology application.

Keywords: high-tech survey means; agricultural survey; unmanned aerial vehicle; personal digital assistant; agronomic parameters collector.

1. Introduction

In China, the agriculture is the primary industry which constitutes the basis of the national economy and has great influences on the national security and society stability (Hao and Ren, 2009). The statistic data are the major information in the agriculture and determine the agricultural policies. The Chinese government always pays great attention to statistical work in villages. However, the investigated ways in the Chinese agricultural statistical survey mainly include household interview and report from local places to the advanced management layer due to many limitations. The conventional tape measurement is still adopted at present which results in heavy work and delayed information and cannot satisfy the accurate and timely requirement in the modern agricultural statistics.

The high-tech survey means has already been applied in agricultural statistical work internationally (Jensen et al. 2006; Bailey and Boryan 2010). One of the popular methods is the spatial information technique, such as the LACIE and AGRISTARS projects, Ag 20/20, the MARS project, and the global crop information warning system in FAO (Yang et al., 2007; Boryan and Craig, 2005). Furthermore, the data acquisition tools based on the information technology also have been applied in statistics, such as PDA used in IBGE (Brazilian Institute of Geography and Statistics) and unmanned aerial vehicle used in the forest fire detection and accurate agriculture by NASA. These high-tech survey means indeed improve the feasibility and efficiency in the agricultural statistics.

Recent years, many relevant studies have been conducted in China. For example, the national statistical key technology research and application based on remote sensing operational system has studied the techniques for crops planting area measurement and yield estimation using remotely sensed methods. In this project, GPS, PDA, unmanned aerial vehicle, and agricultural parameter collector were used in agricultural statistical measurements. However, these tools are still in the test state or used solely. On the foundation of Chinese agricultural statistical survey, this paper will introduce GPS, PDA, unmanned aerial vehicle, and agricultural parameter collector and the agricultural quick survey platform which is established nowadays.

2. The current situations and challenges in Chinese agricultural statistics

As the social economy quickly developed in China, the production mode, plantation structure, and scientific and technological level changed in Chinese agriculture. The modernization and technicalization of Chinese agriculture gradually deepened, and the agricultural products market has great influences on the planting mode. Under these circumstances, the Chinese agricultural statistics still face many challenges.

The first challenge is the inadaptation in respondents. The mainly respondents are peasant household. However, many peasants stay away from home to seek jobs, thus their plantation could not be surveyed. Besides, many peasants write data subjectively, the education level and the

willing to cooperation also influence the quality of statistical data.

Another challenge is the inadaptation of survey means. Traditionally, agricultural data were measured mainly by tapes, resulting low efficiency during surveys and delayed information. Especially, this cannot be used in disaster detections. Thus the contradiction between survey means and missions is more and more obvious.

Aiming at these problems and the requirements in the modern agricultural statistics, the National Statistical Bureau conducted many researches and applications for modernize the agricultural statistical work which were based on spatial information techniques such as remote sensing, geographical information system, and global positioning system. The National Statistical Bureau and many scientific research institutions, i.e. Beijing Normal University, launched the national statistical key technology research and application based on remote sensing operational system. This project was mainly focused on the key techniques and challenges in the agricultural survey application. It included many high-tech survey means as follows:

1. Main crop detection by remote sensing. Different resolution, multi-spectral, and multi-temporal imagery were used to identify wheat, corn and paddy.
2. The collection system including aerial tools and ground surveys. In this part, GPS tools were used to measure samples to collect ground truth data and unmanned aerial vehicle were used for a wide range and high-precision observation.
3. Demonstration of key areas. The above two techniques were applied in different terrain and plantation structures to complete the technical system and provide foundation for business operation.

3. Modern high-tech survey means

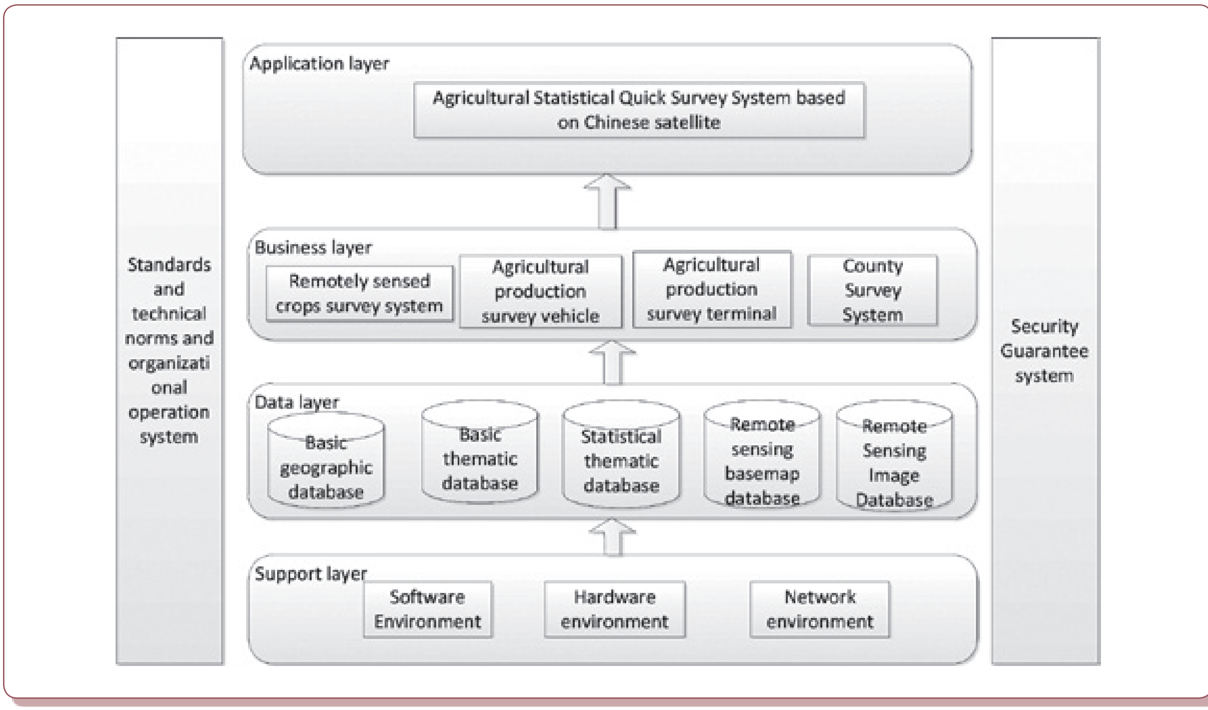
Next, in addition to remote sensing techniques, many high-tech survey means are introduced:

1. GPS and PDA. The function of GPS is to positioning and navigation. However, the national territorial area of China is vast and administrative division is very complex, thus it costs much work to search respondents with very low efficiency, but the navigation feature of GPS could quickly guide the investigators to the pre-defined positions. Moreover, the traditional surveys were conducted using paper questionnaire, which cause environmental problems and were difficult to preserve. However, the questionnaire could be import to PAD electronically. Currently in the market there have been electronic products combining high-precision GPS with PAD, they can not only play their respective advantages, the survey data will also reveal spatial and temporal properties, thus the survey data will become traceable and can be reviewed.
2. Unmanned aerial vehicle (UAV). The UAV has the ability to acquire remotely sensed data quickly, flexibly, and automatically. This tool has been deeply used in many aspects, such as land, resources, agricultural and disasters detections. UAVs could collect a wide range of high-resolution data in relatively short time and neglect the influences of clouds; the rapid movement response and low cost of UAV can supplement or replace part of the ground survey data. Thus it could solve difficult problems in acquiring high resolution rate data and insufficient and unrepresentative samples.
3. Agricultural parameter collectors. The Agricultural parameter collectors mainly gather the NDVI, the leaf area index, canopy nitrogen logger, and soil moisture. The basic principle of these collectors is collect reflected spectral data of leaves and canopies using the designed spectrometer. After denoising processes, these spectral data were used to derive crop reflective spectral information. This information was analyzed by spectral inversion models to obtain agricultural parameter models. The aim of agricultural parameter collectors is to quantitatively characterize the growth situation of crops in order to address the current limitations of observed by the human alone.

4. The technology framework of Chinese agricultural quick statistics survey platform

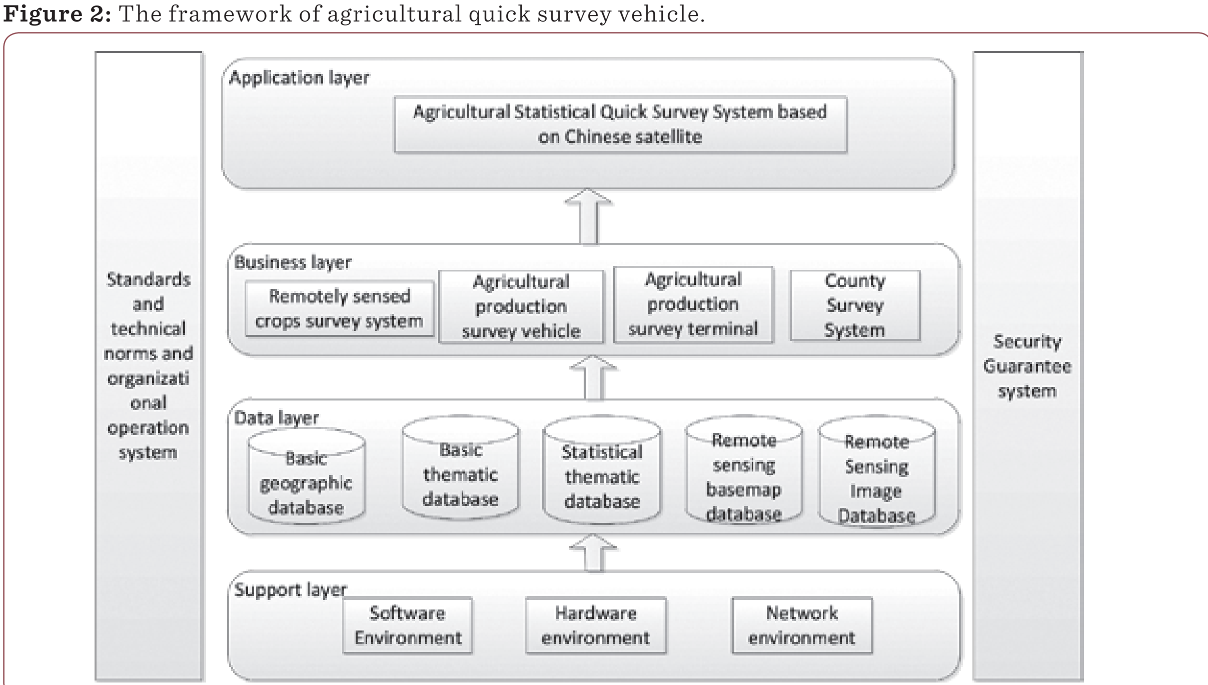
The objective of Chinese agricultural quick statistics survey platform is to integrate existing methods, and to study the agricultural quick survey vehicles based on UAV, GPS and agricultural parameter collectors with the utility of satellite data. The commercial remote sensing agricultural statistics system will be established to fulfill the quick survey of crop planting acreage, yield estimation, growth situation and the impact of disasters on different scales. The basic framework is introduced as follows:

Figure 1: The technique framework of agricultural statistical quick survey platform.



In this platform, the agricultural quick survey vehicle is the carrier of high-tech survey means. The lightweight and off-road performance of survey vehicle could complete the task easily in rural roads. The vehicle is equipped with satellite data transmission system and long-distance voice communication system to send and obtain data and communicate wireless. It is also equipped with mission planning system in order to plan, schedule, navigate and detect the mission. The vehicle-based UAV system could acquire and quickly analyze UAV data. The filed tablet PC measurement system, integrated agricultural parameter collectors, and Roadside Picture and Video (RPV) are used to gather crop information and quickly process and upload the results of survey data. The architecture of the platform is designed as follows:

Figure 2: The framework of agricultural quick survey vehicle.



Then the high-tech in agricultural quick survey vehicle is designed as follows:

1. **UAV equipment**
   With the abilities of highly automation and high-resolution data acquisition, the vehicle could fly according to the pre-defined sampling transect under the supervision of task scheduling subsystem. Thus high-resolution remotely sensed data could be acquired timely and precisely in the UAV, and then transferred into the vehicle using local communicative system.

2. **The field tablet PC measurement equipment**
   In order to reach the ground measured points, the PC equipment navigate to those points using the high-resolution imagery and GPS techniques. Then the reporting feature is used to collect required data in the samples and field photos. These data will be transferred to the vehicle using local network. The filed tablet PC measurement equipment could exchange data with the vehicle any time to increase the mobility and flexibility.

3. **The integrated agricultural parameter collector**
   This collector integrates the spectral detection for the leaf area index, nitrogen, and water content and radiation transfer models. With the established techniques, the collector could output the NDVI, leaf area index, canopy nitrogen content and other parameters of crops on the base of crop spectral information detection.

4. **Roadside picture and Video (RPV)**
   Under the command of vehicle navigation system, the RPV collect the ground information or image information according to a specified sampling interval. These information have GPS positioning coordinates and thus could match other spatial data.

5. Conclusions and outlook

This paper first introduced the importance and urgency of high-tech survey means in Chinese agricultural statistical applications, analyzed the current situation and challenges from the view of survey means. Then some projects which were conducted to address those problems are introduced. Afterward, GPS, PAD, UAV, and agricultural high-tech survey means were discussed in detail. On this basis, we described the agricultural quick survey platform and its objectives and entirety framework design. Besides, the design ideas of survey vehicle and the equipped high-tech survey means are also introduced. As this platform is still at the design stage, we will continue to focus on the construction of agricultural statistical quick survey platform in the future.

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Field Data Collection for an Area Frame Survey Using iPads, the USDA's June Area Survey

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Abstract

The US Department of Agriculture National Agricultural Statistics Service's (NASS) June Area Survey is an area frame based survey conducted by field interviewers using paper questionnaires and an aerial photo of a sample segment of land. Interviewers visit land operators and draw out crop fields, pastures, woods, wasteland, etc. on the aerial photo. In addition, information on agricultural activity occurring within the designated area is collected on the questionnaire. NASS is currently developing a CAPI data collection instrument which eliminates the need for hard copies of the aerial photo and paper questionnaires. The field interviewer uses an iPad which displays the area of interest and provides the ability to draw off polygons and collect attribute data in a GIS layer. Also, the field interviewer records survey responses on land utilization via the iPad. The CAPI instrument is a cloud based web application designed to collect data in both on-line and off-line situations. This presentation will discuss NASS's use of iPads for data collection in this survey as well as other innovations enabled by iPads such as remote training, electronic interviewer manuals, and use of GPS.

Keywords: area frame; Geographic Information System; iPad; electronic data collection.

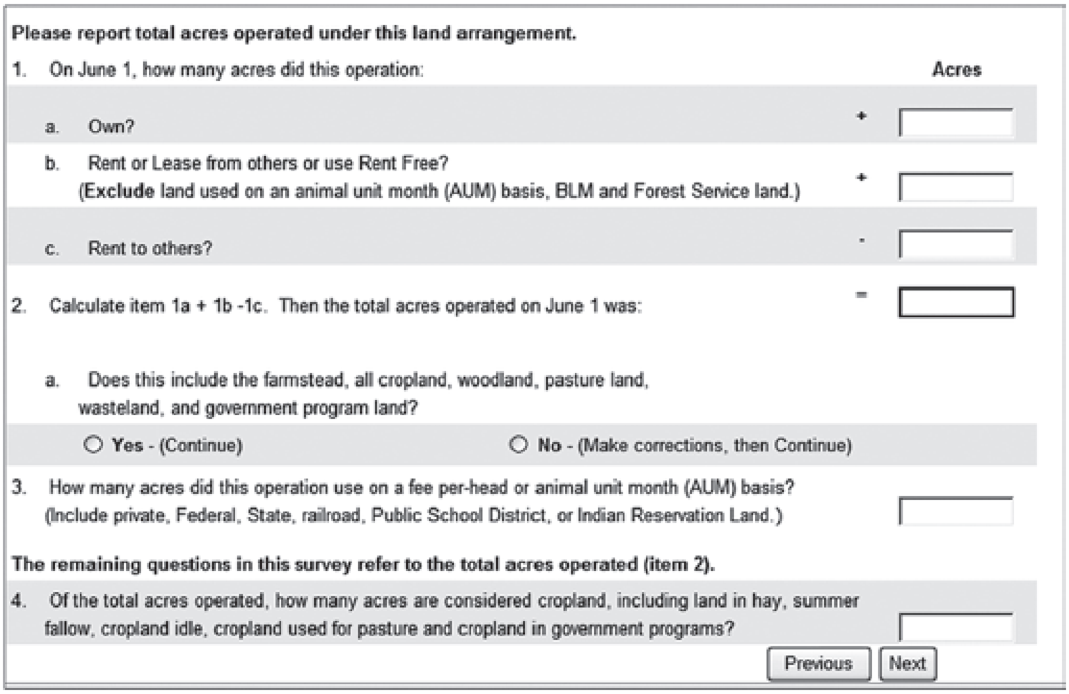
1. Introduction and Background

The US Department of Agriculture's National Agricultural Statistics Service (NASS) conducts hundreds of surveys every year and prepares reports and official statistics covering virtually every aspect of U.S. agriculture. Production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use, and changes in the demographics of U.S. producers are only a few examples. These surveys are typically samples of agricultural operations and agribusinesses. Most surveys conducted by NASS use multiple modes of data collection: mail, telephone, on line reporting and in person interviews. Telephone interviews are conducted primarily with computer assisted telephone interview (CATI) instruments, although some are still conducted with paper questionnaires. Paper questionnaires have traditionally been used for in person interviews, but NASS has recently begun using computer assisted personal interviewing (CAPI). Unlike many other survey organizations, NASS was slow to adopt CAPI interviewing (see Couper and Nicholls, 1998, for a history of computer assisted survey information collection methods). This was for several reasons, including the initial high cost of portable electronics, the need for extended battery power required to travel to distant rural interview sites, usability in a variety of conditions including outside in sunlight, and NASS security measures (Gerling, 2004).

Initial research into using portable laptops or netbooks was conducted and initially tested in several states (Gerling and Harris, 2010). NASS's CAPI solution leverages an existing "in-house" developed system designed to provide web access to respondents for self administered questionnaires. For self administered on-line reporting, a respondent uses a browser window on their computer and logs into the NASS reporting website to access an electronic questionnaire using a pre-provided survey access code. For in person CAPI interviews, the interviewer uses a browser window on their iPad and logs into a similar website to access their assigned questionnaires. The CAPI questionnaire (see below) resembles a traditional paper based questionnaire so it is familiar to interviewers and has eased the transition from paper questionnaires to electronic ones. In early NASS CAPI interviews using netbooks, admittance to systems behind NASS' firewalls or storage of information on the devices' hard drives was not required. This was fairly successful and the set the stage for widespread adoption of CAPI in NASS. However, field staff still had to revert back to paper when there was no wireless broadband signal available.

As technology improved and became less expensive, NASS continued to research alternative CAPI solutions. In 2011, NASS began initial deployment of Apple iPads using a cloud based NASS

Figure 1: Example Screenshot of CAPI instrument.



Please report total acres operated under this land arrangement.

1. On June 1, how many acres did this operation: **Acres**

a. Own? +

b. Rent or Lease from others or use Rent Free? (**Exclude** land used on an animal unit month (AUM) basis, BLM and Forest Service land.) +

c. Rent to others? -

2. Calculate item 1a + 1b -1c. Then the total acres operated on June 1 was: =

a. Does this include the farmstead, all cropland, woodland, pasture land, wasteland, and government program land?

○ **Yes** - (Continue) ○ **No** - (Make corrections, then Continue)

3. How many acres did this operation use on a fee per-head or animal unit month (AUM) basis? (Include private, Federal, State, railroad, Public School District, or Indian Reservation Land.)

The remaining questions in this survey refer to the total acres operated (item 2).

4. Of the total acres operated, how many acres are considered cropland, including land in hay, summer fallow, cropland idle, cropland used for pasture and cropland in government programs?

Previous Next

application to conduct CAPI interviews (Kleweno and Hird, 2012).

NASS's current CAPI solution is unique and incorporates several important characteristics. From a security perspective, NASS did not want to require admittance to systems behind the NASS firewall or store information on the devices' hard drives. Instead, interviewers download survey questionnaires into a browser window when they have a strong data signal. During the interviews themselves, Asynchronous JavaScript and XML technologies (Ajax) are used to send individual survey data responses to NASS servers. If a usable data signal is unavailable, the application will constantly search for a signal and transmit the data as soon as the signal is found. This allows interviewers to complete the interviews as though on the Internet whether a data signal is present or not.

The NASS CAPI solution also does not utilize an IOS native application; instead relying on a non platform specific application that is not downloaded onto the device. Thus, while NASS is using iPads to conduct CAPI interviews, the CAPI system is independent of the device, and could be accessed using any device with Internet access.

NASS has also incorporated mapping of interviewers' assignments using the resident GPS technology on the iPad. Once an interviewer opens the list of their assignments, they can click on an icon to map the assigned interviews. Then they can use the iPads' GIS mapping capabilities to obtain directions (from their current location or any other specified location) to each of the samples.

2. NASS's June Area Survey

NASS conducts many surveys throughout the year, most of them based on NASS's extensive list frame of farm and ranch operations. However, one of the largest surveys NASS conducts is its June Area Survey (JAS), which utilizes an area sampling frame. The area frame consists of all land, stratified by land use, in all states except Alaska. The primary sampling units (PSU), based on land area, provide complete coverage of all agriculture activity occurring on that land and, therefore, all operators in the state.

A sample of nearly 11,000 segments, subunits of a PSU measuring roughly one square mile, is selected from each land use stratum for data collection. All farm operators operating within the boundaries of the selected segments are interviewed. In a given year, approximately 85,000 agricultural and non-agricultural land use tracts are identified within the

sampled segments. From that identification, over 35,000 detailed personal interviews are conducted with farmers operating farms inside the segment boundaries or who have the potential to qualify as a farm.

The JAS is significantly different than most other NASS surveys in a number of ways. Data collection for the June Area survey is completed entirely by personal interview during the first two weeks of June. Personal interviews must be conducted since operators within the selected segments are not known until significant screening is completed. Also, respondents examine an aerial photograph and identify all land they operate in the segment. They must identify each field boundary on the aerial photo and report the crop planted or other land use (pasture, woods, wasteland, etc.). Acreage data for the current crop year, land use and livestock and stocks data for June 1 are reported and entered in a paper questionnaire by the interviewer.

June Area segment is shown above. The red perimeter outline indicates the boundary of the selected segment and is provided to the interviewer on the aerial photo. The interviewer will contact the operators of the land in the segment and manually draw off the tract operated with them. These are indicated in the photo by the blue interior lines and letters (A-E). Within each tract, the operator will indicate the individual fields (an example shown in the photo in tract E, marked with numbers) and report the land usage and acreage for the field, which is recorded on a separate paper questionnaire. Additional questions collect data on the whole operation. This is repeated with additional operators in the segment until all land within the segment is accounted for. Segment boundaries are constructed to follow physical features on the ground so both interviewers and respondents can easily report information for the land in the segment.

The JAS provides direct estimates for several projects and generates a unique population of respondents. Those operations which did not have the opportunity to be sampled from the list frame comprise the non-overlap (NOL) domain. The NOL

Figure 2: Traditional JAS aerial photo with segment drawn off.

domain, identified from this survey, is used as a sampling source to calculate an incompleteness measure for multiple frame estimates for no fewer than 19 major survey projects. The JAS is a unique and key survey for NASS.

Currently the NASS Area Sampling Frames (ASFs) are constructed using a combination of manual and automated processes in two stages. In the first stage, stratification is conducted at the Primary Sampling Unit (PSU) level based on percent cultivation. In the second stage, PSUs which are randomly selected to be in the June Agricultural Survey (JAS) are further broken down into sampling units using physical boundaries. A segment is then randomly selected, from each selected PSU, to be included in the JAS. NASS is also currently researching the possibility of moving from this method of frame construction to one based on a permanent area frame with units having more regular and roughly equal-sized area, and thus lacking physically identifiable boundaries. A prototype frame is being created based on the Public Land Survey System (PLSS). The PLSS is an official surveying method to survey and spatially identify land parcels. The PLSS typically divides land into 6 mile square townships, which are subdivided into 36 one mile square sections. The PSU would be a PLSS "section". In areas not covered by the PLSS (mainly the Northeast/Mid-Atlantic and Texas), an analogous grid can be generated, with a grid cell as the PSU. These PSUs from the prototype frame are a data collection unit.

If NASS were to adopt this research and use this as their ASF, the frame would be used permanently, without the need for periodic updates. With the proposed permanent area frame, the stratification of segments would be automated using primarily the Cropland Data Layer (CDL). Afterwards, the direct selection of these segments would occur. This greatly reduces the time needed for area frame development, stratification, and sample selection.

However, if a permanent grid ASF were to be used, many of the selected segments might not follow physical boundaries on the ground. Using the current (non-CAPI) procedures, it would be quite difficult, for both interviewers and respondents, to collect data for fields that fell only partially within the segment. A CAPI instrument which calculated the areas drawn off on a GIS layer would make this possible. Thus the testing of the JAS using NASS's CAPI with GIS is a key component to research on using a PLSS permanent grid ASF.

3. JAS on CAPI

Because of the unique characteristics of the JAS (for example, use of the aerial photo and collection of information about specific fields within tracts), it has not yet been operationally implemented as a CAPI survey.

Instead of simply recreating the JAS as an electronic photo and questionnaire, the iPad makes it possible for NASS to develop a Geographic Information System (GIS) tool that can provide a vast improvement to the current JAS procedures. As part of the research on the use of a grid based area frame described above, NASS has begun working with Iowa State University to develop a prototype instrument to collect the information about the land within the JAS segments.

In keeping with the existing CAPI iPad program at NASS, the prototype instrument the "Geographic Information Running Area Frame Forms Electronically" (or GIRAFFE), was developed with the Center for Survey Statistics and Methodology at Iowa State. OpenLayers, an open-source JavaScript mapping library, was chosen to provide basic web GIS functionality. Several additional tools were added to the OpenLayers map, including zoom tools, selection tools, undo/redo buttons, and a "Cache Imagery" button to automate the tedious image caching process that guaranteed enumerators would have imagery at the time of their interviews.

Interviewers access GIRAFFE using the iPads' Internet browser and the data are transmitted to NASS immediately or as soon as a usable signal is detected. This obviously eliminates the time required to transmit and key data from paper forms filled out in the field. In the GIRAFFE iPad application, a digital copy of the aerial photograph overlaid with a GIS polygon for each segment can be viewed on the iPad's screen. GIRAFFE provides a number of tools allowing the interviewer to split the segment to delineate the fields within the segment. Then the information about the area of the fields and the use of the field (crop or other land use) can be associated with each of the delineated fields.

GIRAFFE used a segment splitting approach, rather than drawing each individual field's boundaries because this ensures that all land within the segment will be accounted for exactly once. In other words, there cannot be any "holes" left between or around the drawn off fields. Likewise, field data for a given area cannot be associated with multiple reports. Respondents can report the acreage of the delineated

fields, but the GIS application can also calculate the area included in any field. This is a key feature if NASS moves to a permanent grid sample or any other area frame sample where sampling units may cross or otherwise not follow natural physical boundaries.

Another advantage of the GIRAFFE application over the traditional aerial photo is that other GIS layers can be shown along with the segment boundaries. The default view in the application is the photo imagery from the National Agricultural Imagery Program (NAIP). The NAIP acquires aerial imagery during the agricultural growing seasons in the continental U.S. A primary goal of the NAIP program is to make digital ortho photography available to governmental agencies and the public within a year of acquisition. The GIRAFFE display mimics the traditional aerial photos although they are shown on the iPad screen in true color instead of the printed black and white photos (printed aerial photos are approximately 2 foot by 2 foot).

While the iPad screen is smaller than the traditional printed photo, the iPad has the advantage that the image can be resized, moved and zoomed the same way images in other electronic tablet applications can be. If the image is zoomed in, much greater detail can be seen than in the printed aerial photo. As seen in the image above, the interviewer can click on the buttons in the upper lefthand corner to change the zoom level. The imagery can be fractionally zoomed from 1 inch per mile scale to approximately 70 inches per mile with a two finger touch and drag. At 16, 8, 4, and 2 niches per mile, the server delivered resolution is displayed. The 8 inch zoom level is equivalent to the traditional JAS aerial photos.

Additional GIS layers that are available are a road layer and NASS's Cropland Data Layer (CDL) for the previous two years (figure 4). The CDL depicts individual crops and land cover derived via remote sensing using a supervised land cover classification approach. Both of these may help identify field boundaries and help interviewers and respondents orient themselves relative to the land depicted.

Figure 3: Screenshot of JAS GIRAFFE on the iPad with NAIP imagery layer shown.

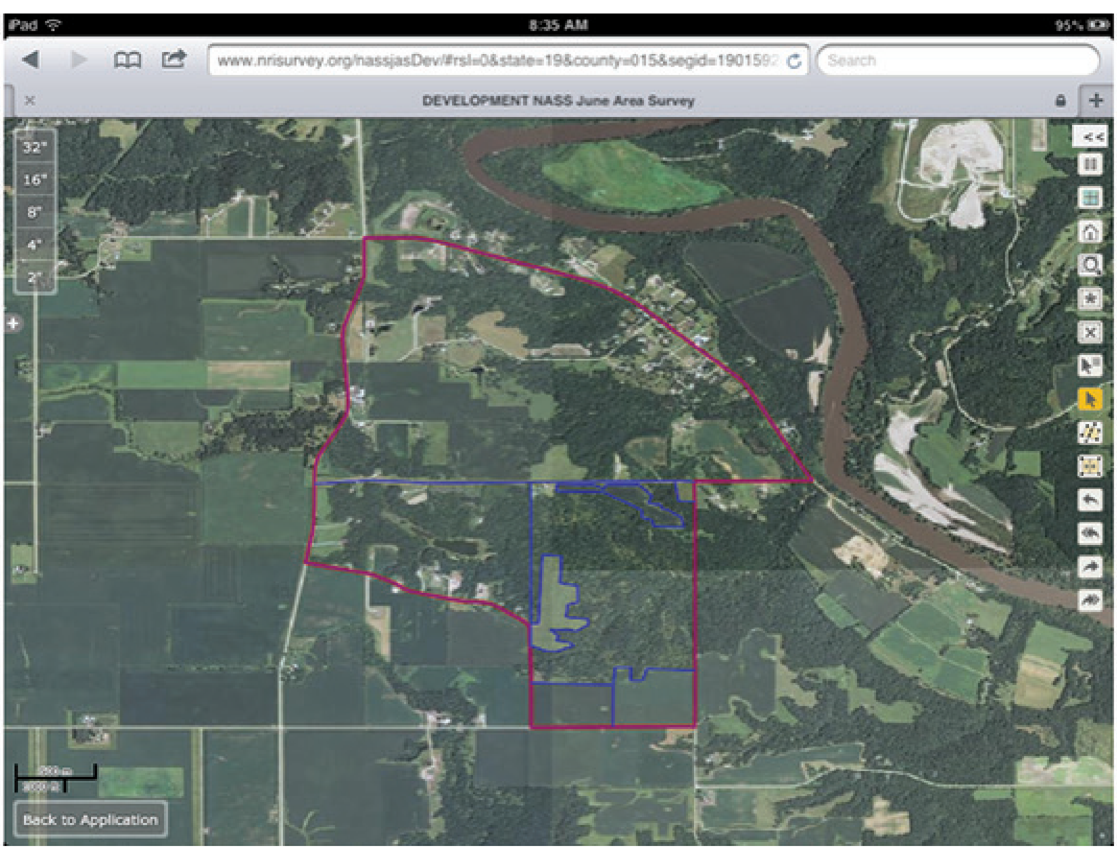
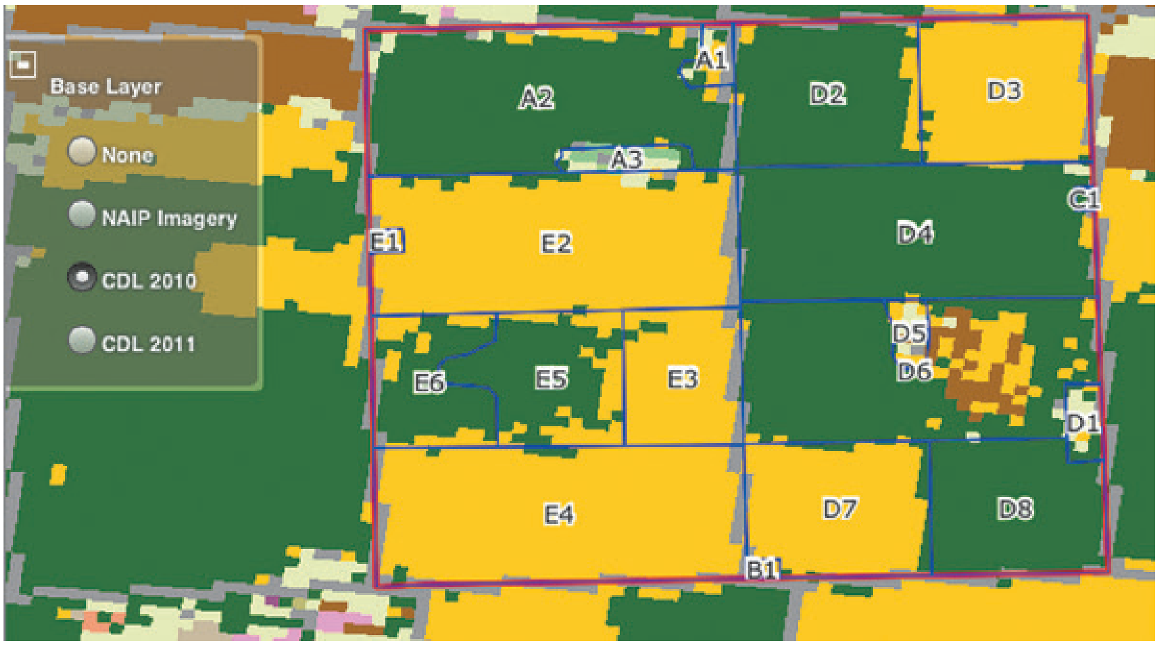


Figure 4: Segment shown with CDL imagery layer (colors indicate different crops or land uses).



Associated with the electronic GIS piece of GIRAFFE is a table to account for every polygon and identify each with tract/field label and general description. The detailed land use and crop information for a delineated field is collected in a fillable electronic form. Typical uses can be selected from a drop down menu. Examples of the polygon accounting table and field data form are shown below.

Figure 5: Screen shot of JAS GIRAFFE with polygon accounting table shown.

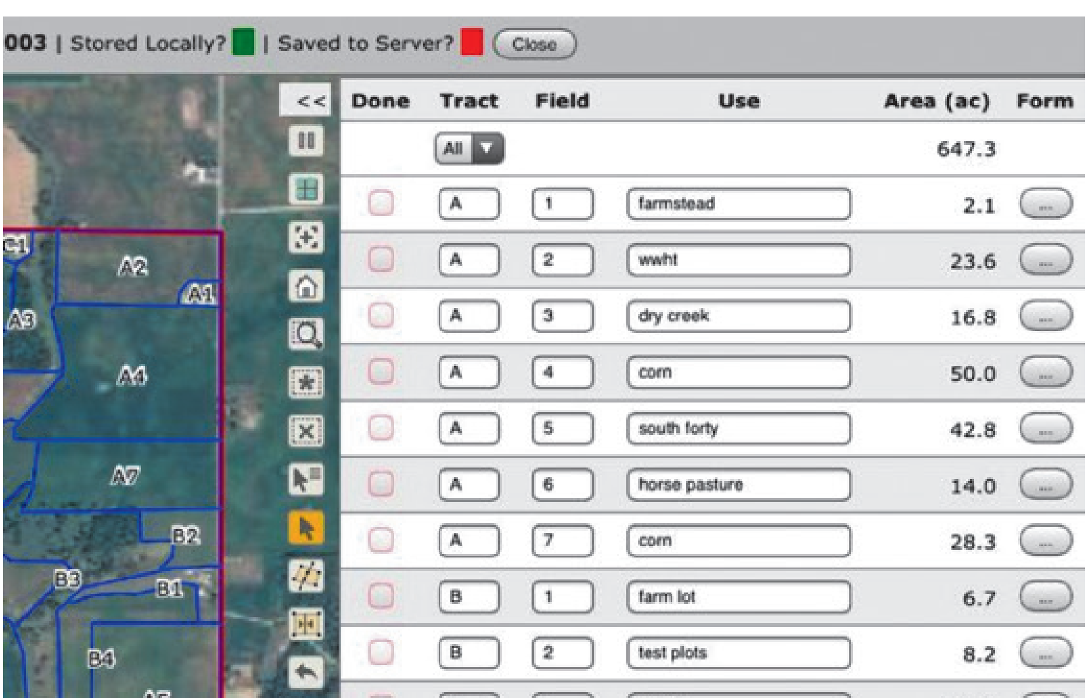
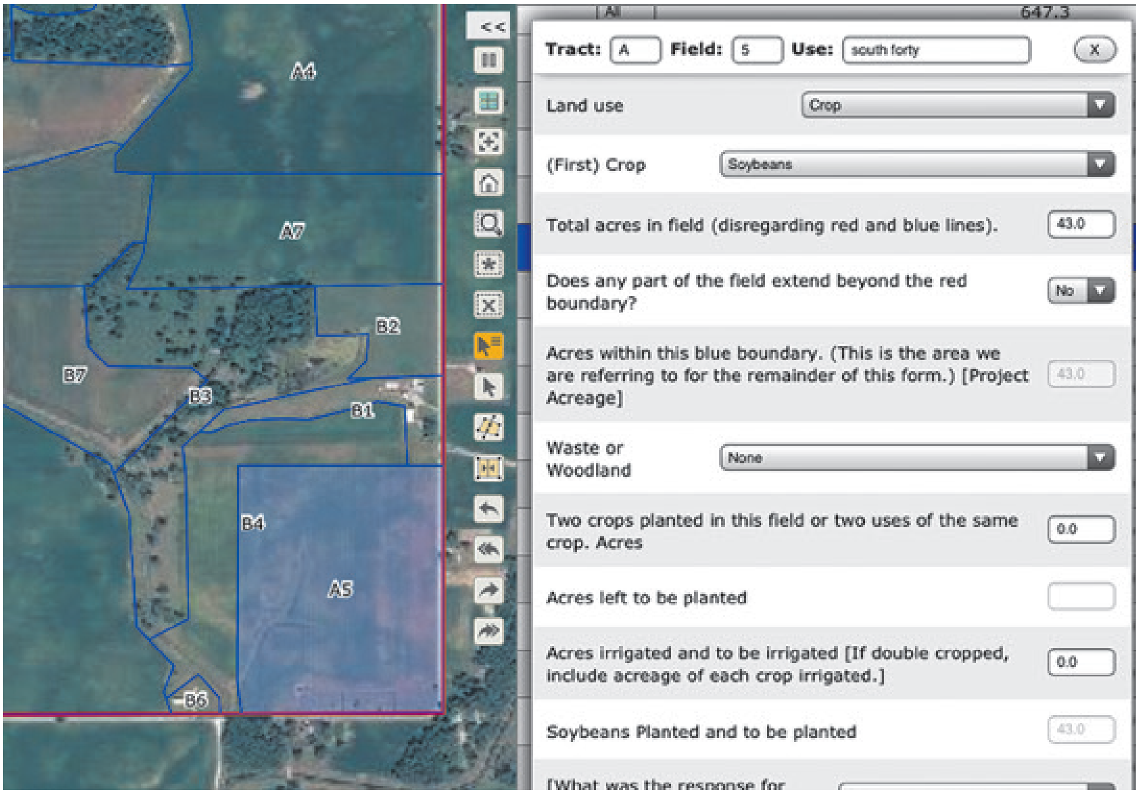


Figure 6: Screen shot of JAS GIRAFFE with field data form shown.



4. Training using iPads

In preparation for the initial testing of the GIRAFFE to collect data, training sessions for the interviewers were conducted. This training consisted of traditional in person training workshops with lectures and hands on practice. iPads also open up the possibility of replacing traditional printed interviewer manuals with e-manuals. Currently, interviewers are provided with paper training materials. Interviewer manuals are also available as PDF files, although these use a standard 8 by 11 inch page format. NASS is also experimenting with developing e-book formats for the interviewer manuals, which could be displayed on the iPads. These would have the added advantages over the current hard copy or PDF files that they would display appropriately for the iPad, they could include dictionaries or embedded links to other information, and the features of typical e-books such as bookmarking, annotation, etc. would also be available.

In addition to the traditional classroom training, training videos were developed to allow interviewers to independently review how to use the GIRAFFE application and its features. The videos were also used to allow interviewers to practice with the application on their own. An inexpensive video camera was used to record project staff demonstrating various features of the application, and some practice exercises. These were edited using Windows Movie Maker. The video clips were loaded to an interviewer training website and interviewers could use the iPad browser to access this site directly. This allowed interviewers to review the training as much as they liked, pause and replay any sections, and access it at their convenience. Videos of practice exercises were also provided.

The use of videos for training was well received by the NASS interviewers. While providing information on the GIRAFFE application, it also showed the interviewers exactly how the application would appear and behave. Interviewers who were unable to attend the initial training, (for example, newly hired interviewers) could also use these training videos. Use of the training videos had a number of benefits. First it guaranteed that the training was complete, accurate and consistent for all interviewers. It also allowed interviewers to view the material as many times as they wanted, whenever they wanted, pausing and rewinding to review any portions they wished.

It also saved costs normally used to print and mail hard copy training materials. If changes were made to the application, videos could be added or modified quickly and easily.

5. Conclusion

NASS is developing and testing the use of a GIS application to complement the current use of iPads for CAPI interviewing. Use of iPads to collect data for an area frame based survey is novel but has the potential to improve data collection substantially. As with any move from hard copy paper based data collection to electronic data collection, there are potential reductions in costs for printing and mailing photos and questionnaires. Moving survey materials electronically also speeds up the time it takes to distribute data and get the data back from the field. This means that data collection windows can be lengthened.

For the JAS there are additional benefits to using the GIRAFFE instrument. Segments on the photo can be drawn off more precisely if interviewers are able to zoom the image to sizes larger than the traditional photo. In addition, the use of a segment splitting approach, rather than simply drawing around each field, guarantees that all land in the segment will be accounted for. The GIS calculation of acres should be at least as or more accurate than farmer reports. In particular, this may be the only way to obtain accurate acreage estimates for fields that fall only partially within the segment.

However, there are still hurdles to overcome. NASS interviewers have long used aerial photos and grease pencils to draw fields in segments for the JAS. They are experienced and comfortable with these existing procedures. Using an iPad certainly requires additional training and technical expertise. During the development of the GIRAFFE application, significant resources went into developing training materials and working with a pilot group of interviewers. On line training videos viewable on the iPads themselves were a key piece of the training.

As with any technology, there are also potential technical problems, the extent of which we hope to discover in our development and testing. Some potential problems include problems with visibility of the iPad screens in bright outdoor conditions (which are likely to occur for interviewers who may be literally "in the field" in the JAS.) In addition, the NAIP imagery must be obtained from its host computer servers. If these are unavailable for any reason, interviewers will not have access to the photos. Pre-caching them on the iPads may mitigate this, but it is unknown if this may be a potential problem. And of course, the typical technology problems are always a potential issue – will hardware and software work reliably? Will batteries hold power long enough? Will interviewers be able to use them correctly? What other "glitches" will be discovered?

NASS will continue to develop and test the GIRAFFE application to identify both the benefits and any potential problems. But it appears to be a novel addition to the CAPI data collection that should bring substantial benefits to both the data collected and to NASS.

6. References

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Geospatial Data Collection in the US National Resources Inventory

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Abstract

Because agricultural and natural resource surveys are inextricably linked to the land, they generally require they maps, imagery and other forms of geospatial information throughout the survey process. Geospatial data are most effectively leveraged via computer tools and survey software because it is easier to integrate and summarize information in relation to the land. Although it may seem simple to integrate digital geospatial information into the survey process, there are many challenges in designing software and survey methods. Focusing on data collection, we illustrate some of these issues with examples from the US National Resources Inventory (NRI) survey program. NRI surveys monitor conditions and trends in natural resources on US non-federal land, particularly as it relates to agriculture. The main NRI survey involves remote sensing of low-altitude aerial imagery and other spatial resources. These layers are displayed in a geospatial survey instrument, and feature boundaries are delineated in area segments by data collectors. We discuss how the interface reduces burden and increases the efficiency of geographic data collection. In addition, we focus on challenges that occur in detecting and delineating changes on the landscape.

Keywords: computer-assisted data collection; natural resource survey; landscape monitoring.

1. Introduction

Agricultural and natural resource surveys are inextricably linked to the land. Because of this, data collection nearly always involves some form of geospatial information resources (Nusser and House 2009). Maps, imagery and other forms of geospatial data may be used for navigating to the sample unit, identifying the location of sample or observation unit, collecting data about land features, as auxiliary spatial data supporting data collection. Geospatial data are especially useful when offered in digital form, with software tools to overlay related maps and images, calculate numeric summaries of features that have been delineated on the land, and denote a person's current location on a map via a global positioning system (GPS) icon (Nusser 2007).

Developing methodologies that exploit spatial data while minimizing survey error can be challenging. In this paper, we outline some methodological considerations for using geospatial data to reduce survey error and improve field efficiency. We then illustrate approaches to using digital geospatial data with survey software with examples from the National Resources Inventory (NRI), a US Department of Agriculture survey program that monitors conditions and trends for natural resources on US lands. The NRI makes extensive use of digital geospatial information and tools in its survey process for both remote sensing and field-based surveys.

2. Methodological considerations

Although it may seem simple to integrate digital geospatial information into the survey process, there are many challenges in designing software and survey methods. Ideally, methodologies for using geospatial data and tools should provide effective support for the survey process while minimizing survey errors.

Off-the-shelf GIS software and standard survey methodological approaches often do not address the need to support efficient operations that minimize survey errors. For example, standard approaches to administering questionnaires, such as controlled linear flow of the interview process, do not work well for collecting data on geographic features (e.g., boundaries). Geospatial data are typically represented as two dimensional surfaces or objects on the land. This format inherently complex and requires a more ad hoc interactive style in implementing protocols.

At the same time, some control of the process is useful, and often only a few spatial data functions are needed to complete a survey protocol. Although it is tempting to use a commercial geographic information system (GIS) to support spatial data viewing and manipulation, an off-the-shelf solution has several limitations. GIS packages are generally developed for single instance applications (e.g., create a map, fit a surface), and not for repeatedly and consistently applying the same data collection protocol. One consequence of this is that it can be difficult to invoke some gross-level procedural control (e.g., to require

a data collector to delineate water bodies before delineating roads). In addition, survey protocols generally require a small subset of the functions provided by GIS packages, and thus offer an overly complex interface relative to data collection needs.

Using commercial GIS is especially problematic for enumerators. There is considerable natural variation in the ability of individuals to process and extract information from maps or imagery. Even though mapping tools are now commonly available in mobile devices and computers, variation in the ability of field staff to utilize geospatial information and software can affect field efficiency, protocol accuracy, and the consistency with which protocols are implemented (Batinov et al. 2011, Murphy and Nusser 2003, Whitney et al. 2010, Whitney et al. 2011). In surveys that involve household or farm interviewers who are hired for their interviewing skills rather than their ability to interpret spatial information, it may be useful to explicitly consider map display designs that minimize confusion for those who have more difficulty processing visual spatial information.

Surveys that involve repeated visits and/or link multiple sources of spatial information are also subject to linkage and location errors that can ultimately induce measurement error. Geospatial data are expressed in a variety of formats, and integrating two data layers requires careful consideration of the coordinate system and projection specification for each data source to ensure the linkage is sound. The resolution of materials can also create difficulties, particularly at boundaries of two land types or when smaller features are important. A special problem arises in surveys aimed at quantifying change over time. Two images obtained for the same area of land in the same format will not align perfectly because of differences in the camera position or sensor. In this setting, relocating a sample unit can involve more than overlaying the sample unit boundaries on the image.

For surveys that require a small number of tools to accomplish tasks with digital spatial information, it's useful to consider an alternative approach. There are many choices to make in designing methodologies for using geospatial information in the survey process. We illustrate some examples from the National Resources Inventory.

3. The National Resources Inventory (NRI)

The National Resources Inventory (NRI) is a survey program that monitors conditions and trends in natural resources on US non-federal land, particularly as it relates to agriculture (Nusser and Goebel 1997). It is conducted by the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) in cooperation with Iowa State University. The NRI survey program consists of a large annual remote sensing survey and several smaller annual on-site surveys that focus on specific resource concerns (currently, grazingland and cropland). Because NRI is a land-based survey, the survey relies on geospatial information resources and technologies in sampling, data collection, and weighting. One area that has become increasingly sophisticated is the data collection tools for collecting spatial data. This section provides background information to assist in understanding the examples presented in subsequent sections.

The main NRI survey is conducted annually on a stratified random sample of 75,000 area segments distributed throughout the US. Area segments are typically 0.8 km x 0.8 km. In a second stage of sampling, three points are randomly selected within each segment in a manner that encourages geographic spread within the segment. The primary purpose of the survey is to detect changes on the land. The 75,000 segments consist of a core and a supplemental panel that are selected from the 1997 NRI sample of roughly 300,000 segments. The core sample represents about 40,000 area segments and is observed each year. The annual supplement consists of about 30,000 segments from the 1997 NRI non-core segments, which are observed less frequently.

For the main NRI survey, data collectors use specialized survey software that displays high-resolution low-altitude aerial imagery as the basis for collecting data. Also available in the software are auxiliary spatial resources such as topographic maps, national water and wetland layers, soils maps, and spatially-linked administrative data on crops grown in fields. Using available resources and the current year imagery as a backdrop, data collectors delineate the boundaries of water bodies and streams/rivers, roads and urban tracts within the segment boundaries, and mark individual dwellings that are not part of urban tracts. Most of the analysis data are land classifications collected at the sample points within a segment. Data collectors record the land cover/use at the point, and depending on the type of cover, record additional information such as the presence of a wetland or livestock grazing, conservation practices and resource concerns, factors related to soil erosion, and so on. Some of these items are photo-interpreted,

while other items are sent to state staff to record data that is contained in program files.

Geospatial data are also used in field surveys. Onsite surveys for grazingland are conducted on a small subsample of grazingland points from the main survey, which are field visited by grazingland specialists. The specialists use ruggedized handheld computers with GPS to navigate reach the vicinity of the point location, and then use photographs and data to identify the location on the ground. Field data on health and plant community characteristics are recorded at each point.

Onsite surveys for cropland are conducted in collaboration with the USDA National Agricultural Statistics Service (NASS). NASS enumerators conduct interviews with producers for a randomly selected set of agricultural fields. They are given aerial imagery with the target field denoted with a symbol to assist in identifying the operator. Once the producer is identified, they document the current boundaries of the field on an iPad geosurvey instrument, and proceed with the interview.

4. Locating the sample or observation unit

Locating a sample segment boundary or point coordinate for the first time in land-based surveys is reasonably straightforward, assuming the format for the locations and other supporting data layers are correctly specified. It is more difficult to return to the unit in some form, either as a repeated observation on a new image taken at a later date or as a field visit to collect different information. In fact, properly relocating the area on the ground covered by a sample unit is the most critical step in minimizing measurement error in a monitoring survey.

In NRI's remote sensing survey, repeated observations involve identifying the sample unit's location on a new image. The protocol calls for identifying the segment and point locations on the ground that represent where the data were observed in the prior survey. Because the historical and current image will not have precisely the same coordinate system, one cannot simply overlay the point location on to the new image. Figure 1 illustrates the naïve placement of a segment on two different images photographed in different years using a simple overlay. Between Time 1 and Time 2, some of the farmland in the Time 1 image has been lost to urban development, which is visible in the Time 2 image. Although the images appear to cover a comparable area, there is sufficient difference in the image coordinate systems to yield a problem in detecting change within the area segment. The yellow circle in Figure 1 highlights a region of the segment that does not cover the same physical area on the ground in the two images. The left boundary of the segment at Time 1 extends to cover more surface area to the left of the curve in the road than represented by the segment boundary overlaid on the Time 2 photograph. Without further correction to properly place the segment boundary so that it covers the same ground area for the two images, the change measurement will underestimate the amount of farmland lost to urban development between Time 1 and Time 2.

The potential for location error can be mitigated by registering the initial and subsequent images to a common coordinate base. In NRI, the common base is an orthorectified image. Orthorectification is a process removes distortion in imagery due to topography, lens distortion and camera tilt. The resulting image represents an accurate projection of an image onto the earth's surface. Figure 2 shows an image before and after the orthorectification process has occurred. If done properly, orthorectification will mitigate the kinds of problems observed in Figure 1, allowing comparable area measurements to be made at different time points.

Figure 1: Locating the boundary of a sample unit on images photographed a few years apart (images are registered to a common coordinate system, but not orthorectified).

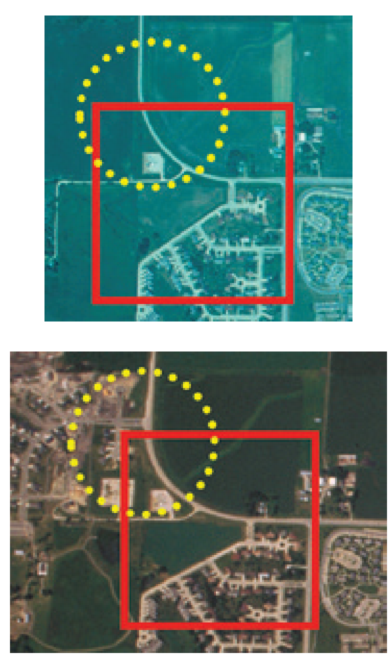
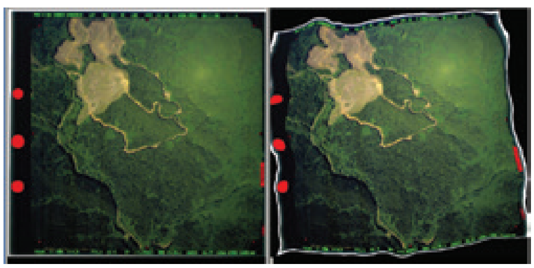


Figure 2: An image that has been registered to a coordinate system (left) and the same image after it has been orthorectified (right), correcting distortions in the image acquisition process.



An analogous problem arises in field surveys conducted to obtain more detailed ground measurements. In this case, the error is introduced in using GPS to navigate to the sample point. The accuracy of a GPS signal depends on available satellites and their configuration, external barriers for signal transmission (e.g., trees or buildings), and the quality of the GPS unit. Even though NRI uses ruggedized devices with a high level of accuracy, it is not possible to relocate the point using only GPS coordinates. It is important to have the aerial image used to collect NRI data and information on the expected land cover/use at the point. As a result, data collectors are instructed to use the point coordinate and GPS only to get to the vicinity of the point. The actual location on the ground is identified by comparing the ground conditions to the aerial photograph with segment and point locations displayed.

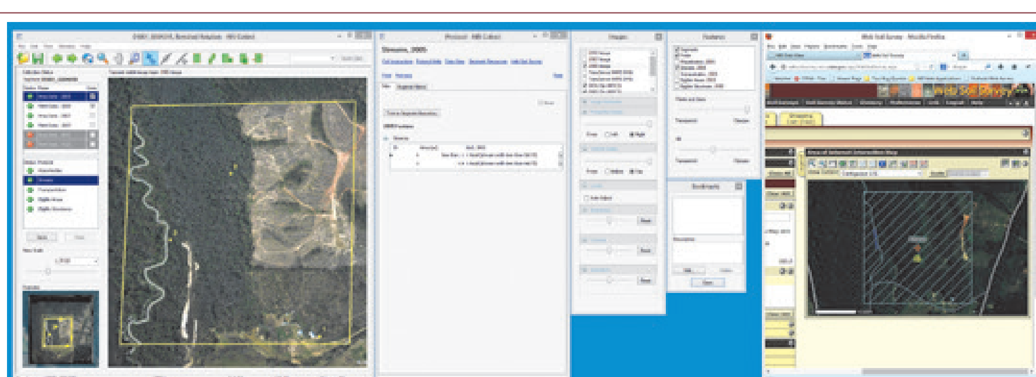
5. Collecting geospatial data

Collecting geospatial data objects that meet survey definitions can be challenging. Feature boundaries can be difficult to discern and thus a source of measurement error. Comparing multiple sources of information to decide on the characteristics of a feature can be confusing, even when registered to the same coordinate system. When monitoring is involved, a reliable method for capture change is needed. Post-data collection processing of the geometric shapes collected is also required to obtain variables for the survey database, such as area or length measurements for features or classifications at a sample point.

NRI has developed custom software to display geospatial information resources and to support flow control, data capture and post-data collection processing. Figure 3 depicts elements of the software designed to elucidate spatial context, geometric data collection protocols and tools, forms for entering data about features, and access to auxiliary resources. The left half of the figure has the main data collection interface and tools, while the right half offers additional tools for modifying the imagery displayed in the main interface and a web interface for auxiliary resources used in data collection.

Orthorectified imagery and supporting layers are displayed in the center of the main window. Geospatial data to be collected in this window

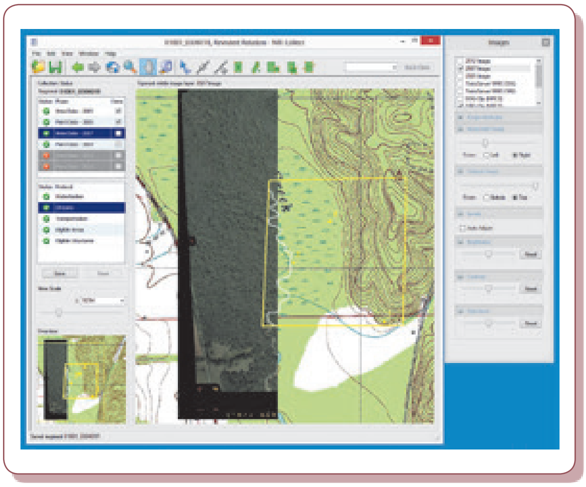
Figure 3: Custom software for implementing protocols, collecting geospatial and tabular data, and accessing resources. From left to right, resources include main geospatial data collection interface (left), tabular data collection form for recording characteristics of geospatial data objects (upper center), imagery and auxiliary layer control panel (upper right) and web access to instructions and other resources (lower right).



include transportation (roads, railways), developed land (housing units, developed areas), and large water bodies and river. The survey process begins by reviewing data from the prior survey year before delineating changes on the land that are detected by comparing past and current year imagery.

It is often useful to review imagery from different survey years in determining whether change has occurred. The tall rectangular interface to the right of the main window allows the user to select one or more resources to be displayed in the window. Below the list of resources, the user can use tools to manipulate the appearance of an image to enhance the visibility of features. A very useful tool in detecting change is to "swipe" two images, which incrementally adds the image below the currently displayed image (Figure 4). The user can also choose to display delineations for one or more feature types in the next window to the right to assist in implementing a protocol.

Figure 4: Example of an image swipe, where the aerial photograph is being added to the topographic may display from left to right as the user moves the swipe tool from left to right.



The flow of data collection is controlled for sets of protocols called "phases" (e.g., review prior year area data before collecting current year change data, collect area data before point classifications can be recorded), but not for specific data elements to be collected within a phase (e.g., changes in roads can be delineated before or after waterway changes are delineated). This ensures that the broad outline of the data collection process is followed, but allows the user to engage in a nonlinear process as s/he examines the resources and collects specific data elements during a protocol phase. Flow control logic is executed via a list of the survey phases (to the left of the image display area), which prevent moving to a new phase if prior phases have not be successfully completed.

The user begins by examining the image time sequence and other auxiliary resources. Tools for image display are available in the bar near the top of the main window. Image view tools include tools to return to most recent view, to return to the original view displayed upon opening up the segment, standard pan and zoom tools, and a measurement tool to decide whether a feature meets a dimension requirement for eligibility. It's easy for users to get lost in an image while zoomed in to examine ground detail. To mitigate this issue, a spatial context window is presented in the lower left, which allows the user to see the image display area in the larger landscape.

After reviewing the available spatial resources, the data collector is ready to digitize and collect attributes for features. An additional set of tools is offered that include creating a new polygon, delineating a linear feature with width, depicting gain in a feature present in the prior year, depicting loss of area associated with a prior year feature, and splitting a feature.

The area loss and area gain tools reflect the mode of change measurement required by survey protocols. As a monitoring survey, NRI is primarily interested in changes from survey to survey, and this is measured through change polygons. Figure 5 displays an example of a segment that has both an increase in XX and a decrease in XX. The prior polygon is highlighted in tan. Areas of gain for a feature type are shaded green with plus (+) symbols. Loss polygons are shaded red with minus (–) symbols.

Note that the interface is entirely tailored to the survey process and towards enhancing the usability of the interface for data collection, while at the same time simplifying the display to reduce user burden and confusions.

Figure 5: Examples of digitized change areas. Gains depicted as green with plus signs; losses depicted as red with minus signs.

6. Conclusion

NRI survey program has harnessed geospatial data tools to transform a manual, paper-based process into an entirely digital process. The Collect software discussed in Section 5 is one component of a larger system that supports distributed digital data collection and review, and that tracts the status of each sample segment and each data collector's work. The move towards digital processes and tools has increased overall efficiency, and also reduced measurement error associated with positional error from the manual processes and with feature delineation difficulties in using static paper materials.

The NRI program has been able to leverage this design in the iPad environment for joint work with the USDA National Agricultural Statistics Service (NRI). The basic NRI infrastructure design was used in combination with open-source libraries to develop an interface that is usable by NASS enumerators (discussed in another talk in this session).

An important strategy in maintaining such systems is ongoing development and improvement of the software and tools. Feedback from users has helped improve usability and clarity of the interface, and has led to new tools that reduced the workload of data collectors. Further, ongoing development allows testing and integration of technologies as they evolve.

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2012 National Agricultural Survey

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Abstract

In Mexico, by law, the censuses are conducted by the National Institute of Statistics and Geography. The population, economic and agricultural censuses are periodically carried out. The population and economic censuses are performed every 5 years and the agricultural census every 10, since the year 1930 when the first was done. However, after the 1991 Agricultural Census, the periodicity was lost due to budgetary issues; therefore it was not until 2007 that the next one was carried out.

To date it is unknown when the next Agricultural Census will be performed, and what´s more, INEGI does not have a continuous survey system for the agricultural sector that meets the great demand of information that exists in the country, opposite to what is done with the rest of the economic sectors, for which INEGI produces monthly and yearly information based on a survey system.

Conscientious of the scarcity of agricultural information, INEGI is making an effort to provide statistical information that supports decision-making. The Institute is working within the Global Strategy for Improving Agricultural and Rural Statistics, promoted by the Food and Agriculture Organization of the United Nations (FAO). On this path, INEGI started designing an Agricultural Information System, integrated by the agricultural census and surveys, as well as by images of the national territory, Geo-statistical Frame, list of producers and data from administrative registers. This project is worked on together with the Ministry of Agriculture, counting on the support of some experts from FAO.

In this context, INEGI designed the first National Agricultural Survey, taking the 2007 Agricultural Census as the frame. Its objective was to obtain updated statistical data on the 33 most important agricultural products in Mexico, which were selected according to their contribution to the sectorial Gross Domestic Product (GDP), as well as by national and international recommendations. The survey has a stratified sampling design and the size of the sample is of 97 442 production units. The field work was performed in the entire country from October 22 to December 14, 2012.

One of the main strengths of this survey was the use of mobile computer devices (tablets). The digitalized cartography, the satellite images as well as the questionnaire were loaded in these devices. Data collecting was carried out by a face to face interview with the producer, followed by a specific procedure that was specially designed for the survey.

The use of this type of technology has been an important experience, and for the process represents key learning. This survey is expected to be the beginning of a Mexican continuous survey system, as part of our Agricultural Information System.

Keywords: mobile computer devices; continuous survey system; agricultural information.

1. Introduction

The National Institute of Statistics and Geography (INEGI) has gone through a relevant experience when incorporating technology into the processes of producing statistical and geographical information. The great challenge for the Institute, in this sense, is to create systems that enhance the statistical information collecting methods, and way guide the interviewer in a friendly way through the steps to follow to do this task, besides contributing in reducing the standardization process time, the validation, the data analysis and the publication of the results.

INEGI has 9 years of experience in the use of mobile electronic devices (DEM) for data collecting. In 2004, the collection of the Economic Census data in Mexico was harnessed to perform a test with these devices, called Personal Digital Assistant (PDA English acronym), to capture information in 10% of the small and medium economic establishments.

In the period 2005-2007, different tests were made on data collecting and operation monitoring processes in PDA, to guarantee an optimum collection that was controlled and with higher quality than the one performed until then. So, three years after the 2004 Economic Census, the Institute decided that all the interviews to collect the information directly from the farmer for the VIII 2007 Agricultural, Livestock and Forestry Census, were to be done with PDA, this marked a historical precedent, since

mobile devices to capture census information were then used massively for the first time in Mexico.

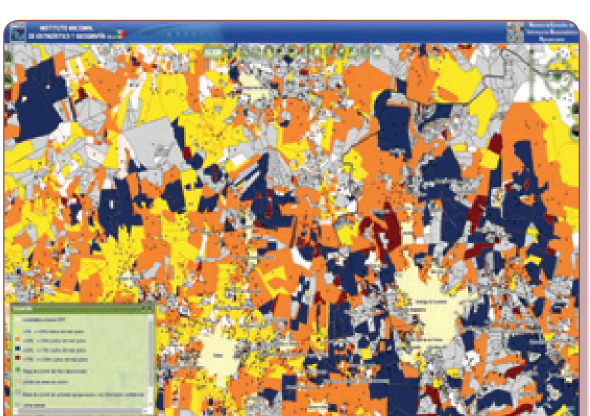
After the 2007 Agricultural Census, INEGI used the PDA in the 2009 Economic Censuses again, but in this occasion, it was used to capture data from 100% of the small and medium establishments, thus reducing time and enhancing the quality of the information.

2. Technological Innovations for data collecting

With the experience in the use of PDAs and the harnessing of technological advances in terms of geographical information systems, the Institute sought for the data capturing projects to include digital cartography for the planning stages, execution, operational monitoring and the presentation of results. That is why as of 2010, tests are run to collect information with electronic devices such as tablets:

- In terms of planning, the generation and distribution of the workloads were evaluated.
- In the stage of execution, a comprehensive capturing system with three components was tested: questionnaire, catalogs and cartographic material.
- As for operational monitoring, the linkage of various systems allowed registering the progress as interviews were concluded, assigning field codes to each interview and questionnaire.
- Regarding the presentation of results, the use of the tablet allowed the farm´s data to be associated to the exact physical space where the activity develops at the moment of the interview, so Geographical Consultation Systems can be created from the results obtained.

Figure 1: Agricultural Geo-statistical Information Query System (SCIGA).



The goal was mainly to increase the quality of the data that was collected on field, above all in the production unit´s total area variable, considered the most important and basic variable, whose capturing until that moment was based on drawing the shape of the agricultural land plots and noting the area stated by the farmers, and subsequently digitizing the vertices of the land plots in a geographical information system with satellite images.

As a consequence of that way of obtaining this variable, the farmer could provide unreal data on the area: the producers of the small farms tended to state more area than they really had, and the opposite happened with the large farms that stated less, affecting good part of the variables from the questionnaire, as the planted, harvested area, with irrigation availability, as well as crop yields, among others; instead, with this new way, we ensure that the data reported by the producers improves, since some of their answers are being validated during the interview, they tend to respond more faithfully, so that increases the quality of the collected information; for example, in the 2012 ENA the difference between the reported area and the cartographic area of the production units was reduced to practically zero. From the expectations and projected scopes, the features of the electronic device that would be used in the 2012 National Agricultural Survey (ENA) were determined. The characteristics were:

Figure 2: Electronic Device tablet type.

Processor	Intel N2600 1.6Ghz 512K L2
Ram	2 GB
Hard disk	64 GB
Screen	Touchscreen of 10.1" with 1024x1600 resolution
Battery	6 cells 10.8V
Operational system	Windows 7 Home Premium in Spanish
Maximum weight	3.5 pnds. (1.6 kg)

For this survey INEGI acquired 814 tablets with which 97,442 interviews were applied. The equipment continues to be used in different capturing projects performed by INEGI.

Tablet´s capturing system

The tablet used in the 2012 ENA operated through data capturing system based on three basic components:

- **The operational routine:** the part of the system that contains a series of questions and instructions which provide the order of development of the interview with the farmers.
- **The cartographic module:** the geographic part of the system that has the digital cartographic elements to create or update, directly with the farmer, the land plot vector files and capture elemental data of plots and farmers.
- **The electronic questionnaire:** the system´s third component which allows capturing the information on the features and the way of managing the farms.

For the correct functioning of each of the components, a series of inputs were used and these were integrated by the following:

- **The workload for each interviewer**, formed by a directory of farmers with names and addresses.
- **The digital cartography**, that included satellite images, vector files with the delimitation of each land and geographical information layers that allowed locating and identifying the farmer´s lands more easily.
- Catalogs through which it was possible to assign homogenous codes to crops and livestock species, as well as to the land area. Through these catalogs it was possible to standardize all the products and areas in units of the decimal metric system.

Operational Routine

The operational routine is the part of the system that contains the questions and indications that the interviewer must follow to define the characteristics that each producer has and determine the type of questionnaire that will be applied; also, it is the link between the cartographic module and the questionnaire. The data on names and addresses is updated in the operational routine, all the producer´s plots are updated in the cartographic module, and once they are all updated the module is closed and the operational routine is reestablished, in which the production unit is automatically integrated, this is the basis to go to the next system´s component which is the electronic questionnaire.
To perform the interviews, the initial activity consists on locating the farmer in the address registered in the directory; then, it is sought to find out if the person is still a farmer, identifying the main activity performed and the interviewer continues capturing or updating socio-demographic data. Data capturing in the system starts from the first contact with the

Figure 3: Electronic Device tablet type.

farmer, who is asked the questions contained in the operational routine, with which the operational controls are being established, allowing the interview to be guided according to the features of each farm.

The operational routine is the part of the system that allows the interviewer to navigate to characterize each farmer and determine the type of questionnaire that will be applied, besides being the link between the cartographic module and the questionnaire.

Cartographic Module

Once the farmer registered in the directory is identified, each of his/her lands are verified. For this, the system displays the cartographic module on the screen, through which the farmer with the support of the interviewer and based on the cartographic information included in the tablet, identifies and locates each of the land plots under his/her responsibility.

In particular, it is worth highlighting that the cartographic module operates as a Geographical Information System´s tool, since it displays the satellite image on screen that can be zoomed in or out according to the needs, and different layers of information can be overlapped, such as the land layers that were produced in the 2007 Census, with its corresponding geo-statistical information, the size and the producer´s general data, making their location easy when performing an operation like the 2012 ENA.

The cartographic module also has an option for creating land polygons, so that when a farmer´s plot is not displayed on the shape file, the interviewer marks the vertices based on the physical features of the image and on the indications that the producer gives on the location of each vertex.

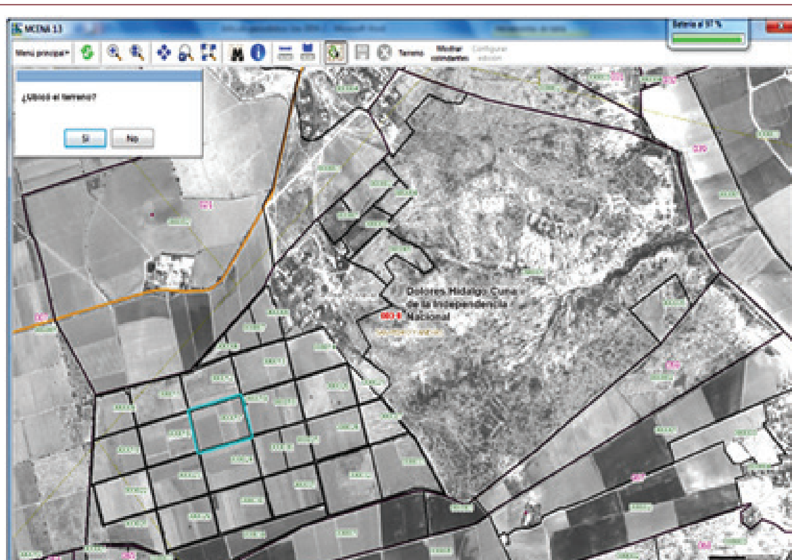
In the case of the area, the cartographic module generates the data on the size of the plot and the system compares it with the producer´s answer; in case the result of the comparison comes out of the difference range permitted (established in advance), the system displays a warning indicating the pollster to confirm the answer.

One of the main concerns was that the producers could discard the area data "calculated" by the system when it was very different to the one they reported, or even affect the producer´s willingness to continue answering ENA´s questions. However it was not the case: the data yielded by the system was well accepted and in general the producers corrected their answers after seeing their plot displayed on the tablet and the measurement done by the system. In some cases this led to thinking if the plot limits that the producer had initially pointed out were the correct ones or not, and even check if the plot´s they had reported were theirs or not, or if there had been an error.

Electronic Questionnaire

Once the verification of all the producer´s plots is done, the system automatically integrates the production unit and displays the electronic questionnaire to

Figure 4: Cartographic Module displayed on the tablet.



continue with the interview. This format facilitates several processes that in a printed questionnaire would not be so simple, for example, while answering the questionnaire, the system performs the codification of crops and livestock species based on preloaded catalogs, the system also has some internal validation processes incorporated, in which among other data, the production unit´s total area consistency is validated regarding the breakdown on the use of land, the consistency between the total of each livestock species regarding its breakdown by age or zoo-technical function.

When completing the questionnaire, the system generates a report with the detected inconsistencies and the interviewer can check each of these with the producer.

Personnel training and characteristics

The use of the tablet requires training where the instructor teaches the interviewers the instrument´s functioning and handling, prioritizing on the exercise through field practices, which will allow the development of skills and abilities needed to efficiently perform the assigned activities. Training must be centralized on aspects related to the knowledge of the capturing system´s components, combining the theory with the practice, in which the interviewer trains through the simulation of interviews; but the key is the field work experience directly with the farmers, since that is where real situations will be faced and that will allow the acquisition of confidence and security in the handling of the device.

Data collection through a device, tablet type, preferably requires hiring a group of interviewers integrated by personnel with experience in the handling of electronic devices. It has been proven that the people that are best qualified for handling these tablets are the young, whereas adults and mainly the elders have more difficulty handling a tablet, especially in rural areas where this type of technology is not very common.

Another important element when hiring pollsters is the academic profile, evidently those that have a professional or technical career related to the agricultural sector or earth science, quickly assimilate the transmitted knowledge, but also, the knowledge they have allows them to overcome any operational issue during the field work. However, in a massive event it is complicated to hire only personnel with that academic profile, so that is why in occasions others with the experience in events of the same nature are hired.

Figure 5: Field practice during training.

3. Results from the use of DEM in the 2012 ENA

The use of mobile electronic devices (DEM) in data collecting has great advantages over the traditional collecting method done by printed questionnaires. Some of those advantages are described below:

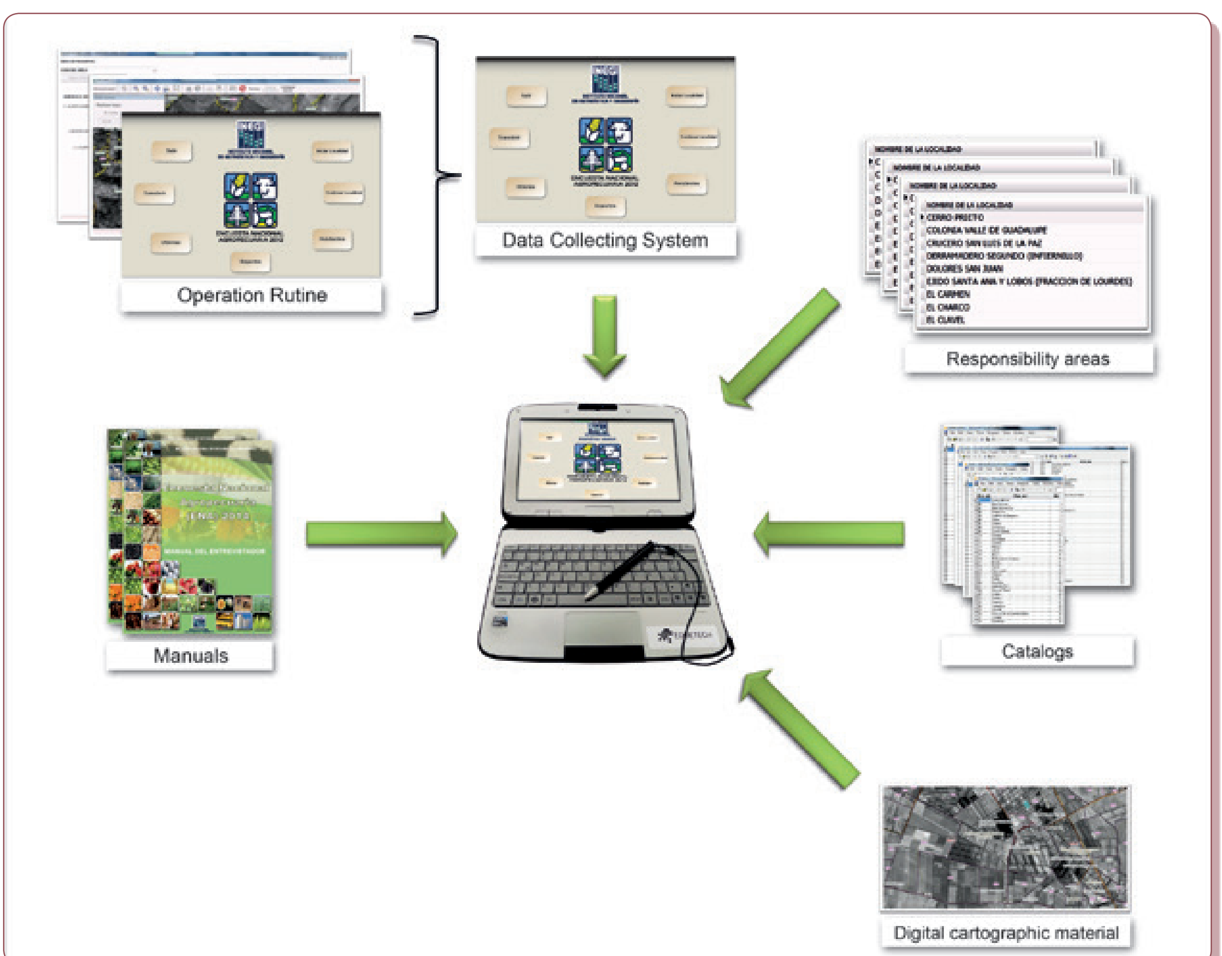
- Using the DEM allows validating the farm area stated by the farmer vs the cartographic data obtained when digitalizing the land plot vertices at the moment of the interview. Validating the production unit's area variables in real time during the interview allows substantially enhancing data quality, since the system applies maximum area parameters, and if these are surpassed by the size of any farm, the system immediately sends a message to confirm the data stated by the farmer. The use of DEM suppresses the use of questionnaires, cartography and printed control formats, which represent a significant savings of paper. For example, the printing of 103 thousand maps, 615 thousand manual pages, 159 thousand directory pages and 2.6 million questionnaire pages was cancelled.
- Each interviewer stopped carrying approximately 149 farmer directory pages, 61 plot list pages, 180 questionnaires and 135 maps.
- Makes it unnecessary to hire additional staff for capturing, coding and validating captured information, as well as the staff who would perform land digitalization. Altogether saved hiring 512 employees for three months.

- Enabled the execution of basic validation processes, codifying and standardizing the questionnaire´s variables during the interview.
- Streamlines the transfer of the data collected on field to the central data-base, through USB or internet.
- Agiliza la generación de reportes de control y avance operativo, debido a que la integración de la información captada en campo se realiza de manera automatizada.
- Increases the security of the captured information, since only authorized personnel can extract it from the device or transfer it to its final destination (national data-base).
- Guarantees the confidentiality and integrity of the information provided by the farmers, since the access to the systems is through personalized passwords.

In brief, the use of the DEM constitutes a great qualitative leap forward compared to the traditional way of capturing information, because it enables the combination of (and as mentioned before, with great operational and economical advantages, regarding the information´s security and processing, etc.) the questionnaire, the cartography, the geographical and operational catalogs in a single place, together with all the applications needed to guarantee that the statistical information is perfectly linked with the place where the economic activity takes place.

Now, given the advantages obtained when capturing information through electronic devices, INEGI has created a trend using these devices in its projects, for which, and as part of the Economic Censuses that will be conducted in 2014, is making the purchase of 17,667 DEMs, that will also be used this year for the 2013 School, Teachers and Students Census, and later for different surveys, as well as the Agricultural Census programmed for 2017.

Figure 6: Input loaded through the system on the tablet type device.



SPP 4
Crop and Yield Forecasting

Organizers: Naman Keita and Nancy Chin, FAO and Javier Gallego, EC/JRC

Chairs: Naman Keita, FAO and Javier Gallego, EC/JRC

Reliable data on expected food crop production is recognized as key factor for addressing effectively the growing food market volatility and its consequence on food security situation of populations, particularly in developing countries. This Session will discuss the extent to which, advances in Remote Sensing and use of geo-referencing and digital tools provide new opportunities for improved methodologies for producing timely and more accurate food crop production forecast. The focus of this session is on methodologies for accurate and cost-effective methods for improving forecasts of crop and yield, which remain a challenge in many developing countries. Of particular interest are submissions on methods and tools used for food crop production and yield forecast, in developing country context, particularly in presence of mixed crops, repeated cropping, and continuous cropping and for root crops. The emphasis will be on cost efficient data collection methods, based on new technologies such as remotely sensed data, GIS, digital technology.

Possible Topics for invited papers:

1. Overview of successful Crop Forecasting methods and their potential for developing countries;
2. Recent advances in the use of Remote Sensing and implication for crop forecasting particularly in developing countries;
3. Yield and production forecast in the context of mixed crops, repeated cropping, and continuous cropping and for root crops.

Papers:

- Jean Baptiste Habyarimana (Rwanda), "Crop Yield Estimation with Farmers' Appraisal on Weather Condition"
- U C Sud, Hukum Chandra (India), "On Precise Estimation of Crop Yield at Smaller Area Level by Integrating Agricultural Survey Data and Population Census Data Through Use of Spatial Models"
- Nansubuga Resty (Uganda), "Reliability of Rainfall for Crop Production – a case study in Uganda"
- Bettina Baruth (EC/JRC), "MCYFS - MARS Crop Yield Forecasting System, Crop Monitoring in Europe" *

*No abstract or paper have been submitted in relation to this presentation.

Crop Yield Estimation with Farmers' Appraisal on Weather Condition

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Abstract

Crop yield is mainly affected by weather condition, inputs, and agriculture policies. In the crop yield estimation, farmers' perception on weather conditions lead to the assessment of how well yield would be compared to the previous seasons. This paper applies Bayesian estimation method to estimate crop yield with farmers' appraisal on weather condition. The paper shows that crop yield estimation with farmers' appraisal on weather condition takes into account risk proportionally to climate change. In light of the United Nations efforts aimed to build a consolidated agriculture statistical system across countries, the statistical model developed here should provide an important tool both for the crop yield estimation and food price analysis.

Key words: crop yield estimation; farmers' appraisal on weather condition; crop growing condition; Bayesian estimation method.

1. Introduction

Land productivity is a vital factor in feeding the population. It is also a critical factor in the struggle of developing countries to improve the availability of food. In line with MDGs, developing countries have undertaken different measures to improve land productivity. Following all those policies the main challenge for agriculture statistician in many developing countries remains to be the development of statistical models that could provide reliable crop yield estimates with high exactitude to monitor and assess the progress of agricultural land productivity. This study undertakes this task to offer a method complementary to those available in the literature such as crop cutting and famers' estimate.

2. Literature Review

In most of the cases, yield forecasts are based on reports by crop correspondents at regular intervals during the growing season using crop appearance as an indicator. In this context, the most accurate method of estimation consists of crop cutting method" (G.R. Spinks).

Thus, crop condition data has the potential to provide a simple, regular source of information about the realized yield. In addition, weather affects crops differently during different stages of crop growth (Ranjana Agrawal, 2012).

To overlook the impact of weather condition on crops growing and yields, Stasny, Goel and other researchers at the Ohio State University developed a Bayesian mixed-effects county yield estimation algorithm with a spatial component involving correlations among neighboring counties (Michael E. Bellow, 2007). In addition to this, Bayesian probability approach of obtaining yield forecasting involves the collection of expert opinion data of farmers who are actually engaged in raising the crop regarding their assessments about the likely crop production (Chandrahas).

3. Estimation Method

Drawing on the crop yield forecasting and estimation literature, crop yield is a function of weather condition, inputs and agro-ecological conditions including weather, land and external input use. To cover the gap between crop yield and risk resulting from climate change, this paper models crop yield as a function of weather and crop growing conditions (appearance) subjected to farmers' information on weather.

3.1 Statistical Model

From a Bayesian standpoint, true model parameters were unknown and therefore considered to be random, and they were assigned a joint probability distribution. Prior distribution was used to summarize our state of knowledge, or what is currently known about the parameters. Once the data were observed, the evidence provided by the data was combined with the prior distribution using Bayes' Theorem. The result of combining prior information and empirical evidence was an updated posterior distribution for the parameters.

In this context, four piece of information was used "actual yield, yield targets, realized performance towards yields targets, and farmers' appraisal on weather condition". Those pieces of information were also used to estimate variance and covariance information on yield. In the empirical example for model illustration six crops were considered when trying to forecast yields.

In the first stage of parameter estimation, average yields "y_{fj}" was computed using actual yields of Maize,

Rice, Beans, Cassava, Irish Potatoes, and farmers' appraisal on weather conditions:

$$y_{fj} = \frac{\sum_{i=1}^{4} y_{ij}\omega_{ij}c_{ik}}{\sum_{i=1}^{4} \omega_{ij}c_{ik}}$$

Where $\omega_{ij} = y_{ij} * p_{ij}$ and $p_{ij} = \frac{y_{ij}}{\sum_{i=1}^{4} y_{ij}}$

Where y_{ij} = {1, 2, 3, 4 | yield values for four percentiles dividing actual yields into five equal groups} for crop j = Maize, Rice, Wheat, Beans, Cassava, and Irish Potatoes. Four scales weather conditions are denoted by k = Poor, Fair, Good, Very Good; and ω_{ij} = expected yield in each scale for crop "j". Weather conditions "$\mathbf{C_{ik}}$" are associated with actual yield y_{ij} by C_{ik} with {C_{ik} = {1=Poor, 2=Fair, 3=Good, 4=Very Good | i percentile is linked with its corresponding k weather condition}.

In the second stage, actual performance to reach yield targets for each crop "j" "$\mathbf{R_j}$" was computed using average yields "y_{fj}" and yield targets "y_{tj}":

$$R_j = \frac{y_{fj}}{y_{tj}}$$

In the third stage, average yields "y_{fj}", yield targets $\mathbf{Y_{tj}}$ and actual yield performance $\mathbf{R_j}$ and their associated reliabilities were used to estimate covariance and variance information on yields.

To develop Bayesian methods for generating yield estimates from readily available crop and weather conditions information; it was assumed that average yield are normally distributed "$d_1|x^1 \sim N_p(D_1x^1\ \Sigma_1)$" and that posterior distribution of yields is given by " $x^1|d_1 \sim N_n(\mu; V)$" where μ_{t+1} = Estimated average yield and V = Variance.

$\mu = (A\ HA^{+T})D^T{}_1\Sigma^{-1}d1)$ and
$V = A^+HA^{+T} - A^+HA^{+T}D^T{}_1\Sigma^{-1}D1A^+HA^{+T}$
$A^+ = A^T(AA^T)^{-1}$ "Moore-Penrose inverse"
and $\Sigma_0 = \Sigma_1 + D1A^+HA^{+T}D^T$.
(see Theorem 1 in Magnus, Tongeren and Vos (2000).

4.Case study development

Agriculture sector is predominant in Rwanda and the Government of Rwanda has invested a lot in agriculture sector by introducing new seed varieties, reinforcing the use of chemical fertilizers and pesticides, soil management and land rehabilitation, anti-erosion activities, farmers field school, etc.. But controversially, Rwanda experiences food prices fluctuation over time. Hence, as growing season forecasts of crop yields are of considerable interest to commodity market participants and price analysts, the main problematic issue remains to be the development of consistent method with compatible predicting statistical model able to make yield estimations with much higher precision to explain those controversial phenomena.

The yields data for empirical illustration used in this paper came from Crop Assessment Surveys.

This paper hypotheses that Bayesian estimation method that consider past information on crop yields, present farmers' knowledge on weather conditions and present agro-ecological information could provide a simpler and peerless complementary statistical model to estimate crop yield.

5.Results and Discussion

Farmers' problem is an optimization problem in which estimated yield should be close to forecasted yields as possible. The optimization problem shows that:

1. The expected yields are less than average of yields recorded in 22 past seasons.
2. Forecasted yields are less than the average of yields of two latest previous seasons.
3. Estimated yields are greater than average of yields recoded in 22 past seasons.
4. The final results show that the estimated crop yields tend to deviate from the forecasted crop yields by the mean of yields recorded in 22 past seasons.

5.1 Descriptive Statistics

Table 1 shows descriptive statistics "Mean yield (Kg/Ha), Standard deviation, Minimum and maximum yields (Kg/Ha) realized in 11 past years with 22 observations".

Table 1: Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
maize	22	1264	717	559	2820
wheat	22	1096	598	377	2208
rice	22	4020	1063	1890	5751
beans	22	837	190	500	1101
iris potato	22	8003	2241	5409	12605
cassava	22	9093	3135	5177	13974

Figure 1, shows the trends (2002 to 2012) of Maize, Wheat, Rice, Beans, Irish Potato and Cassava yields. Trends show an overtime increase of yields for all crops considered.

Figure 1: Trend of Crop Yield over last 11 Years.

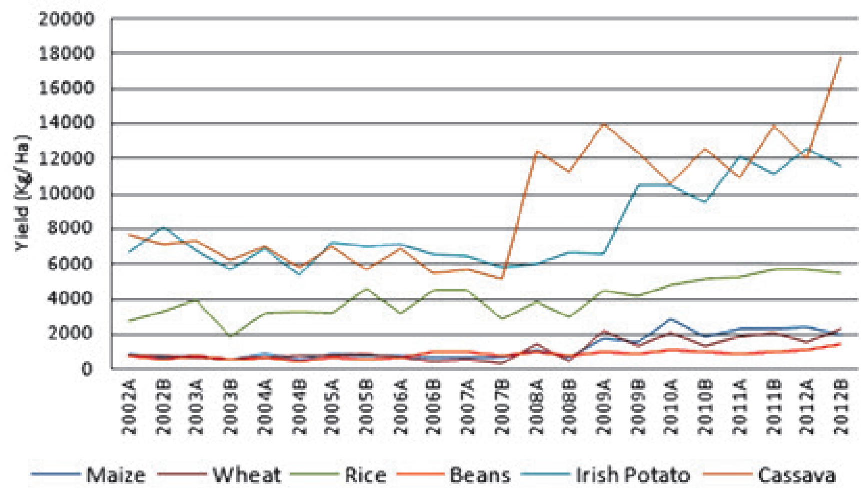

Table 2: Crop Yields Estimates.

	Maize	Wheat	Rice	Beans	Irish Potato	Cassava
Y_j = Actual Yields (2002 – 2012)	1,260	1,125	4,031	855	8,055	9,326
ω_j = Expected Yields	1,123	1,118	3,378	701	6,497	7,847
Y_{2012} = Actual Yields	2,186	1,916	5,597	1,265	12,115	14,934
Y_{tj} = Targeted Yields1	3,750	3,500	7,000	1,850	27,500	35,000
Y_{fj} = Forecasted Yields	1,459	1,440	3,980	829	7,809	9,417
Y_{ej} = Estimated Yields for 2013A	2,934	2,889	5,878	1,397	17,793	22,965

5.2. Crop Yield Estimates

The final results showed in table 2 revealed that when estimated yields for 2013 Agriculture year are compared to actual yields realized in 2012 Agriculture Season; yield (Kg/Ha) for Maize, Wheat, Rice, Irish Potato, and Cassava and Beans could increase if the weather condition does not change or change slightly as it was appraised by farmers.

Table 2 shows that expected yield are less than the mean of actual yields. The mean of actual yields are less than forecasted yields. Forecasted yield are less than estimated yields.

5.3. Assessment of the progress of agricultural land productivity

To assess the progress of land productivity to feed population and make available food at markets, performances were computed as the basis of crop yield monitoring. i) Performance with forecasted yields that combines past information, states what was the performance to reach targeted yields by the time of setting those targets; ii) Actual performance was computed referring to the average yields of the latest two agriculture seasons to state how far agriculture households were to reach targeted yields in 2012; iii) Performance with estimated yields was computed referring to the estimated yields and targeted yields to state how far agriculture households should be to reach targeted yields in 2013.

Performance ratios derived from the model formulated using prior information and empirical evidences could in meaningful way be used in land productivity and food market price analyses. Performance ratios could also describe the relationship between agriculture production on one hand and the effort made to improve land productivity such us introduction of new seeds varieties; use of fertilizers and pesticides; soil management and extension services on the other hand. The used model could play an important role when analyzing the impact of climate change on agriculture sector and the effort made to face the problem of climate change.

Table 3: Land productivity assessment.

	Maize	Wheat	Rice	Beans	Irish Potato	Cassava
$\mathbf{R_j}$ = Performance with Forecasted Yield	39%	41%	57%	45%	28%	27%
Actual Performance	67%	75%	71%	66%	64%	63%
Performance with Estimated Yield	78%	83%	84%	76%	65%	66%

6. Policy implication

The estimation model developed in this paper could help decision takers and policymakers: i) To monitor land productivity and yield targets; ii) To link crop yield and crop production; iii) To monitor food availability, food demand and market access when assessing food shortage and planning for food redistribution"; iv) To link weather condition a constraints to land productivity and food availability with meaningful early warnings to lower crop production risks and ensure public awareness and preparedness to act; v) To correlate food prices with agriculture production and climate change.

7. Concluding remarks

This paper develops predicting statistical model laying on Bayesian Method. The developed Statistical model for crop yield estimation could contribute to the development and credibility of agricultural statistics. This paper comes with new insights and paves the way for agricultural policy analysis by providing timely high precision, credible and compatible yield estimates that could lead to reliable crop production estimation. As crop yields have significant impact for both commodity prices and farmer income, growing season estimates of crop yields provided by this model could be of considerable utilization to price and food security analysts.

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Annexes

Methodology

To perform Bayesian Estimation Method for Crop yield forecasting, five matrixes d_{6x1} Matrix of Targeted yields, $[D_{6x12} = (I_{6x6}\ 0_{6x6})]$ Matrix for Crops to be used in yield forecasting, A_{12x12} Matrix of Actual level to reach targeted Yield "Y_{tj}", Variance Matrix (E_I), Covariance Matrix (H) were estimated and used in the Bayesian Estimation Model. The matrices dimensions follow the number of crop which we want to estimate their yield. In the empirical example for model illustration six crops were considered which yield estimates are needed for each and every crop (6+6=12). The full steps to estimates those matrices are illustrated bellow:

In the first stage of estimating parameters, Forecasted Average yield "y_{fj}" using actual yields for Maize, Rice, Beans, Cassava, Irish Potatoes, and Farmers Appraisal on weather condition was computed as follow:

$$y_{fj} = \frac{\sum_{i=1}^{4} y_{ij}\omega_{ij}c_{ik}}{\sum_{i=1}^{4} \omega_{ij}c_{ik}}$$

Where $\omega_{ij} = y_{ij} * p_{ij}$ with

$$p_{ij} = \frac{y_{ij}}{\sum_{i=1}^{4} y_{ij}}$$

Where y_i = {1, 2, 3, 4 |yield values for four percentiles dividing actual yields into five equal groups} for crop "j" with j = {Crops | Maize, Rice, Wheat, Beans, Cassava, and Irish Potatoes}, k = {Poor, Fair, Good, Very Good | C_k =Weather Condition}; and ω_{ij} = expected yield in each category for crop "j". Weather Conditions "$\mathbf{C_{ik}}$" are associated with Actual yield y_{ij} by C_{ik} with {C_{ik} = {1=Poor, 2=Fair, 3=Good, 4=Very Good | i percentile is linked with its corresponding k weather condition}.

In the second stage, actual performance to reach yield targets for each crop "j" "$\mathbf{R_j}$" is computed basing on y_{fj} = Forecasted Yield for Crop (j) and Y_{tj} = Yield Target for (j):

$$R_j = \frac{y_{fj}}{y_{tj}}$$

In the third stage, $\mathbf{Y_{fj}}$ and their associated reliabilities (in this paper reliability was assigned to be High Medium "HM = 3%" and Medium "M = 6%") were used to estimate Variance Matrix (E_l); while $\mathbf{Y_{tj}}$, $\mathbf{R_j}$, and their associated reliabilities were used to estimate Covariance Matrix (H). Matrix D was estimated using Identity Matrix (6x6) of 6 Six crops used in this paper and Zero Matrix (6x6) of forecasted Yield for six crop therefore $D_{6x12} = (I_{6x6}\, 0_{6x6})$, the column matrix ($d_{6x1}$) of Laboratory yield.

Assuming that "$d_l|x^l \sim N_p(D_l x^l\ \Sigma_l)$ where $D_{1,(p;n)}$ has full row-rank and Σ_l is positive definite (hence non-singular); (ii) $Ax^l \sim N_m(h;H)$ where $A = (A1 : A2)$, a column vector $h = (h1; h2)$; a block diagonal matrix $H = (H1;H2)$ with H_l associated with A_l and H_2 with A_2; (iii) A has full row- rank and H may be singular. Then the posterior distribution of x^l is given by $x^1|d_l \sim N_n(\mu; V)$" with: $A^+ = A^T (AA^T)^{-1}$
$\mu = (A^+HA^{+T})D^T{}_1\Sigma^{-1}d_1)$ and $V = A^+HA^{+T} - A^+HA^{+T}D^T{}_1\Sigma^{-1}D1A^+HA^{+T}$
Where $A^+ = A^T (AA^T)^{-1}$ "the Moore-Penrose inverse", and $\Sigma_0 = \Sigma_1 + D1A^+HA^{+T}D^T$.

Description of data

Crop Yields 2002 - 2012 (22 Agricultural Seasons)

Yield (Kg/Ha)	Maize	Wheat	Rice	Beans	Irish Potato	Cassava
2002A	927	800	2,714	755	6,682	7,700
2002B	664	755	3,335	595	8,067	7,098
2003A	804	725	4,000	773	6,818	7,318
2003B	577	538	1,890	550	5,682	6,255
2004A	845	725	3,188	709	6,864	7,045
2004B	559	760	3,300	500	5,409	5,773
2005A	860	785	3,188	709	7,259	7,032
2005B	736	940	4,583	514	7,000	5,727
2006A	824	628	3,188	680	7,168	6,905
2006B	709	503	4,525	1,007	6,535	5,478
2007A	723	533	4,525	988	6,500	5,671
2007B	706	377	2,817	833	5,800	5,177
2008A	1,114	1,430	3,791	988	6,050	12,425
2008B	718	419	2,917	831	6,667	11,300
2009A	1,797	2,208	4,479	1,019	6,533	13,974
2009B	1,551	1,371	4,159	843	10,537	12,345
2010A	2,820	2,127	4,786	1,076	10,563	10,616
2010B	1,853	1,329	5,137	970	9,563	12,609
2011A	2,270	1,924	5,211	937	12,102	10,917
2011B	2,283	2,039	5,751	1,011	11,186	13,933
2012A	2,406	1,562	5,725	1,101	12,605	12,072
2012B	1,965	2,270	5,469	1,428	11,625	17,795

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
maize	22	1264	717	559	2820
wheat	22	1096	598	377	2208
rice	22	4020	1063	1890	5751
beans	22	837	190	500	1101
iris potato	22	8003	2241	5409	12605
cassava	22	9093	3135	5177	13974

	Cut-of	Y_{ij}	p_{ij}	ω_{ij}	C_{ik}	$Y_{ij}\omega_{ij}C_{ik}$	$\omega_{ij}C_{ik}$
Maize Percentiles	20	708	0.15	107	0.476	36,077	51
	40	808	0.17	139	0.247	27,818	34
	60	1077	0.23	248	0.148	39,489	37
	80	2087	0.45	931	0.128	248,604	119
Wheat Percentiles	20	536	0.12	64	0.476	16,201	30
	40	756	0.17	127	0.247	23,639	31
	60	1252	0.28	347	0.148	64,283	51
	80	1970	0.44	860	0.128	216,844	110
Rice Percentiles	20	3079	0.19	586	0.476	858,479	279
	40	3426	0.21	725	0.247	613,516	179
	60	4516	0.28	1260	0.148	841,942	186
	80	5167	0.32	1649	0.128	1,090,556	211
Beans Percentiles	20	646	0.19	123	0.476	37,696	58
	40	784	0.23	181	0.247	34,970	45
	60	963	0.28	272	0.148	38,816	40
	80	1014	0.30	302	0.128	39,194	39
Irish Potato Percentiles	20	6320	0.20	1285	0.476	3,865,861	612
	40	6709	0.22	1448	0.247	2,399,805	358
	60	7241	0.23	1687	0.148	1,807,711	250
	80	10812	0.35	3761	0.128	5,205,257	481
Cassava Percentiles	20	5755	0.16	916	0.476	2,508,073	436
	40	7056	0.20	1377	0.247	2,399,246	340
	60	10857	0.30	3259	0.148	5,236,726	482
	80	12499	0.35	4319	0.128	6,910,351	553

Model Estimation

Estimation of Matrix D

Maize	Rice	Wheat	Beans	Cassava	Irish Potatoes	MaizeF	RiceF	WheatF	BeansF	CassavaF	Irish PotatoesF
1	0	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0

Estimation of Variance Matrix (E Matrix)

Crops	Mean	Reliability	PrioSev= Mean * Re	PrioV = $PrioSe^2$
Maize	1260	0.01	13	159
Wheat	1125	0.05	56	3164
Rice	4031	0.05	202	40622
Beans	855	0.05	43	1828
Irish Potato	8055	0.05	403	162208
Cassava	9326	0.05	466	217436

Estimated Variance Matrix

Maize	Wheat	Rice	Beans	Irish Potato	Cassava
159	0	0	0	0	0
0	3164	0	0	0	0
0	0	40622	0	0	0
0	0	0	1828	0	0
0	0	0	0	162208	0
0	0	0	0	0	217436

Estimation of covariance Matrix (H Matrix)

	Yfj	Ytj	Pi	Reability	PrioSe	PrioV	Bij^2	PrioV*Bij^2
Maize	1,459	3750	0.39	0.01	0.004	0.0000	14062500	213
Wheat	1,440	3500	0.41	0.05	0.021	0.0004	12250000	5181
Rice	3,980	7000	0.57	0.05	0.028	0.0008	49000000	39600
Beans	829	1850	0.45	0.05	0.022	0.0005	3422500	1716
Irish Potato	7,809	27500	0.28	0.05	0.014	0.0002	756250000	152446
Cassava	9,417	35000	0.27	0.05	0.013	0.0002	1225000000	221679

Estimated Covariance Matrix

Maize	Wheat	Rice	Beans	Irish Potato	Cassava	MaizeF	WheatF	RiceF	BeansF	Irish PotatoF	CassavaF
213	0	0	0	0	0	0	0	0	0	0	0
0	5181	0	0	0	0	0	0	0	0	0	0
0	0	39600	0	0	0	0	0	0	0	0	0
0	0	0	1716	0	0	0	0	0	0	0	0
0	0	0	0	152446	0	0	0	0	0	0	0
0	0	0	0	0	221679	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	10	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

Estmation of A Matrix (Pi)

Maize	Rice	Wheat	Beans	Cassava	Irish Potatoes	MaizeF	RiceF	WheatF	BeansF	CassavaF	Irish PotatoesF
-0.39	0	0	0	0	0	1	0	0	0	0	0
0	-0.41	0	0	0	0	0	1	0	0	0	0
0	0	-0.57	0	0	0	0	0	1	0	0	0
0	0	0	-0.45	0	0	0	0	0	1	0	0
0	0	0	0	-0.28	0	0	0	0	0	1	0
0	0	0	0	0	-0.27	0	0	0	0	0	1
-1	0	0	0	0	0	1	0	0	0	0	0
0	-1	0	0	0	0	0	1	0	0	0	0
0	0	-1	0	0	0	0	0	1	0	0	0
0	0	0	-1	0	0	0	0	0	1	0	0
0	0	0	0	-1	0	0	0	0	0	1	0
0	0	0	0	0	-1	0	0	0	0	0	1

Estimation of dT Matrix

	Maize	Rice	Wheat	Beans	Cassava	Irish Potatoes
Y_{fj}	1,459	1,440	3,980	829	7,809	9,417

On Precise Estimation of Crop Yield at Smaller Area Level by Integrating Agricultural Survey Data and Population Census Data Through Use of Spatial Models

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Abstract

In this article we demonstrate an application of small area estimation technique to produce district level estimates of crop yield for three major crops of the State of Uttar Pradesh using the Improvement of Crop Statistics Scheme data and the auxiliary data from various secondary sources. In particular, we use a spatial model for small area estimation to improve the district level crop yield estimates. The results show significant improvement in the yield estimates by using a spatial model in small area estimation.

Keywords: crop cutting experiments; improvement of crop statistics; district level estimates; small area estimation; spatial model.

1. Introduction

In India, the crop yield estimates are generated on the basis of scientifically designed crop cutting experiments (CCEs) conducted under the scheme of General Crop Estimation Surveys (GCES). The GCES covers a total of 68 crops in 25 States and 4 Union Territories of India. More than 800,000 CCEs are conducted annually for this purpose. The sample size gathered through GCES is sufficient for providing precise estimates of crop yield (i.e., production per hectare of land) at district level. Whereas, the procedure of conducting the CCEs are very tedious and time consuming which makes some of the enumerators not to follow the appropriate technique for CCEs and by virtue of that the data quality of the purpose. The sample size gathered through GCES is sufficient for providing precise estimates of crop yield (i.e., production per hectare of land) at district level. Whereas, the procedure of conducting the CCEs are very tedious and time consuming which makes some of the enumerators not to follow the appropriate technique for CCEs and by virtue of that the data quality of the GCES goes beyond the desired limit. To improve the quality of data collected under the GCES, a scheme titled 'Improvement of Crop Statistics (ICS)' has been introduced by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India and implemented by the National Sample Survey Office (NSSO) and the State Agricultural Statistics Authority (SASA) jointly. Under this scheme, quality check on the field operation of GCES is carried out by supervising around 30,000 CCE by NSSO and State Government supervisory officers. The findings of the ICS results reveal that the crop cutting experiments are generally not carried out properly resulting in data which lacks desired quality. Due to limitation of infrastructure and constraints of resources, there is a felt need to reduce the sample size under GCES drastically so that volume of work of the enumerator is reduced and also better supervision of the operation of CCE becomes possible leading to improvement in data quality. But, with the reduction of sample sizes the standard error of the estimates will increase. The reduced sample size is more of concern when aim is to produce estimates at district level since estimators based on the sample data from any particular district (also referred as area or small area) can be unstable. This small sample size problem can be easily resolved using auxiliary information if available to strengthen the limited sample data from the district. This problem of estimation arising due to small sample size within the districts can be solved by using small area estimation (SAE) technique.

The SAE techniques are usually a model-based method where we use statistical models to link the variable of interest with auxiliary information, e.g. Census and Administrative data, for the small areas to define model-based estimators for these areas. See Pfeffermann (2002) and Rao (2003). The underlying models defining the small area estimators are referred as the small area models. These small area models are broadly classified as the area level (Fay and Herriot, 1979) and unit level small area model (Battese et al., 1988). The area level small area models are used when auxiliary information is available only at area level. They relate small area

direct estimates to area-specific covariates whereas the unit level small area models relate the unit values of a study variable to unit-specific covariates. Sud et al. (2012) applied SAE techniques under area level model to obtain estimates of average yield for paddy crop at small area levels in the State of Uttar Pradesh in India by linking data generated under ICS scheme by NSSO and the Population Census. They find that the estimates generated through SAE method are reliable and more efficient than the direct estimate from ICS data alone. However, they used the EBLUP estimator under area level random effect model (Fay and Herriot, 1979).

In this paper we consider an application of spatial version of area level random effect (Petrucci and Salvati, 2005, Petrucci et al., 2005 and Singh et al., 2005) to produce the estimates of average yield of Rice, Wheat and Sugarcane crop at district (small area) level in the State of Uttar Pradesh in India using the data under ICS scheme data and the auxiliary data from Population Census 2011 and Fertilizer Statistics 2010. The remaining paper is organized as follows. Section 2 introduces the data used for the analysis and Section 3 describes the methodology applied for the analysis. In Section 4 we compare estimates generated by spatial small area estimator with the usual small area estimator without spatial information and discuss the results. Section 5 finally presents the main conclusions.

2. Data Description

For small area analysis we use data under ICS scheme on paddy, wheat and sugarcane crop for the State of Uttar Pradesh in India collected during the year 2010-11. The variable of interest for which small area estimates are required is yield for paddy, wheat and sugarcane crop and our aim is to estimate the average yield at the district (or small area) level. In the State of Uttar Pradesh there are 70 districts, however supervision, on a sub-sample, of crop cutting experiments work under ICS scheme is carried out in 42 districts for rice, 51 districts for wheat and 29 districts for sugarcane and there is no sample data for the remaining districts. These non sample districts are also referred as the out of sample districts. The area specific sample sizes for these respective sample districts for the three major crops range from minimum of 4 to maximum of 28 CCEs with an average of 11 CCEs in case of rice, minimum of 4 and maximum of 18 CCEs with an average of 9 CCEs in case of wheat and, minimum of 4 and maximum of 22 CCEs with an average of 10 CCEs in case of sugarcane. A total of 442, 472 and 284 CCEs were supervised for rice, wheat and sugarcane respectively for recording yield data in the State of Uttar Pradesh spread over different districts. Further, in a few districts the sample size was so small that the traditional sample survey estimation approaches may lead to unstable estimates. In addition in the non-sampled districts we cannot estimate the crop yield due to unavailability of sample data. Figure 1 shows the distribution of sample sizes in the sampled districts for the three crops i.e. rice, wheat and sugarcane.

The covariates are drawn from the Population Census 2011 and the fertilizer Statistics 2010. There are number of covariates available from these two sources. However, we did some exploratory data analysis, for example, first we segregated group of covariates with significant correlation with target variable. The variables considered were, total population, population density, sex ratio obtained from Census 2011 for all the three crops. Again, we also considered the auxiliary variables like fertilizer consumption during kharif season for Rice and Sugarcane, fertilizer consumption during rabi season for wheat and total fertilizer consumption in the year 2010 for all the three crops. After, the exploratory data analysis, we found that the covariate population density had maximum correlation with the yield of Rice and Sugarcane whereas the covariate fertilizer consumption during rabi season had the maximum correlation with Wheat yield. Hence, we considered the two covariates i.e. population density for Rice and Sugarcane and fertilizer consumption during rabi season for wheat for analysis of the data using small area estimation technique.

3. Methodology

In many SAE problems, it is not always possible to use the unit level small area model simply because of the unavailability of the unit level data. In such circumstances, SAE is carried out under area level small area models. The Fay–Herriot model (Fay and Herriot, 1979) is widely used area level model in SAE. This model relates small area direct survey estimates to area-specific covariates. The SAE under this model is one of the most popular methods used by private and public agencies because of its flexibility in combining different sources of information and explaining different sources of errors. In this section we first elaborate SAE method under area-level Fay–Herriot model (Fay and Herriot, 1979), that

is, the EBLUP estimator under this model. We then introduce the Spatial-EBLUP estimator (Petrucci and Salvati, 2005 and Singh et al., 2005) which takes into account the spatial structure of the data by modeling the random effects according to a SAR specification.

Let the population be divided into D small areas or areas (or district here in this paper) and we use a subscript d to index the quantities belonging to small area or district d (d = 1, 2,..., D). Let $\hat{\theta}_d$ denotes the direct survey estimate of unobservable population value θ_d for area d (d = 1, 2,..., D). Let $\mathbf{x}_d$ be the p-vector of known auxiliary variables, often obtained from various administrative and census records, related to the population mean $\hat{\theta}_d$. The simple area specific two stage model suggested by Fay and Herriot (1979) is,

$$\hat{\theta}_d = \theta_d + e_d \text{ and } \hat{\theta}_d = \mathbf{x}_d^T\boldsymbol{\beta} + u_d, d = 1, 2, \ldots, D. \qquad (1)$$

We can express model (1) as an area level linear mixed model given by

$$\hat{\theta}_d = \mathbf{x}_d^T\boldsymbol{\beta} + u_d + e_d, d = 1, 2, \ldots, D \qquad (2)$$

Here β is a p-vector of unknown fixed effect parameters, u_d's are independent and identically distributed normal random errors with $E(u_d) = 0$ and ww, and e_d's are independent sampling errors normally distributed with $E(e_d \mid q_d) = 0$ and $Var\ (e_d \mid q_d) = \sigma_d^2$. The two errors are independent of each other within and across areas. Usually, σ_d^2 is known while σ_u^2 is unknown and it has to be estimated from the data. Methods of estimating σ_u^2 include maximum likelihood (ML) and restricted maximum likelihood (REML) under normality and the method of fitting constants without normality assumption (Rao, 2003). Let $\hat{\sigma}_u^2$ denotes estimate of σ_u^2. Then under model (2), the Empirical Best Linear Unbiased Predictor (EBLUP) of θ_d is given by

$$\hat{\theta}_d^{EBLUP} = \mathbf{x}_d^T\hat{\boldsymbol{\beta}} + \hat{\gamma}_d(\hat{\theta}_d - \mathbf{x}_d^T\hat{\boldsymbol{\beta}}) = \hat{\gamma}_d\hat{\theta}_d + (1-\hat{\gamma}_d)\mathbf{x}_d^T\hat{\boldsymbol{\beta}} \qquad (3)$$

Where, $\hat{\gamma}_d = \dfrac{\hat{\sigma}_u^2}{(\sigma_u^2 + \hat{\sigma}_u^2)}$ and $\hat{\boldsymbol{\beta}}$ is the generalized least square estimate of $\boldsymbol{\beta}$. It may be noted that $\hat{\theta}_d^{EBLUP}$ is a linear combination of direct estimate $\hat{\theta}_d$ and the model based regression synthetic estimate $\mathbf{x}_d^T\hat{\boldsymbol{\beta}}$ with weight $\hat{\gamma}_d$. Here $\hat{\gamma}_d$ is called the "shrinkage factor" since it 'shrinks' the direct estimator, $\hat{\theta}_d$ towards the synthetic estimator, $\mathbf{x}_d^T\hat{\boldsymbol{\beta}}$.

Prasad and Rao (1990) proposed an approximately model unbiased (i.e. with bias of order o(1/D)) estimate of mean squared error (MSE) of the EBLUP (3) given by

$$M\hat{S}E(\hat{\theta}_d^{EBLUP}) = g_{1d}(\hat{\sigma}_u^2) + g_{2d}(\hat{\sigma}_u^2) + 2g_{3d}(\hat{\sigma}_u^2)V\hat{a}r\left(\hat{\sigma}_u^2\right), \qquad (4)$$

where,

$$g_{1d}(\hat{\sigma}_u^2) = \hat{\gamma}_d\hat{\sigma}_d^2$$

$$g_{2d}(\hat{\sigma}_u^2) = (1-\hat{\gamma}_d)^2\mathbf{x}_d^T\hat{V}(\hat{\boldsymbol{\beta}})\mathbf{x}_d$$

$$g_{2d}(\hat{\sigma}_u^2) = \left[\frac{\hat{\sigma}_d^4}{\left(\hat{\sigma}_d^2 + \hat{\sigma}_u^2\right)^3}\right]\sum_{d=1}^{D} V\hat{a}r\left(\hat{\sigma}_u^2\right)$$

with $V\hat{a}r\left(\hat{\sigma}_u^2\right) = 2D^{-2}\sum_{d\ 1}^{D}\left(\hat{\sigma}_d^2 + \hat{\sigma}_u^2\right)^2$ when estimating $\hat{\sigma}_u^2$ by the method of fitting constants (Rao, 2003).

In Section 2 we noticed that there are many out of sample districts in the data and the conventional approach for estimating small areas in this case is synthetic estimation, based on a suitable model fitted to the data from the sampled areas. This is equivalent to setting the area effect for out of sampled area to zero. Under model (2), the synthetic EBLUP predictor for θ_d is

$$\hat{\theta}_d^{SYN} = \mathbf{x}_d^T\hat{\beta}. \qquad (5)$$

This predictor is referred as the Synthetic EBLUP (hereafter denoted by SYN). Under model (2), the MSE estimate for the synthetic predictor (5) is

$$M\hat{S}E(\hat{\theta}_d^{SYN}) = \mathbf{x}_d^T V\hat{a}r(\hat{\boldsymbol{\beta}})\mathbf{x}_d + \hat{\sigma}_u^2. \qquad (6)$$

In model (2) the random area effects are considered to be independent. However, it is often reasonable to assume that the effects of neighbouring areas (defined, for example, by a contiguity criterion) are correlated, with the correlation decaying to zero as the distance between these areas increase. Consequently, small area models should allow for spatial correlation of area random effects. In order to take into account the correlation between neighbouring areas we consider the use of spatial models for random area effects. We consider a linear regression model with spatial dependence in the error structure. In particular, we assume a Simultaneous Autoregressive (SAR) error process, where the vector of random area effects $\boldsymbol{v} = (v_d)$ satisfies $\boldsymbol{v} = \rho\mathbf{W}\boldsymbol{v} + \boldsymbol{u}$ and ρ is a spatial autoregressive coefficient, W is a proximity matrix of order D and $\boldsymbol{u} \sim N(0, \sigma_u^2\boldsymbol{I}_D)$. Since $\boldsymbol{v} = (\boldsymbol{I}_D - \rho\mathbf{W})^{-1}\boldsymbol{u}$ with $E(\boldsymbol{u}) = 0$ and $Var(\boldsymbol{u}) = \sigma_u^2\boldsymbol{I}_D$, we have $E(\boldsymbol{v}) = 0$ and $Var(\boldsymbol{v}) = \sigma_u^2[(\boldsymbol{I}_D - \rho\mathbf{W})(\boldsymbol{I}_D - \rho\mathbf{W}^T)]^{-1} = \Omega$.

The $\mathbf{W}$ matrix describes how random effects from neighbouring areas are related, whereas ρ defines the strength of this spatial relationship. The simplest way to define $\mathbf{W}$ is as a contiguity matrix. The elements of $\mathbf{W}$ take non-zero values only for those pairs of areas that are adjacent. Then the model (2) with spatially correlated errors is

$$\theta = \mathbf{x}\beta + \mathbf{z}(\boldsymbol{I}_D - \rho\mathbf{W})^{\ 1}\boldsymbol{u} + \mathbf{e} = \mathbf{x}\beta + \mathbf{z}\boldsymbol{v} + \mathbf{e}. \qquad (7)$$

The covariance matrix of the vector θ is $\mathbf{V} = \mathbf{z}\sigma_u^2[(\boldsymbol{I}_D - \rho\mathbf{W})(\boldsymbol{I}_D - \rho\mathbf{W}^T)]^{-1}\mathbf{z}^T + \mathbf{R}$. In practice, the vector of parameters $\boldsymbol{\psi} = (\sigma_u^2, \rho)^T$ is unknown. Assuming normality of the random effects, the parameter vector σ_u^2 and ρ can be estimated via ML as well as REML methods. Numerical approximations to either the ML or REML estimators $\hat{\sigma}_u^2$ and $\hat{\rho}$ can be obtained via a two-step procedure. At the first step, the Nelder-Mead algorithm is used to approximate these estimates. The second step then uses these approximations as starting values for a Fisher scoring algorithm. See Petrucci et al. (2005), Petrucci and Salvati (2005) for computational details. Replacing $\boldsymbol{\psi} = (\sigma_u^2, \rho)^T$ with an asymptotically consistent estimator $\hat{\psi} = (\hat{\sigma}_u^2, \hat{\rho})^T$ and assuming that (7) holds, the spatial Empirical Best Linear Unbiased Predictor (Spatial-EBLUP or SEBLUP) of θ_d is

$$\hat{\theta}_d^{Spatial-EBLUP} = \mathbf{x}_d^T\hat{\beta}^s + a_d^T\hat{v}, \text{ with } \hat{v} = \hat{\Omega}\mathbf{z}^T\hat{\mathbf{V}}^{-1}(\boldsymbol{y} - \mathbf{x}\hat{\beta}^s), \quad (8)$$

where $\hat{\boldsymbol{\beta}}^s = \left(\mathbf{x}^T\hat{\mathbf{V}}^{-1}\mathbf{x}\right)^{-1}\left(\mathbf{x}^T\hat{\mathbf{V}}^{-1}\mathbf{y}\right)$ is the EBLUE of $\boldsymbol{\beta}$ under model (7), a_d is the D-vector $(0,\ldots,1,\ldots,0)^T$ with the 1 in the d^{th} position, $\hat{\Omega} = \hat{\sigma}_u^2[(\boldsymbol{I}_D - \hat{\rho}\mathbf{W})(\boldsymbol{I}_D - \hat{\rho}\mathbf{W}^T)]^{-1}$ and $\hat{\mathbf{V}} = \left\{\mathbf{z}\hat{\sigma}_u^2[(\boldsymbol{I}_D - \hat{\rho}\mathbf{W})(\boldsymbol{I}_D - \hat{\rho}\mathbf{W}^T)]^{-1}\mathbf{z}^T + diag(\sigma_{ed}^2)\right\}$. For out of sampled areas, spatial Synthetic EBLUP (hereafter denoted by Spatial-SYN) of θ_d is

$$\hat{\theta}_d^{Spatial-SYN} = \mathbf{x}_d^T\hat{\beta}^s. \quad (9)$$

An approximately unbiased estimator of the MSE of the SEBLUP (6) is

$$M\hat{S}E(\hat{\theta}_d^{SEBLUP}) = g_{1d}^{(s)}(\hat{\boldsymbol{\psi}}) + g_{2d}^{(s)}(\hat{\boldsymbol{\psi}}) + 2g_{3d}^{(s)}(\hat{\boldsymbol{\psi}}) - \mathbf{B}_d^{(s)T}(\hat{\boldsymbol{\psi}})\nabla g_{1d}^{(s)}(\hat{\boldsymbol{\psi}}), \quad (10)$$

where the first term $g_{1d}^{(s)}(\hat{\psi})$ is due to the estimation of random area effects and is of order $O(1)$ while the second term $g_{2d}^{(s)}(\hat{\psi})$ is due to the estimation of $\boldsymbol{\beta}$ and is of order $O(D^{-1})$ for large D. The third term $g_{3d}^{(s)}(\hat{\psi})$ is due to the estimation of the variance component. Finally, the last term $\mathbf{B}_d^{(s)T}(\hat{\psi})\nabla g_{1d}^{(s)}(\hat{\psi})$ is the bias when ML method of estimation is used for variance component. This term is negligible and thus ignored when REML or method of moment is used for parameter estimation. Various terms of (7) are:

$$g_{1d}^{(s)}(\hat{\boldsymbol{\psi}}) = a_d^T\left(\hat{\Omega} - \hat{\Omega}\mathbf{z}^T\hat{\mathbf{V}}^{-1}\mathbf{z}\hat{\Omega}\right)a_d,$$
$$g_{2d}^{(s)}(\hat{\boldsymbol{\psi}}) = \left(\mathbf{x}_d^T - \mathbf{c}_d^T\mathbf{x}\right)\left(\mathbf{x}^T\hat{\mathbf{V}}^{-1}\mathbf{x}\right)^{-1}\left(\mathbf{x}_d^T - \mathbf{c}_d^T\mathbf{x}\right)^T, \text{ and}$$
$$g_{3d}^{(s)}(\hat{\boldsymbol{\psi}}) = tr\left\{\left(\nabla\mathbf{c}_d^T\right)\hat{\mathbf{V}}\left(\nabla\mathbf{c}_d\right)\hat{V}(\hat{\boldsymbol{\psi}})\right\}$$

with $\mathbf{c}_d^T = a_d^T\hat{\Omega}\mathbf{z}^T\hat{\mathbf{V}}^{-1}, \nabla\mathbf{c}_d^T = \partial\mathbf{c}_d^T/\partial\psi, \hat{V}(\hat{\boldsymbol{\psi}})$, the estimate of the asymptotic covariance matrix of $\hat{\psi}$ defined by the inverse of the relevant observed information matrix and $\mathbf{B}_d^{(s)T}(\hat{\psi})\nabla g_{1d}^{(s)}(\hat{\psi})$ is the bias correction due to ML estimator of ψ.

4. Empirical Study

In this section we present the results from our empirical analysis carried out to produce the district level crop yield estimates. We compare the spatial EBLUP (SEBLUP), the EBLUP and the direct estimator used to generate the district level crop yield estimates. In particular, our aim is to examine the usefulness of spatial information in producing the small area estimates. The analysis has been carried out for three major crops (i.e., that is rice, wheat and sugarcane) using the ICS data of the State of Uttar Pradesh. In the analysis we have used the R-Software and the SAE package developed by V. Gomez. The values of yield estimates generated by using direct survey estimator, EBLUP and SEBLUP estimators along with their percentage standard errors (%SE) are given in Table 1, 2 and 3 for rice wheat and sugarcane crops respectively. The percentage standard error (% SE) of the estimator $\hat{\theta}_d$ in small area or district d is calculated by

$$\%SE_d = 100 \times \frac{SE(\theta_d)}{\hat{\theta}_d}; d = 1,\ldots,D.$$

These results in Tables 1-3 clearly reveal that the SEBLUP method is providing better estimates than the usual EBLUP estimator (Fay and Herriot, 1979) and the direct survey estimator. Further, it can also be seen that there is a significant improvement in the %SE of the SEBLUP over the EBLUP estimator and the direct estimates. Two points emerged from this analysis, (i) the small area estimate provides efficient and better estimates for crop yield as compared to the direct survey estimates, (ii) the use of spatial information improves the precision of the small area estimates as compared to EBLUP, which does not use this information. As a consequence, for out of sample districts we produced the spatial EBLUP estimates. These out of sample districts are 28, 19 and 41 for rice, wheat and sugarcane respectively. The district level yield estimates for these out of sample districts produced using spatial EBLUP are reported in Table 4, 5 and 6 for rice, wheat and sugarcane respectively. It is noteworthy that in some districts %SE is high, in particular, for sugarcane. We observed that the number of out of sample districts in this case is 41, that is, more than the sample districts. We used the fitted model using data from 29 districts to predict

yield for 41 districts. Similar problem was also observed in Rice and Wheat crops but in these crops the number of sample districts are more than the out of sample districts and hence the predictions are a little better.

Using the model developed on the basis of ICS 2010-11 data on rice, an attempt was made to predict the yield for the year 2011-12. The predicted yield for the year 2011-12 was compared with the observed yield for the year 2011-12. The results are given in Table 7. It may be seen that the percentage deviations between the predicted yield and the observed yield are high in some cases. This highlights the need to standardize the model using the data of past several years for accurate prediction.

5. Conclusions

This paper illustrates that the spatial small area estimation technique can be satisfactorily applied to produce reliable district level estimates of crop yield using CCEs supervised under ICS scheme and it leads to improved estimates over the EBLUP. Although the ICS supervised crop cutting experiments number only 30,000 in the entire country i.e. the sample size is very low, the collected data is of very high quality. The estimates generated using this data are expected to be relatively free from various sources of non-sampling errors. Hence, it is, therefore, recommended that wherever it is not possible to conduct adequate number of crop cutting experiments due to constraints of cost or infrastructure or both, spatial small area estimation technique can be gainfully used to generate reliable estimates of crop yield based on a smaller sample to obtain more precise estimates than the ordinary model based small area estimates. Further, use of spatial information can enhance the reliability.

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Table 1: District level yield estimates (gms/CCE plot area) of Rice crop for Uttar Pradesh for 2010-11.

District	Yield			% SE			District	Yield			% SE		
	Direct	EBLUP	SEBLUP	Direct	EBLUP	SEBLUP		Direct	EBLUP	SEBLUP	Direct	EBLUP	SEBLUP
Saharanpur	17256	16984	17397	7.71	7.68	7.17	Kaushambi	17400	17045	16419	8.32	8.29	7.54
M.Nagar	19033	18918	18816	4.25	4.24	4.17	Allahabad	14830	14648	14611	13.84	13.36	10.88
Bijnor	15233	15033	15109	7.74	7.72	7.08	Barabanki	13743	13198	13824	17.09	16.72	11.53
Moradabad	16613	16506	15741	11.95	11.51	9.96	Faizabad	16021	15780	15738	10.33	10.16	8.61
J.P. Nagar	12050	12044	12113	2.61	2.6	2.57	Ambedkarnagar	18696	18608	18277	3.83	3.82	3.76
Ghaziabad	21833	27652	19985	15.01	10.92	14.61	Sultanpur	17438	16672	15843	12.07	12.01	9.32
Buland Shahar	14321	14125	13890	8.77	8.73	8.09	Bahraich	13543	13417	13490	7.89	7.86	7.27
Aligarh	6539	7111	10015	31.35	27.5	16.14	Shrawasti	13131	11816	12859	22.58	22.76	15.23
Etah+Mainpuri	15325	15385	15441	8.05	7.88	7.26	Gonda	11441	11388	12212	11.84	11.64	9.6
Badaun	15879	15521	15059	8.47	8.49	7.73	Sidharthnagar	13950	13663	13809	13.36	13.11	10.73
Shahjahanpur	18225	17475	16529	13.72	13.35	10.44	Sant Kabir Nagar	15592	15092	15140	17.06	16.3	12.31
Khiri	13833	13184	13854	13.85	13.93	10.97	Maharajganj	16010	15873	15635	6.28	6.26	5.97
Sitapur	13060	12739	13434	14.1	13.91	11.06	Gorakhpur	13688	13973	14202	15.78	14.68	10.98
Hardoi	14717	14001	14586	14.53	14.5	10.77	Kushinagar	13979	14009	14287	8.65	8.49	7.74
Rai Bareilly	14125	13920	14407	8.66	8.63	7.75	Azamgarh	11311	11327	11480	4.38	4.37	4.24
Farrukhabad	21967	16448	15941	26.44	25.99	13.67	Mau	12469	12843	12476	18.27	16.75	12.97
Kannauj	14950	14253	14982	15.36	15.18	11	Balia	9195	9311	9878	11.7	11.4	10.13
Etawah	24588	20101	17034	15.18	16.02	11.96	Ghazipur	12376	12388	12291	7.25	7.18	6.86
Auraiya	18242	14866	15769	23.69	24.03	13.64	S.R.Nagar	12700	12982	13181	10.87	10.41	9.35
Kanpur®	18081	15324	14946	20.11	20.61	14.55	Mirzapur	8763	8245	10238	41.72	38.45	20.5
Kanpur(u)	11319	11845	13120	16.43	15.11	11.42	Sonbhadra	6308	6038	8259	29.98	30.06	19.55

Table 2: District level yield estimates (gms/CCE plot area) of wheat crop for Uttar Pradesh for 2010-11.

District	Yield			% SE			District	Yield			% SE		
	Direct	EBLUP	SEBLUP	Direct	EBLUP	Direct		Direct	EBLUP	SEBLUP	Direct	EBLUP	SEBLUP
Saharanpur	15560	14999	15684	12.75	12.65	10.6	Hamirpur	9148	9148	10474	0.45	0.45	10.61
M.Nagar	16985	16950	16611	2.7	2.7	6.38	Banda	11284	11241	11315	4.3	4.3	4.18
Bijnor	14865	14272	13046	13.03	13.01	12.79	Chitrakoot	7506	7501	9662	2.75	2.75	16.47
Moradabad	13906	13870	13843	9.29	9.14	13.98	Fatehpur	13220	12995	13216	8.68	8.69	9.13
J.P Nagar	10175	10081	10895	13.99	13.8	7.78	Kaushambi	12544	12083	12302	19.44	18.89	10.97
Meerut	16700	16694	15077	1.72	1.72	9.14	Allahabad	10600	10610	11965	9.02	8.92	9.69
Bagpat	15788	15744	15533	3.43	3.42	3.37	Barabanki	15892	15728	15063	5.52	5.52	7.76
Ghaziabad	14050	17542	13886	17.33	13.21	10.42	Faizabad	13280	13160	12778	10.29	10.16	8.54
Bulandshahar	16919	16723	16761	5.44	5.45	2.68	Ambedkarnagar	12044	11866	12679	17.74	17.11	11.91
Aligarh	13154	12923	13649	14.19	13.51	9.41	Sultanpur	9351	9319	9382	14.85	14.57	2.19
Hathras	13363	11248	13398	41.75	37.35	6.42	Bahraich	11513	11367	11300	9.57	9.56	9.41
Agra	14335	14156	14714	10.3	10.17	10.24	Balrampur	8988	8791	9240	20.29	19.97	7.32
Firozabad	16883	16379	15512	10.76	10.69	8.36	Siddrathnagar	10281	10274	10564	4.37	4.36	16.58
kansiramnagar	14550	14553	14390	4.46	4.44	4.27	Maharajganj	14256	14228	13680	3.23	3.23	8.43
Mainpuri	18388	17428	14627	10.12	10.26	10.95	Gorakhpur	11938	12011	11981	11.26	10.96	2.38
Badaun	16038	15518	15939	9.71	9.76	2.8	Kushinagar	11679	11698	11767	8.42	8.31	7.67
Shshjahanpur	12729	12723	13753	5.54	5.51	9.53	Deoria	11786	11797	11871	7.04	6.98	6.9
Sitapur	10539	10519	10739	5.08	5.08	4.09	Azamgarh	11949	11947	11938	3.65	3.64	9.25
Hardoi	12675	12555	12731	7.14	7.14	6.3	Balia	13321	13283	12266	5.96	5.93	17.62
Unnao	13504	13049	13503	12.5	12.52	0.3	Ghazipur	9943	9958	11252	7.87	7.8	16.34
Raibareilly	10557	10524	10864	6.14	6.13	5.67	Chandauli	8900	8876	9319	10.47	10.39	9.03
Etawah	11717	11124	12543	19.89	19.71	10.55	Varanasi	10681	10704	11421	2.38	2.37	12.43
Aurriya	13200	12945	12888	9.65	9.66	6.57	S.R.Nagar	12067	12094	11951	4.52	4.5	4.42
Kanpur(D)	17713	16358	15591	12.67	12.96	8.61	Mirzapur	7713	7534	9172	25.38	24.87	16.25
Jhansi	12892	10866	12586	26.18	27.49	8.54	Sonbhadra	4967	4883	5216	24.76	24.75	8.24
Lalitpur	11500	10448	11483	19.54	20.31	3.91							

Table 3: District level yield estimates (gms/CCE plot area) of Sugarcane crop for Uttar Pradesh for 2010-11.

District	Yield			% SE			District	Yield			% SE		
	Direct	EBLUP	SEBLUP	Direct	EBLUP	SEBLUP		Direct	EBLUP	SEBLUP	Direct	EBLUP	SEBLUP
Saharanpur	15560	128546	138556	23.22	21.22	19.69	Barabanki	16038	75366	102398	35.55	30.63	22.54
M.Nagar	16985	136228	141221	10.87	10.61	10.23	Faizabad	12729	155410	152544	11.76	11.48	11.69
Bijnore	14865	110182	110586	23.45	21.88	21.8	Bahraich	10539	101962	102690	32.8	30.51	30.29
Muradabad	13906	75216.1	76210	38.95	27.81	27.45	Balrampur	12675	82256	102835	15.02	14.73	11.78
Rampur	10175	133211	134296	8.41	8.3	8.24	Gonda	13504	108348	109281	13.12	12.78	12.67
Meerut	16700	119689	133674	40.36	25.97	23.25	Basti	10557	86976	103127	24.5	21.94	18.5
Baghpat	15788	160367	165735	11.08	10.94	10.58	Maharajganj	11717	141447	145278	3.29	3.29	3.2
Bulandshar	14050	123911	125889	7.44	7.41	7.3	Gorakhpur	13200	122220	133102	23.29	19.24	17.67
Mathura	16919	136580	139892	5.95	5.95	5.81	Kushinagar	17713	136393	139429	8.76	8.54	8.36
Bareilly	13154	139917	144012	10.41	10.15	9.86	Deoria	12892	126231	145755	8.6	8.39	7.26
Pilibhit	13363	111760	121665	22.82	23.17	21.28	Mau	11500	148889	152082	3.36	3.35	3.28
Shahjahanpur	14335	89277.5	92747	38.74	33.63	32.38	Jaunpur	9148	178756	179878	19.05	18.16	18.04
Khiri	16883	135532	136961	5.64	5.67	5.61	Varanasi	11284	153410	207675	18.36	13.91	10.27
Sitapur	14550	72145.9	102106	23.17	21.52	15.21	J.P.Nagar	7506	102673	102998	45.84	35.16	35.05
Hardoi	18388	163052	167252	6.9	6.96	6.78							

Table 4: District level yield estimates (gms/CCE plot area) of Rice crop for out of sample districts using Spatial EBLUP (SEBLUP).

Districts	Yield	% SE	Districts	Yield	% SE
Rampur	14244	42.41	Jaunpur	14464	42.67
Mathura	13796	43.84	Agra	14426	41.88
Bareilly	14420	41.89	Firozabad	14366	42.05
Pilibhit	13531	44.77	Bagpat	14242	42.42
Unnao	13690	44.2	Mahamaya nag	13997	43.18
Lucknow	15747	38.74	Baharich	13859	43.61
Banda	13193	46.16	Chandauli	13834	43.69
Fatehpur	13618	44.46	Kanshiram nagar	13767	43.91
Pratapgarh	14003	43.16	Mainpuri	13685	44.18
Balrampur	13658	44.32	Jhansi	13175	46.13
Basti	14115	42.8	Jalaun	13117	46.58
Varanasi	16808	37	Chitrakut	13011	47.2
Meerut	14878	40.67	Mahboba n	12959	47.02
Deoria	14678	41.18	Hamirpur	12942	46.7
G B Nagar	14667	41.21	Lalitpur	12891	47.31

Table 5: District level yield estimates (gms/CCE plot area) of Wheat crop for out of sample districts using Spatial EBLUP (SEBLUP).

Districts	Yield	% SE	Districts	Yield	% SE
G B Nagar	9565	11.41	Jalaun	9676	25.6
Mathura	9692	27.68	Mahoba n	9523	6.05
Bareilly	9825	44.27	Pratapgarh	9660	23.61
Pilibhit	9742	33.98	Shrawasti	9523	6.06
Shahjahanpur	9884	51.38	Gonda	9738	33.39
Lucknow	9664	24.08	Basti	9691	27.57
Rai Bareilly	9692	27.71	S.K.Nagar	9616	18.01
Farukhabad	9783	39.05	Maunathbhanjan	9644	21.55
Kannauj	9658	23.33	Jaunpur	9727	32.07
Kanpur(u)	9836	45.59			

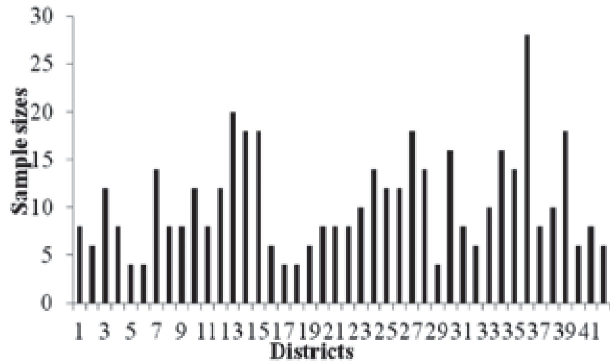
Table 6: District level yield estimates (gms/CCE plot area) of Sugarcane crop for out of sample districts using Spatial EBLUP (SEBLUP).

Districts	Yield	% SE	Districts	Yield	% SE
Ghaziabad	11249	12.16	G B nagar	9718	34.58
Etah	9817	17.87	Agra	9643	37.48
Badaun	9417	23.84	Balia	9640	35.98
Unnao	9416	27.46	Gazipur	9635	63.77
Lucknow	10051	24.56	Firozabad	9625	65.00
Rai Bareilly	9447	32.46	Mahamaya Nag.	9511	53.31
Farrukhabad	9519	29.87	Baharich	9468	47.92
Kannauj	9471	35.93	Chandauli	9461	48.75
Etawah	9417	38.14	Kanshiram nagar	9440	45.11
Auraiya	9416	44.83	Mainpuri	9415	44.46
Kanpur®	9389	42.12	Mirzapur	9351	43.04
Kanpur(u)	9846	44.13	Jhansi	9257	41.61
Banda	9263	47.06	Jalaun	9239	39.98
Fatehpur	9394	43.01	Chitrakut	9207	38.29
Pratapgarh	9513	42.8	Mahboba n	9191	36.5
Kaushambi	9537	41.76	Sonbhadra	9188	34.58
Allahabad	9641	40.57	Hamirpur	9186	32.56
Ambedkarnagar	9606	39.59	Lalitpur	9170	30.42
Sultanpur	9513	38.66	Aligarh	9598	27.6
Shrawasti	9327	37.84	Sidharthnagar	9528	25.17
S K Nagar	9615	41.6	Ajamgarh	9672	22.25
S R Nagar	9892	41.79			

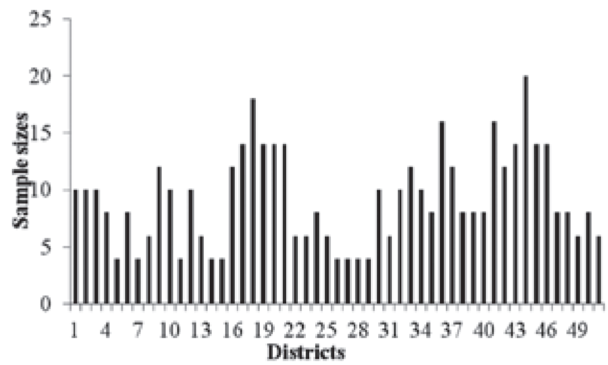
Table 7: Predicted values of Rice for the year 2011 along with % Deviation on the basis of model using the data of the year 2010.

District	No. of Expts	Average Yield (green)	Predicted	%Deviation
Saharanpur	4	9819	14157	44.17
Bulandshahr	14	16768	13890	-17.16
Aligarh	6	18328	14280	-22.08
Firozabad	4	19738	14366	-27.22
Manpuri	6	16483	14988	-12.34
Sitapur	4	12320	13846	-12.37
Hardoi	12	12133	13692	-12.84
Farukhabad	6	16300	14023	-13.97
Ramabai Nagar	4	11088	13799	-24.44
Lalitpur	6	9550	12891	-34.98
Baharaich	12	12025	13859	-15.25
Shravasti	4	14350	13402	6.60
Deoria	4	15100	14678	2.79
Balia	4	16738	14415	13.88
Jaunpur	6	12167	14464	-18.87
Sonbhadra	4	15463	12951	16.24

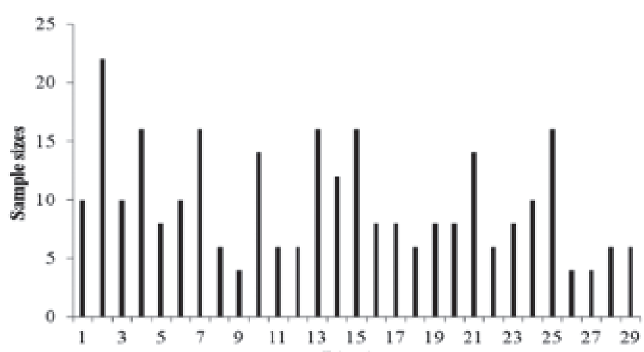
Figure 1: District wise sample sizes for (a) Rice (b) Wheat and (c) Sugarcane under ICS of Uttar Pradesh in 2010-11.



(a)



(b)



(c)

Reliability of Rainfall for Crop Production – a case study in Uganda

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Abstract

Drought has occurred in various parts of Uganda many times seriously affecting crop production, food market prices and ultimately, the cost of living (NEMA, 2001). Uganda's population is sustained by crops, which are largely produced under rain fed conditions. In recent years, however some areas have experienced significant drought. This phenomenon requires the attention of those involved in the formulation of agricultural policies. To address some of these concerns, a study was carried out to determine the reliability of rainfall in relation to crop water requirements, for different crops in climatic region in Uganda. Available rainfall data from these regions were examined for consistency using the double mass curve and in filled using Markov generation methods. The data was then subjected to statistical tests to determine the probability distributions that best fit them. Probability distributions were selected from among the Log-Normal, Pearson types and the Gumbel Extreme Value Type I distributions. Two methods were applied in determining the most suitable distribution, namely, the Chi-square test and regression analysis. Representative crops from the districts were then selected and their crop water requirements determined. These were compared to the rainfall to determine the effectiveness of the rainfall in meeting crop water requirements. The crop water requirements were adjusted with respect to the effective rainfall to find a planting date that minimizes the additional water requirement. Crops that required additional water were identified and the yield reduction due to moisture stresses determined. Irrigation schedules were then developed for the crops that required additional water.

Keywords: crop water requirements; Chi Square test; probability plot; rainfall reliability; return period; yield reduction.

1. Introduction

Like for many of her neighbours in the East and Central African region, rainfall is the primary determinant of crop production in Uganda. However, rainfall is highly variable in most parts of the country both in terms of length of the rainy season and amount of rainfall (DWD, 1995). This variability means that Uganda can be divided into different climatic regions using various statistical methods and according to the parameters determined. This variability has also had significant impact on rain fed agriculture as well as the environment of Uganda. Drought has occurred in various parts of Uganda many times seriously affecting crop production, food market prices and ultimately, the cost of living (NEMA, 2001). This uncertainty regarding agricultural production as well as investments in agricultural improvements has caused concerns in both local authorities and world bodies alike, which have been collaborating to combat drought.

In order to optimize the use of available rainfall, the crop water requirements for the different representative crops need to be determined in order to assess their suitability for a particular area. Other factors like soil moisture content and recharge, potential evapotranspiration, soil type, planting seasons and cropping methods all need to be considered. It is therefore necessary to give adequate attention to rain fed agriculture as a key element in food security in Uganda. Alternatives to meet additional water requirements, by irrigation, can subsequently be considered so that crop production can be increased appropriately. Herein, the rainfall reliability with respect to meeting crop water requirements in each of the regions has been investigated. Knowledge of the rainfall characteristics will facilitate the improvement of crop scheduling and Irrigation where necessary. The objectives of this study were therefore to: determine the most suitable statistical probability distribution that represents rainfall data and the rainfall depth return period relationship, in the selected region, estimate the effective rainfall in a region and crop water requirements of selected crops; determine the rainfall deficiency and consequent reduction in yield and to estimate the irrigation requirements to correct the deficit.

2. Methods

The study covered the regions of Hoima (D), Masindi (E), Kitgum (F), Lira (H), Soroti (I), Kumi (K),

Tororo (L), and Kabale (C) which are shown on fig. 1 and represent the areas in parenthesis, according to the classification of Uganda into climatic regions by Basalirwa (1995). These include some of the areas that have been predominantly hit by drought in recent times. The available daily rainfall data was collected from the Meteorological Department of the Ministry of Water, Lands and Environment. The number of years of data available for each of the stations ranged from 23 to 38 years. It was examined for consistency using the double mass curve technique. Missing values were synthetically generated using the Markoveneration technique (Haan, 1982). The annual rainfall values were analyzed to obtain the statistical distribution using the following methods (Viessman & Lewis, 1996; Shaw, 1994; Subramanya, 1995; Wilson, 1978). They were ranked and plotted on different probability paper according to Weibull formula as follows:

P = m / (N+1), where P is probability of an event (1)
m is the order of rainfall event
N is the number of the sample

The coefficient of correlation provided an indication of the best fit. The results obtained were compared with the Chi Squared goodness of fit test given below as:

$$x^2 = \sum \left(\frac{0-E}{E}\right)^2 \quad (2)$$

Where:
X^2 is a value that should be the smallest among the distributions tested
O is the actual (observed) value and
E is the expected (predicted) value.

For crop water calculations, the following formulae were used:

$$ET_0 = \frac{0.408\,\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34\,U_2)} \quad (3)$$

$$ET_o = K_c\,ET_o \quad (4)$$

$$P_{eff} = \frac{P_{tot}\,(125 - 0.2\,P_{tot})}{125} \quad (5)$$

$$P_{eff} = 125 + 0.1\,P_{tot} \quad (6)$$

$$IR = ET_c - P_{eff} \quad (7)$$

$$\left[1 - \frac{Y_a}{Y_m}\right] = K\left[1 - \frac{ET_{cadj}}{ET_0}\right] \quad (8)$$

P < 250 mm
P > 250 mm

Figure 1: Map of Uganda showing the different climatic regions.

where ETo is the reference crop evapotranspiration, Rn is net radiation at the crop surface, G is the heat flux density, T is the mean daily temperature, u2 is the wind speed at 2m height, es is the saturation vapour pressure, ea is the actual vapour pressure, D is the slope vapour pressure curve and g is the psychometric constant, Peff is effective rainfall, Ptot is actual rainfall measured, IR is irrigation requirement, Kc is crop coefficient, ETc is crop evapotranspiration. Ya is the actual crop yield. Ym is the maximum crop yield when ETc = ETc adj; Ky is a yield response factor that describes the reduction in relative yield according to the reduction in ETc caused by soil water shortage and ETc adj is the adjusted actual evapotranspiration (FAO, Doorenbos & Pruitt, 1977).

The reference crop evapotranspiration was calculated according to equation (3) and then the crop evapotranspiration according to equation (4) for the different crops according to their growth stages. The effective rainfall for the average year in a region was estimated according to equations (5) and (6). When comparing the effective rainfall and crop water requirements, the planting date was adjusted so as to minimize the irrigation requirements. The irrigation requirements (rainfall deficiency) were then estimated using equation (7). Equation (8) gives the relationship between the crop yield and available moisture. Finally, the reduction in yield according to the available moisture was estimated, providing a basis on which decisions regarding investments in irrigation can be made

3. Results And Discussion

The results of the statistical analysis are presented in the Tables 1 and 2. Table 1 provides a summary for the testing of statistical distributions for the climatic regions using the Chi squared values and correlation coefficients. Table 2 provides a summary of the statistical parameters and the rainfall depth return period relationship for the regions.

Table 1: Testing of statistical distributions.

Region	Chi Squared Values X2				Correlation Coefficient			
	LN	P. III	LP	EV1	L N	P.III	L P	EV1
Hoima (L)	8.75	14.40	13.14	3.34	0.975	0.965	0.974	0.977
Masindi(K)	0.12	10.3	0.08	1.26	0.967	0.960	0.979	0.963
Kitgum (H)	5.22	21.24	28.54	6.78	0.981	0.961	0.955	0.974
Lira (I)	2.59	9.43	10.45	3.12	0.984	0.977	0.978	0.983
Soroti (E)	2.02	16.06	10.18	1.89	0.988	0.982	0.921	0.991
Kumi (F)	2.14	9.32	10.53	0.96	0.989	0.985	0.984	0.992
Tororo (D)	7.69	43.34	48.03	7.28	0.970	0.949	0.941	0.981
Kabale (C)	12.00	8.474	10.38	1.60	0.980	0.989	0.983	0.991

Key: LN - Log Normal, P. III -Pearson Type III, L P - Log Pearson EV1 - Extreme Value Type 1

Table 2: Statistical parameters and trend.

Region	Mean annual Rainfall mm	StandardDeviation	Skewness	Best statistical Distribution	Rainfall depth return period relationship
Hoima (L)	118.76	12.6	-0.216	Extreme Value Type 1	118.76 + 12.6KT
Masindi(K)	112.02	13.8	0.5092	Log Pearson Type III	2.05 + 0.053KT
Kitgum(H)	117.75	21.24	-649	Log Normal	2.064 + 0.077KT
Lira (I)	119.36	15.80	0.568	Log Normal	2.073 + 0.056 KT
Soroti (E)	116.97	18.45	0.383	Log Normal	116.97 + 18.45 KT
Kumi (F)	108.80	15.94	0.563	Extreme Value Type1	108.8 + 15.94KT
Tororo(D)	124.45	19.93	-0.253	Extreme value Type	124.45 +19.93 KT
Kabale(C)	86.7	10.73	0.2	Extreme Value Type	86.7 + 10.73KT

Table 3: Regions selected crops and irrigation requirements.

Region	Crop	Irrigation	Yield reductions percentage	mm/dec
Hoima (L)	Banana	Yes	30.1	130.8
Masindi (K)	Banana	Yes	29.2	147.6
Kitgum (H)	Potatoes	Yes	10	22.5
Lira (I)	Ground nuts	No	0	0
Soroti (E)	Sorghum	No	0	0
Kumi (F)	Sun flower	No	0	0
Tororo (D)	Potatoes	Yes	10	216.2
Kabale (C)	Bananas	Yes	18.1	53.6

Conclusions

From the analysis, the statistical distributions for the annual rainfall for the selected climatic region were determined together with their rainfall depth return period relationships. Five of the stations are represented by EV1, two by LogNormal and one by Log Pearson Type III. It was also observed, in all cases there was slight decrease in rainfall over the years. The effective rainfall and crop water requirements were also determined for a selected crop in each of the regions.

It was observed that in most cases the rainfall is bimodal this means two sets of crops can be grown per year like forlegumes. After synchronizing the planting date to keep additional water requirements to a minimum, Irrigation requirements were determined, where the effective rainfall was insufficient to cater for the crop water requirements. It was noted that all the cases of both bananas and potatoes, irrigation was required in all the regions investigated. The reduction in the yields when irrigation requirements were not met was also determined. It was also noted that yield reduction was more in clayey loams, as compared to coarser loams (Kiiza, 2001).

This study can provide a basis on which agricultural policy makers can plan for irrigation in particular regions and provide a strategy for combating drought. It can also be extended to other regions in order to target high yielding crops and those with a high market value as was done in the Sudan (Dafalla, 1996; Ibrahim, 1999). The authors are in the process of developing a computer programme that will handle this aspect the limitations in the study are because of insufficient and missing data and because of the inherent assumptions in frequency analysis (Subramanya 1995).

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SPP 5
New Developments in Livestock and Fishery Statistics

Organizer: Alberto Zezza, World Bank and Flavio Bolliger, IBGE

Chair: David Babalola, Nigeria NBS

While a large number of developing countries exhibit serious weaknesses in statistics pertaining to the crop sector, the deficiencies in terms of nationally-representative data on the livestock and fishery sectors are even more acute. Indeed, only recently – with growing consumption of high-value foods in the developing world – there is increased attention towards the potential contribution of these sectors to economic growth and poverty reduction.

The proposed session aims to be a platform for discussing recent advances in approaches and methods for improving the availability and quality of livestock and fishery statistics, with a particular focus on developing countries. Quantifying and valuing the net contribution to household livelihoods and the role of livestock and fisheries in the economy requires the availability of reliable and complete data as well as sound analytical methodologies. Both livestock keepers and fisher-folks are often not well represented in national sample surveys, either for structural difficulty in sampling and surveying mobile and/or geographically remote households or for outright neglect at design stage, or lack of a specific definition.

The session will feature papers and presentations reporting on the development and application of new data collection methods on livestock and fisheries, with the aim to identify best practices and ideas that can be further validated or are ready to be scaled up in national data collection processes. The contributions in this session will contribute to starting a debate on livestock and fishery statistics in the context of the implementation of the Global Strategy.

Papers:

- Guilherme Guimarães Moreira, Marcos Paulo Soares de Freitas, Antonio José Ribeiro Dias et al. (Brazil), "Fishery Statistical Metodology: onboard fishing"
- Sachiko Tsuji, Jennifer Gee (FAO), "How to integrate Agricultural Census with Regular Data Collection of Aquaculture and Fishery Statistics"
- Carlo Azzarri, Elizabeth Cross (USA), "Integrating Data from Different Sources: improved spatially-disaggregated livestock measures for Uganda"
- Ugo Pica-Ciamarra (FAO), Alberto Zezza (USA), Derek Baker (Kenya) et al. "Questions that Count: a livestock module for multi-topic household surveys"
- Alberto Zezza, Giovanni Federighi (Italy) "Milking the Data: measuring income from milk production in extensive livestock systems – experimental evidence from Niger"

Fishery Statistical Methodology: onboard fishing[1]

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Abstract

In 2008, the Special Secretariat of Aquaculture and Fisheries (SEAP), nowadays Ministry of Fisheries and Aquaculture (MPA), created a working group to discuss the fishery statistics conducted by ESTATPESCA (IBAMA, 1995 and ARAGÃO, 2006), a statistical monitoring program implemented by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), and by other state agencies.

After 4 years of discussions, simulations and pilot surveys, this group produced a technical report (LIMA-GREEN and MOREIRA, 2012) on a methodology of a probabilistic sample survey to measure the variability of estimates of production and effort of fisheries.

Since May 2011, this methodology has been applied in Espírito Santo, a Brazilian Federation Unit (UF), bringing very encouraging results.

In this paper, we describe the sampling plan proposed and its advantages and differences in relation to the previous methodology (ESTATPESCA methodology). Furthermore, we present the results of point and variability estimates of fishery production and effort of the Federation Unit of Espírito Santo.

Keywords: fishery monitoring; sampling; production; fishery effort.

Background

In 1962, when the Superintendence for Fishery Development (SUDEPE) was created, fishing was recognized as a staple industry for financial support by official credit lines. From then to the mid-1980s a number of fishery programs were developed and applied especially in order to develop the fishing activity in Brazil.

With the recognition of fishing as a staple industry, the sector's statistics now became more relevant from the economic-financial viewpoint. They had been formerly calculated and published by the Production Statistics Service of the Ministry of Agriculture and by IBGE (PEIXOTO FILHO & DIAS, 1988), and were now attributed to SUDEPE in 1967, which undertook and completed this task until 1979. In 1980, this activity was then again allocated to IBGE in conjunction with SUDEPE, which adopted the methodology created by the latter, and which used three questionnaires: one for the fishing industry, another for colonized fishing and a third for the non-colonized fishing. This administrative-methodological model prevailed until 1989, in which IBGE and SUDEPE produced and published the fishery statistics.

That same year, Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) was created in the sphere of the Ministry of the Environment, and this new institute absorbed SUDEPE duties and personnel. As a result of this merger process the production of statistics was interrupted for some years. It was only in 1991 that fishery landing data collection was resumed by IBAMA, when it created and developed a fishery methodology of its own called the Fishery Statistics Program, or simply EstatPesca. At the start, this program was put in place in the Northeastern Brazilian States, and was later extended to all Brazilian coastal States.

In 1995, the then President of the Republic Fernando Henrique Cardoso signed Decree no. 1694, creating the National Information System for Fisheries and Aquaculture (SINPESQ). Once again IBGE was given the task to coordinate production, systematization and publication of fishery statistics in Brazil. The purpose of this system is to collect, aggregate, process, analyze, exchange and disseminate information about the national fishery sector.

SINPESQ, under the decree, should basically contain data and information produced by the Brazilian Institute of Geography and Statistics (IBGE) and the Ministries of Agriculture, Supply and Land Reform, the Environment, and Tourism, for example, as well as those available from the other federal, state and local agencies, learning and research institutions and agencies involved in the fishing sector. Moreover, it should prepare a working plan defining the duties and those responsible for actions arising from its

adoption. Most of the activities and information required refer to the statistical monitoring of fishery and aquaculture, namely, the ongoing systematic collection of information relating to the fishing activity throughout Brazil.

Although IBGE is officially given this task, it no longer collects the information nor produces the sector's statistics. IBAMA and other regional institutions carried on with these activities and only in some States does IBGE participate only in closing the annual results. In other words, the 1995 decree remained with no practical consequences, a situation that lasted until the mid-2000s, when the Special Board of Fishery and Aquaculture (SEAP) was created under the Provisional Measure 103 dated January 1, 2003, and then later on June 29, 2009, adopted ministry status to become the Ministry of Fishery and Aquaculture (MPA).

As soon as SEAP was created, it felt the need for more detailed data on the fishing activity, which culminated in 2007 in a seminar, attended by various fishery-related agencies, as well as by representatives of the civil and academic societies. At this seminar some problems were raised regarding the methodology used by IBAMA for estimating fishery statistics: EstatPesca (IBAMA, 1995). As a result of these comments, SEAP sought the help of IBGE to be able to solve the problems with EstatPesca.

Some studies were carried out and a new methodology was suggested to correct the earlier problems. A pilot survey was then undertaken between May and July 2009 in the States of Ceará and Pernambuco. Slight adjustments were made and the methodology concluded in 2010 and published by IBGE in 2012.

In January 2011 the then Ministry of Fishery and Aquaculture, in an agreement with the Federal University of Espírito Santo (UFES) resolved to implement the Fishery Study to be carried out under the new methodology developed by IBGE but not yet published, along the coast of Espírito Santo State. There, the Fishery Statistical Methodology: Onboard Fishing, or simply MEPE, was fully put in place, the team was trained by IBGE and MPA specialists and the data collected from April of that year. The results point to an estimated total fish catch of 8,473 t for the 12-month period - April 2011–March 2012 - with a variation coefficient of 2.4%.

That same year, 2011, another agreement, this time with the Federal University of Rio Grande (FURG), was reached to estimate the volume of sea fish caught and/or landed in Patos Lagoon. In 2013, after the successful implementation of MEPE in Espírito Santo, it was now fully adopted by FURG. IBGE specialists visited Rio Grande, in Rio Grande do Sul State, to train the coordination, supervision and collection teams.

In 2014, it is expected to put MEPE in place all along the Brazilian coast.

After this brief background of the fishery statistics in Brazil, the next sections will address the problems that triggered the request for a new collection and estimation methodology for production and fishery information by SEAP, now MPA, and some of the main results from the experiment in Espírito Santo will be presented.

Problems with the EstatPesca Sample Design

The sample design adopted in EstatPesca is the "Partial control of the fleet in some locations" type, with stratification of the locations by the size measured by the total number of registered boats. The ports with a large number of vessels formed the Management Stratum, in which all locations were selected. Other ports with fewer vessels formed Sampled Strata, in which some of the locations were selected.

It was found that:

- There was effective control in some of the landing locations but the stratification criteria by size and their selection were not only unexplained but apparently were only adopted in some of the landing locations. For example, large locations - even larger than others in the correct stratum – are not controlled.
- At each selected location some of the vessels were selected (in some cases census-based), depending on the size of the location and type of fishing practiced there. The probability selection criteria are not explained and it is not certain whether it was done at random. From the interviews with the collectors working in the visited ports, there are reasons to believe that this did not strictly occur or, at best, only partly. Some of the controlled fleet was apparently selected at random, taking into consideration a subjective criterion of the collector.

Although recommendable from the methodological viewpoint, there is no sign that a rotation of part of the selected fleet was provided for control purposes.

The sample design adopted in EstatPesca foresees that catch estimates result in the product of another two estimates:

- The first is estimated based on the data collected in the monitoring according to the sample design that has just been summarized above.
- The second is the result of registration update that must be done monthly, according to which the design provides this in all fishery landing locations in the State and not only where monitoring is undertaken.

This is undoubtedly one of the weakest characteristics of every sample design applied in EstatPesca. A monthly survey of the number of active vessels operating in each port of the State is provided. Not to mention that this information, even if perfect, would still be insufficient since as proxy for the fishery effort, which is the role it plays in this case, is not taking into account the key characteristics of the production unit, namely the number of fishermen, number of fishery equipment items, fishery strategy, etc. So, one of the estimation portions is a result of a very fragile procedure, which undermines the overall estimates.

New methodology and its benefits for EstatPesca

The new fishery statistical research methodology for onboard fishing, MEPE, solved the problems of the old methodology with regard to the sample design and data expansion.

The MEPE, in statistical terms, is a production statistical survey that has a complex sampling design, which uses phase sampling. This design has three phases as follows:

- Phase 1: Ports and/or landing locations in each Brazilian State are grouped in strata according to their size in relation to the volume of fish landed there. There may be a management stratum, in which the larger ports and those that desire special treatment (e.g. Santo Antonio, the only fishery landing location on the archipelago of Fernando de Noronha). In the other strata a sample of ports is selected.
- Phase 2: In the port and/or landing location strata other than the management stratum, a simple random sample is taken of ports and/or landing locations within each stratum.
- Phase 3: In all ports and/or landing locations selected to be part of the sample the landings will be stratified in two strata as follows: those from local large vessels, where a census will be taken; and those from local small vessels where a systematic sampling of the vessels according to their order of arrival at the location.

This design solves the three aforementioned problems, as follows:

- Selection criteria of the sample of landing locations in this case are clear. The ports in the management stratum are self-representative, namely, they represent themselves and their selection probability is therefore 1. Now those belonging to the sampled strata of location will be selected according to a simple random sample, and there selection probability will be given by the ratio of the number of locations allocated to this stratum by the total number of places contained therein.
- Since the sample involves actual landings rather than active production units, this could raise a major problem regarding registration. This problem was solved using in the last selection stage a systematic sampling of landings occurring at the location of question. The benefit of this type of sampling is that it is the only type of probability sampling where there is no need to have a list of units beforehand, built up during the sample section process. This selection strategy has also solved the third problem of the rotation of the sample of the selected units, since the permutations of landings occurring in one day are different from those on the other days and a totally different sample has to be taken daily from the day before.
- With regard to calculating the estimated catch production, whether total or by fishery type, since there is a probability sample design, such problems were solved since the selection probabilities of ports and landings are fully explicit and anyone can calculate them.

Calculating the estimates of the total and their variability

The major benefit of using a probability sample design is that we can calculate the size of a required sample in order to have a sampling error of the size we want. If we want a small sample error, then we will have to have a relatively large sample, if the sample error could be larger, the sample will be smaller.

In the case of the State of Espírito Santo, we did not know the level of the variability of the main variable of interest: all fish unloaded during landing.

To attempt to solve this problem, a high number of locations, known to have a large volume of fish landed there, were placed in the management stratum. Moreover, in 23 of the 24 ports selected as part of the port sample of the State a census sampling was taken of local small vessels, because at these locations there were very few landings of this category, on average less than 40 landings a day. Therefore, the variation coefficient of all landed fish in Espírito Santo was approximately 2.4%, with an estimated total volume of 8,473 t over the 12 months between April 2011 and March 2013.

The estimated total fish caught in the State is calculated by:

$$\hat{Y} = \sum_{h=1}^{H} \frac{M_h}{m_h}\left[\sum_{p=1}^{m_h}\left(\sum_{i=1}^{N_{hp}^{(G)}} y_{hpi}^{(G)} + k_{hp} * \sum_{i=1}^{n_{hp}^{(P)}} y_{hpi}^{(P)}\right)\right]$$

where,

H is the total number of location strata;

$h = \{1,2,\dots,H\}$

M_h is the total number of landing places of the h-th location stratum;

$m_h = \{1,2,\dots,M_H\}$ is the number of places in the sample belonging to the h-th location stratum;

$p = \{1,2,\dots,m_h\}$

$N_{hp}^{(G)}$ is the total number of landings from locally considered large vessels of the p-th port of the h-th location stratum;

$n_{hp}^{(P)}$ is the number of sampled landings from locally considered small vessels of the é p-th port of the h-th location stratum;

k_{hp} is the leap in systematic sampling associated with the p-th port of the h-th location stratum;

y_{hpi} is the total fish caught and landed by the i-th unloading at the p-th port of the h-th location stratum.

The estimated variance of the total is calculated by the sum of the variations within each stratum, which is given by the following expression:

$$\widehat{Var}(\hat{Y}) = \sum_{h=1}^{H} \widehat{Var}(\hat{Y}_h)$$

where,

$\widehat{Var}(\hat{Y}_h)$ is the estimate of the variance of the estimate of all fish unloaded in the h-th location stratum.

The estimate of the variance of the estimation of the total for the management strata, each port belonging to this stratum being considered as only one stratum, is given by the following expression:

$$\widehat{Var}(\hat{Y}_h) = \sum_{p=1}^{1} (k_{hp} * n_{hp}^{(P)})^2 * \left(1 - f_{hp}^{(P)}\right) * \frac{\sum_{i=1}^{n_{hp}^{(P)}}\left(y_{hpi}^{(P)} - \bar{y}_{hp}^{(P)}\right)^2}{\left(n_{hp}^{(P)} - 1\right)}$$

where, $\bar{y}_{hp}^{(P)}$ is the simple sampling average of the fish caught from considered small landings of the p-th port in the h-th location stratum;

$f_{hp}^{(P)} = \frac{n_{hp}^{(P)}}{N_{hp}^{(P)}} = \frac{1}{k_{hp}}$ is the correction factor of a finite population for the p-th port in the h-th location stratum;

$N_{hp}^{(P)}$ is the total number of landings from locally considered small vessels of the p-th port in the h-th location stratum.

On the other hand, for the samples location strata, the variance of the estimated total is estimated by the following expression:

$$\widehat{Var}(\hat{Y}_h) = \frac{M_h}{m_h} * \sum_{p=1}^{m_h} \frac{\left(n_{hp}^{(P)} * k_{hp}^{(P)}\right)^2 * \widehat{Var}(\hat{Y}_{hp})}{n_{hp}} + \frac{M_h^2}{m_h} * (1 - f_h) * \frac{\sum_{p=1}^{m_h}\left(\hat{Y}_{hp} - \bar{Y}_h\right)^2}{(M_h - 1)}$$

where,

$\bar{Y}_h = \frac{\sum_{p=1}^{m_h} \hat{Y}_{hp}}{m_h}$, is the estimate of the average total of fish caught in the h-th location stratum;

f_h is the correction factor of a finite population for the h-th location stratum;

$\widehat{Var}(\hat{Y}_{hp}) = (k_{hp} * n_{hp}^{(P)})^2 * (1 - f_{hp}^{(P)}) * \frac{\sum_{i=1}^{n_{hp}^{(P)}}\left(y_{hpi}^{(P)} - \bar{y}_{hp}^{(P)}\right)^2}{\left(n_{hp}^{(P)} - 1\right)}$, is the estimate of the variance of the estimated total of fishery catch in the p-th port of the h-th location stratum.

Actual estimates calculated using the MEPE

The MEPE was fully used for the first time to estimate the fishery production in the State of Espírito Santo. There the information was first collected in April 2011 and proceeded until late December 2012. The MPA provided the microdata for the first collection year: April 2011- March 2012. For this one-year period the fishery production of a Brazilian State was estimated using a probability sample for the first time.

This allowed us to calculate for each estimate, statistics to indicate the quality of information estimated therein. This quantity is the variation coefficient of the estimate. In this way we estimated that the landed fish all along the Espírito Santo coast was 8,473 t, and its estimated variation coefficient was 2.4%. This means that the estimate error for all landed fish along the Espírito Santo coast is at most more or less 4.7%.

The table below shows the estimates of total fishery of the 12 main species landed there, for which

Table 1: Estimates of the total fishery catch in Espírito Santo State for the main species.

Espécie		Estimativa de Captura	
Nome Popular	Nome Científico	Peso (t)	CV (%)
Total		8.473	2,4
Camarão Sete Barbas	*Xiphopenaus kroyeri*	2.046	3,8
Dourado	*Coryphaena spp.*	1.750	0,2
Albacora Lage	*Thunnus albacares*	650	0,1
Bonito	*Sarda sarda*	397	0,7
Pargo	*Pagrus pagrus*	339	15,4
Cação	*Selachimorpha spp.*	290	3,2
Pescadinha	*Isopisthus parvipinnis*	267	13,8
Corvina	*Micropogonias furnieri*	257	5,3
Baiacu	*Lagocephalus laevigatus*	210	9,1
Peroá	*Balistidae spp.*	142	3,7
Espadarte	*Xiphias gladius*	124	0,3
Sarda	*Scombrinae spp.*	103	2,9

the total estimated landing exceeds the 100 t mark and their variation coefficients.

As Table 1 shows, the estimates for the total fishery per species are very good, since they present a variation coefficient of less than 10% for almost all species, except sea bream and whiting. The variation coefficients for the estimated variation of the total sea bream and whiting landed on the Espírito Santo coast are higher than the others due to the fact that these species of fish are mostly caught by smaller vessels, and because quite widespread fishing of these species are found off the State coast.

Since this kind of vessel forms the bulk of the fleet of small and medium-size ports and/or locations, and since they are allocated to the sampled strata, we have, therefore, an explanation for the high variability associated with fishing sea bream and whiting: their landings are associated with the vessel size strata and locations associated with the variability of the process, since unit sampling is taken in these strata – whether landings or ports.

Conclusions and next steps

Having completed the pilot tests and put the MEPE in place in the States of Espírito Santo and Rio Grande do Sul, where the collection is being currently done using this methodology, we consider the results very satisfactory, especially since we can use a technique that permits the calculation of the estimates and their sampling errors, and consequently, a measure of quality for each calculated estimate.

The variation coefficients are small, which indicates that the sample size is suitable for estimating these quantities.

MPA is working to put the MEPE in place all along the Brazilian coast, with the start of the collection expected in the first half of 2014.

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Endnotes

1 IBGE is exempt from any responsibility for the opinions, information, data and concepts presented in this report which are exclusive responsibility of the authors.

How to Integrate Agricultural Census with Regular Data Collection of Aquaculture and Fishery Statistics

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Abstract

The fishery and aquaculture sub-sector, especially those of small-scale operations, play an important role in supplying high-protein food to local communities and in providing alternative measure of livelihood and opportunity for poverty alleviation in rural area. Also, the fishery and aquaculture sub-sector does not exist in isolation but is closely linked with other sectors activities, society, economics and environment of local communities, e.g. composite operations such as rice-paddy aquaculture, competition as well as symbiosis over land and water uses, engagement to multiple activities of individuals and households, seasonally sharing of resources, linking to tourism etc. While quite substantive knowledge and case studies have been accumulated on such interrelationship among different components, we do not have standard methodology to collect data that represents an overall rural picture on a regular basis. The Global Strategy for Improving Agricultural and Rural Statistics adopted in 2010 by the United Nations Statistical Commission (UNSC) would provide a powerful framework to integrate statistics from various domains into one comparable system. The paper explored the similar strategy and framework to enhance an integration of data obtained by various existing mechanisms. The framework was developed with the assumption that the fishery and aquaculture survey modules would be systematically incorporated into the 2020 round of World Agriculture Census. The framework envisages its coherence and integration into national statistics and SEEA compilation.

Keywords: fishery; aquaculture; statistics; SEEA; census; data integration; small scales.

1. Background and Overall strategy

The fishery and aquaculture sector, especially those of small-scale operations, play an important role in supplying high-protein food to global and local communities and in providing alternative measure of livelihood and opportunity of poverty alleviation in rural area. The small scale and subsistence component of the sector accounts for 90 % of people engaged in fisheries and, in fact, produces about half of the global production. This component of the sector interacts more with other sectors in the same local community than the industrial component: competing for land and water access; labour and markets; sharing infrastructure; and being mutually dependent or in conflicting interests. Despite its significance and complexity, it is quite rare for countries to maintain any reliable statistics on small scale and subsistence fishery and aquaculture and they are mostly aggregated into the agriculture sector, or even not counted at all. This often causes under-representation of the sector's interest in national and regional policy making and lead to marginalization of the sector.

This document explores a pragmatic procedure to improve national capacity to monitor the fishery and aquaculture sector, especially the small scale and subsistent component. The primary focus is to obtain an overall but more accurate picture indicating relative importance and needs of the fishery and aquaculture in the context of overall national policy. The proposed framework intends to achieve i) coverage on various aspects of the sector activities and impacts and ii) improved integration and comparability with other sectors' information as well as the national statistics as a whole. With full recognition of the general difficulty of investing resources to monitor a relatively minor sector, the emphasis is given to enable full and effective utilizations of existing instruments and frameworks, rather than developing new instruments.

2. Overall concept of the framework

The framework was developed in accordance with the basic concept adopted by the Global Strategy of Improving Agriculture and Rural Statistics (World Bank, 2010). The Global Strategy was composed with three pillars including i) the establishment

of a minimum set of core data that countries will provide to meet the current and emerging demands, ii) the integration of agriculture into the national statistical systems mainly through a Master Sample Frame for Agriculture, Integrated Survey Framework, and a Data Management System and iii) the enhanced foundation through governance and statistical capacity building. Here the Fishery and Aquaculture Data Collection Framework is a set of propositions to achieve the second pillar of the Global Strategy for the fishery and aquaculture component. The main objectives are to show a way to integrate data and information collected with existing systems, to enhance comparability and integration of fishery and aquaculture statistics into the agriculture as well as into the national statistical systems, and to obtain better visibility of benefits and needs for the sector in national policy making.

The framework is composed of a core data frame, a set of tables assisting with coordinating data collection by various data collection and monitoring mechanisms, and general guidelines for data integration and compilation of standard statistics.

A core data frame was defined based on the general structure of the System of Environmental and Economic Account (SEEA)[1] whose central framework was adopted by the United Nations Statistical Commission at its 43rd Session in 2012, as the first international standard for environmental-economic accounting. The SEEA Central framework provides a basis to measure sustainable use of natural resources, including those important for fishery and aquaculture, such as land, water and aquatic living resources. Unlike the case of a 'minimum set of core data' of the Global Strategy, a core data frame does not indicate the minimum required data to be collected by all data collection mechanisms but reflects a caveat of information potentially obtainable through existing data collection mechanisms either with or without slight modifications. Certain information of emerging needs is also included in a core data frame without identifying any corresponding mechanisms if not applicable. The main role of this data frame is to review an actual situation and potentials, to identify gaps and duplication and to move toward development of an implementation plan to realize further coordination and integration among different mechanisms.

Although the minimum set of core data to be collected commonly is not clearly defined, the framework requires always identifying the geographical attribute of information collected. When geographical attributes does not match with the geographical attributes of operators, the information linking between geographical attribute of activities and geographical attribute of operators should be collected. This would be used to combine the framework with those under the Global Strategy.

A set of data template tables are used to shows a range of information collected in typical cases through data collection mechanisms. These tables describe a range of data items collected from the prospect of individual data collection mechanisms and show how to link to a core data frame. The tables included in this paper merely indicate examples of the concept. Though these could be utilized as guiding templates, actual tables should be developed in a case by case manner based on real situations.

In this framework, the censuses (e.g. population census, agriculture census and fishery and aquaculture census, if applicable), including specialized surveys conducted in conjunction with censuses for selected communities, would provide a snapshot covering the full spectrum of the fishery and agriculture sector throughout a country. Census data should be analysed to evaluate similarities in operational patterns and productivities among different geographical areas and segments, e.g. through cluster analysis and/or component analysis and then to develop a multiple layers of stratifications that would be used to estimate for non-surveyed cells. On the other hand, existing mechanisms of collecting regular fishery and aquaculture statistics, and monitoring relating with fishery management would play a role in tracking temporal changes, in particular of production and other resource use, as well as social and economic aspects to a lesser extent, and providing reference for temporary change when estimating data in non surveyed time-area cells.

In principle, estimation of non-surveyed cells would be done by multiplying frame data, such as numbers of fishers, fishing boats, and aquaculture farms, as well as overall extent of aquaculture facilities, with average productivities (e.g. average daily catch, monthly farm production of certain categories, etc.) of corresponding stratification. Therefore, it is important that the majority of data collection mechanisms in the framework ensure collection of these two datasets is done consciously with a clear description of the time and area that the survey represents. It should be noted that the general

guideline of standard methodology encourage the collection of a daily catch from random surveys that is multiplied with the number of boat-days fishing to obtain capture fishery production statistics (FAO, 2002).

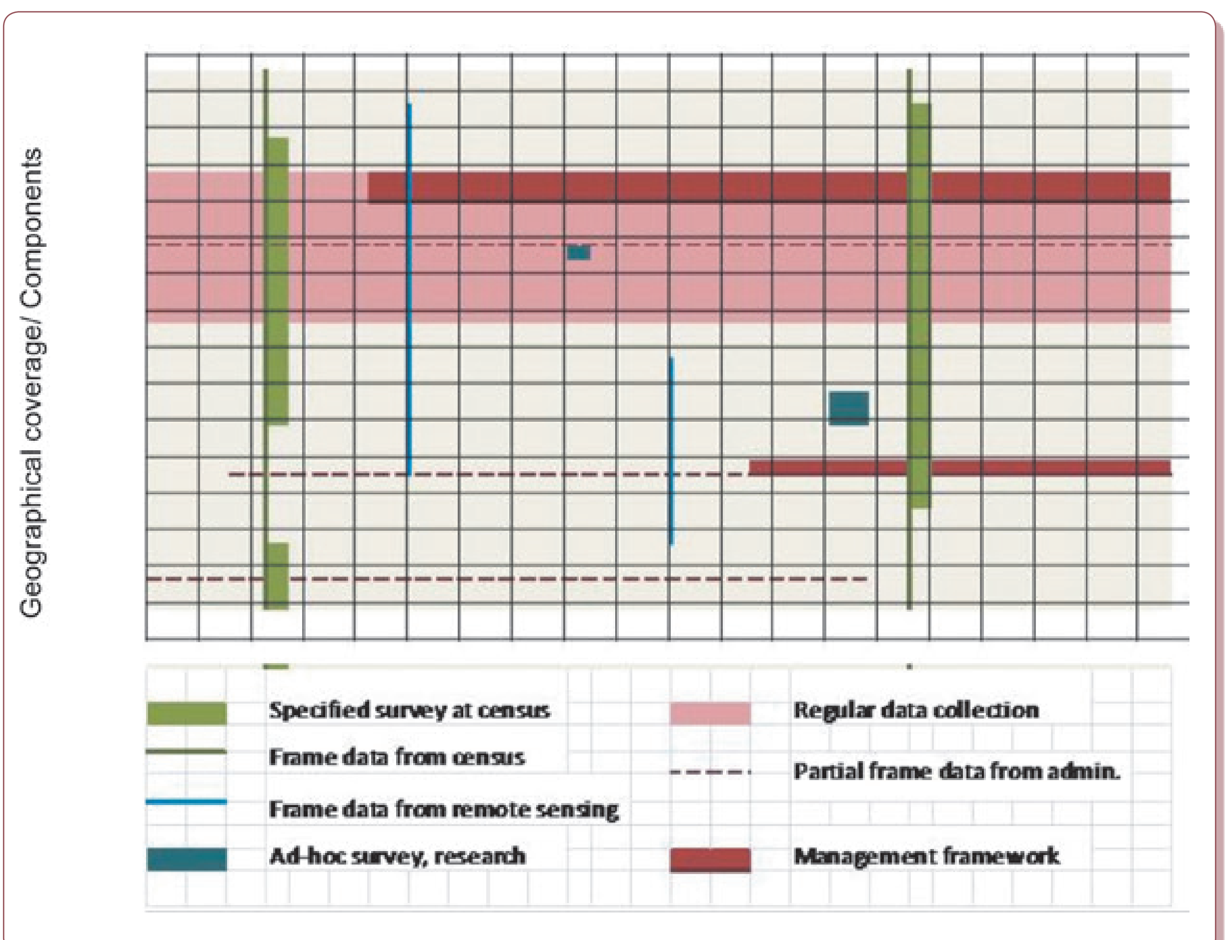
Administrative data, especially registration of vessels, port entry and exit reports, and registration of aquaculture facilities, would provide direct measure of temporary changes of frame, although it must be recognized that these are less representative for small-scale operations. Remote sensing, if applicable, is a powerful tool to identify the existence of aqua-farming and can provide another independent data source to supplement spatial and temporal changes of frame data in aquaculture.

In addition, field projects, field surveys, case studies, and dedicated specialized ad-hoc surveys in an area of fishery or aquaculture can provide additional opportunity to obtain in-depth detailed information on specific time-area. By asking for the completion of the standard specific survey questionnaires, in a similar structure as those utilized in census and corresponding surveys, those ad-hoc surveys can also provide precious point reference information to adjust estimation on that specific area/component surveyed. This will also help to evaluate the relative value of such ad-hoc survey in relation with overall national condition and policy making.

The concept is shown in Figure 1 in a schematic way.

Temporary changes

Figure 1: Schematic concept of Integrated Fishery and Aquaculture Data Collection Framework. Lines representing frame data collection and collared space for productivities and other data collection. Width of bars reflects indicative coverage in geographical and content spaces.



3. Core data frame - Expanded SEEA for Fishery and Aquaculture

The core data frame is a list of data items primarily required in the management of fisheries and aquaculture. It follows an accounting structure in general and concepts and data requirements established in SEEA but is adjusted and expanded to address additional information needs specifically for fishery and aquaculture sector management.

Capture fishery in particular, and to a lesser extent aquaculture, heavily rely on healthy and sustainable aquatic ecosystems and accessibility to such ecosystems by the sector. In turn, fishing and aquaculture activities themselves have substantial impacts on sustainability and maintenance of healthy and productive aquatic ecosystems. Monitoring aquatic ecosystem health and fishing resource condition is not an easy task, partly because we cannot see directly underneath the water. Recognizing the difficulty to manage things not clearly visible, the two global guiding instruments, the United Nations Convention on the Law of the Sea of 10 December 1982 (UNCLOS)[2] and Code of Conduct of Responsible Fishery (CCRF)[3], place an emphasis on the importance of management based on best available information. This has implications not only for information on stock conditions and fishery operations, but also for social and economic aspects. Transparency in decision making, especially participation of stakeholders, is accepted as critical through accumulation of experiences, for successful implementation of fishing measures, which also facilitate retrieving high-quality information from stakeholders. Here, fishers are not the only stakeholder. Multiple, sometime mutually conflicting, interests coexist in relation to the conservation and utilization of aquatic ecosystems. Also, many of the factors affecting health and sustainability of aquatic ecosystems originate from the external components, including urbanization, industrialization, and waterfront development and these often cause pollution and serious degradation of important productive habitat. The concept of an ecosystem approach for fishery management and aquaculture management (EAF/ EAA)[4] (FAO, 2003, 2010) defines how to establish an integrated management mechanism under such requirements, which in the end is a feedback adaptive management based on a range of indicators, i.e. leading more information needs in a broaden areas.

The range of information required to be monitored can be summarized as:

- Social contribution by the subsector: engagement in the sector, by separation of fully, partially or occasional, and disaggregated by age and gender;
- Economic contribution of the sectors: cost of production, total production in value, value added, fish prices, imports and export, market access;
- Environmental cost: total extraction from natural living resources, release to natural environments (e.g. seeds, wastes, chemicals), water utilizations (intake, release, occupied, access), land use;
- Natural environment conditions: water resource availability, accessibility, and quality, biodiversity, protected area, conservation measures;
- Climate change impacts: economic and physical loss by hazards (physical, and biological – outbreaks of certain organisms, diseases);
- Contribution to food security: total supply as fish food, utilization to non-food products, fish food consumption; and
- Government expenditure: subsidies, registration fees, fees of access agreements, cost for Monitoring, Surveillance and Control (MCS), government operated support facilities including hatchery, technical research and development, cost for environmental conservation and restoration.

Monitoring of degradation of natural ecosystem, pollutions, wastes, and urbanization are other areas that are quite important for the sector, but no information is readily available for these areas.

The SEEA, in fact, provides a framework covering quite large part of the above listed information, either as directly targeted items or input to compile asset or flow tables. In addition, following the decision taken by the United Nations Statistical Commission in 2012, the core central framework of SEEA was adopted as the global standard measure of sustainable use of natural resources, including land, water and living resources. New frameworks for fishery and aquaculture, when developed in accordance with SEEA basic concepts, would imply easy link and comparability with similar information collected for other sectors, as well as the information collected under the new framework could be directly integrated into the national statistics. Last, but not

least, as long as individual compilation units are mutually exclusive and classification breakdown follows a common hierarchy, an accounting system allows integrating a compilation of results from various sizes of compilation units containing various levels of data detail. This is strongly beneficial when considering the integration of information obtained from various schemes of different objectives, coverage and principle requirements.

Table 1 indicates a first draft of a core data frame mainly covering the components in common with those in the SEEA-Agriculture (SEEA-Agri.), on-going parallel activities under FAO, which would be a primary part of integration in a short to medium term. The authors actively participate in developing SEEA-Agri., specifically for its application to fisheries and aquaculture, to ensure full coherence between the two initiatives.

Table 1: Draft content table of a core data frame of fishery and aquaculture. Superscript letter indicates duplication of the same information item in multiple places.

Information items	Census	Regular surveys	Admin. data	Others
I. Asset and use of aquatic living resources (physical/monetary)				
Farmed stock				
1. Opening and closing stock	✓	✓		
Addition:				
2. Seeds and brood stock inputs from wild	★	★★		
3. Import of seeds/ brood stock		★★		
Intermediate supply and use:				
4. Supply seeds to other farms	★	★		
5. Purchase of seeds from other farms	★	★		
Reduction:				
6. Gross harvest b	★	★		
6a. Harvest loss				
7. Release to natural environment (e.g. stocking) a	★	★	★★	
8. Catastrophic losses -- diseases				★★
9. Catastrophic losses -- others			★	★
Supplementary information:				
10. Number of aqua-farmers	★	★★	★	
11. Other inputs – feeds, energy	★			★
Wild stock				
12. Opening and closing stock				★
Addition:				
Farmed seeds released (e.g. stocking) a	★	★	★★	
Reduction:				
13. Gross harvest c by national flag	★	★★★		
13a. Gross harvest within national waters		★★		
13b. Gross harvest outside national waters		★★★		
14. Gross harvest by foreign flag within national water			★★★	
Supplementary information (incl. stock evaluation):				
15. Fishing days		★★	★★	
16. Number and capacity of fishing boats		★★	★★	
17. Number of fishers	★★	★★		
18. Other inputs – baits, fuels	★		★	★

II. Supply and use of fish and fish commodities (physical/ monetary)				
Supply				
Gross harvest – aquaculture b	★	★★★		
Gross harvest – capture c	★	★★★		
19. Import		★★	★★★	
Use				
20. Intermediate consumption				
For food processing				
For fish meals/ fish oils				
For other industrial use				
21. Export		★★	★★★	
Export – ornamental				★★
22. Household consumption	★			★
23. Loss/ waste				
Supplementary – Intermediate output				
24. Production of fish food commodities		★★		
III. Land and water use (physical/ monetary)				
Opening/ closing stock				
25. Land area used for aquaculture	★		★	
26. Rice-fields with/without aquaculture	★	★		★
27. Inland water bodies/ marine water (incl. EEZ)			★★	
27a. Occupied by aquaculture facilities	★	★★	★	★
27b. Enhanced area (areas under management)			★	★★
27c. Protected area (no access to fishing)			★★★	
Water use by aquaculture				
28. Water stock within aquaculture facilities	★	★	★	
29. Turnover rate	★	★	★	
30. Chemical inputs	★	★		★
31. Quality of returning water	★			★
Water use by capture fishery				
32. Water area used by fishery	★			★
33. Fishing days/ fishing gears used		★★	★★	
34. Abandoned/ lost gears			★	
Seasonal waters				
35. Maximum/ minimum extent of water area		★	★	★
36. Months accessible by fishery	★	★		★
Supplementary				
37. Waters with ownership/ tenure/ access right	★		★	
IV. Government expenditure (monetary)				
Income				
38. Access fee for foreign fleet			★★★	
39. Tariff, registration/ quota fee etc.			★★★	
Expenditures				
40. MCS and other management costs			★★★	
41. Loan, grants, subsidies			★★★	
42. Protection of stocks, environment			★★★	
43. Hatcheries, stocking			★★★	
44. Information dissemination, statistics			★★★	
45. Protected areas, reserves			★★★	

The core data frame is currently composed of four components:

i. Asset and use of aquatic living resources (physical/ monetary);

ii Supply and use of fish and fish commodities (physical/ monetary);

iii Land and water use (physical/ monetary); and

iv Government expenditure (monetary).

The first three components are in accordance with those developed under SEEA-Agri, including the component i) which specifically corresponds to the asset table of aquatic living resources of the SEEA central framework. Component iv) is an expansion of Government expenditure table in the System of National Account and was added to address specific interests from fishery sector.

Items are added mainly to enable assessment of social contribution, operational cost and contribution to food security, which are not the main objectives of SEEA. The absolute estimates of opening and closing stocks of wild aquatic resources are usually not readily available. A method of rough evaluation is currently under development but the list of information items under wild stock asset monitoring reflects the minimum data need to conduct such estimation.

The table also indicates initial thoughts on possible and existing data sources in four categories: i) the censuses (population census, agriculture census and fishery and aquaculture census, if applicable) plus specialized surveys conducted in conjunction with censuses for selected samples, ii) existing mechanisms of collecting regular fishery and aquaculture statistics, and monitoring relating with fishery managements, iii) administrative information, including registrations, licensing, port entry and exit report, inspection reports, and tax declaration, as well as those collected under MCS on fishing activities, and iv) any other information available including remote sensing data, researches, results from field projects, field surveys, case studies, etc.. In the table, one tick means "potential to be a source with moderate modifications of procedures and classifications", two and three ticks correspond to those "currently providing partial data" or "data of reasonable coverage", respectively.

The table will guide to identify gaps and duplication and to develop actual strategy of integration to be implemented in the next phase.

4. Data collection by main instruments and a link with core data frame (examples)

This section describes examples of data template for key data collection instruments indicating a range of information currently collected or potentially collected to support integration into a core data frame. The coverage and level of details of information collected would vary according to the original objectives of individual data collection mechanisms. In some cases, data collection procedures and classification may need to modify to enable integration to a core data frame. In that case, the modification should be kept as minimum and in a way ensure data continuity as much as possible.

4.1. Censuses and corresponding specialized module surveys

The framework plans to utilize various censuses (population census, agriculture census, fishery and aquaculture censuses, when applicable) to obtain national snapshots covering a full spectrum of components in either frame data or more detailed sectoral information. The information collected will provide a basis for establishing multiple layers of stratifications that will the be used to estimate non-surveyed cells by interpolation as well as to redesign regular sampling strategy to improve representativeness of small-scale operations without increasing sampling cost substantially.

The FAO expanded the expected coverage of the World Census of Agriculture (WCA) starting with the 2010 round to include whole agriculture activities in a broad sense, i.e. including fishery and forestry, and introduced the concept of two-layered survey, the census focuses on collecting structural and engagement information and surveys on more detailed contents for selected communities (FAO, 2005). The second layer surveys would be conducted in a census manner but using various modules specialized for individual sub-sector activities and information needs. Relating to fisheries and aquaculture, FAO plans to provide a guideline toward full integration of the sector in the 2020 round of WCA and implementation guidelines and standard questionnaires for the capture fishery modules as well as revision and updates of the aquaculture module (FAO, 1997) currently under development. Table 2 reflects current consideration of WCA-2020 plans and expected fishery and aquaculture survey modules.

Table 2: A range of data to be able to collect using census frameworks including corresponding specialized surveys. Data items listed takes into account new fishery and aquaculture survey modules currently under development.

National census		
Engagement Engagement to fishing Engagement to aquaculture	Gender/ Age group Full time/ part time/ occasional Employment status Main or secondary	Households Individual
Access to water bodies Water bodies, ponds owned and used for fishing Water bodies, ponds with exclusive access right for fishing Water bodies, ponds usually used for fishing	Main species	Communities Households Individual
Aquaculture facilities		
Registered/ licensed aquaculture facilities: Locations, type, production capacities Facilities, land and water areas occupied Current operational status	Administrative data	Registered owner
Water bodies, ponds, tanks owned	Primary and secondary use	Farming households
Water surface occupied for aquaculture facilities	Main species	
Facility for fishing		
Registered/ licensed fishers/ fishing companies: Area actually fished in the previous unit period Catch and effort in the previous unit period Current operational status	Administrative data Main species Gears	Registered owner
National and regional regulations Access limit/ closed season and areas Protected area Restriction on aquaculture	Types of activities	Administrative units
Community survey		
Total area		
Land area occupied by aquaculture facilities	Ownership - public/ community/ private Operation - public/ community/ private Hatchery/ growing facilities Main species produced	
Land area to support fishing activities	Landing areas Boat/ gear maintenance/ storage	
Total water area:	Ownership - public/ community/ private Exclusive access right	
Water area occupied by aquaculture facilities	Ownership - public/ community/ private Operation - public/ community/ private Brood stock/ growing facilities Main species produced	
Water area used by fishery	Main species Gears	
Total population	Gender/ Age group	
Supporting facilities for aquaculture and fishery - Hatchery/ feed supply plants Landing area/ boat & gear storage and maintenance Corporative association Marketing Ice plants/ cold storage etc.	Ownership - public/ community/ private Operation - public/ community/ private Carrying capacity	
Conservation measures applied Access limit: licenses/ closed season and areas/ Protected area Stocking Habitat maintenance/ restoration etc.	Types of activities Operation - public/ community/ private	

Community survey – Aquaculture – households and aquaculture companies	
Status Licensed/ registered (specify) Participation to cooperative associations	
Engagement [households] – individual member of household Members engaged in aquaculture activities Self-employment/ employee Time to be engaged	Gender/ Age group
Number of employees Management Technical Administrative clerks Labour	Gender/ Age group Full time/ part time/ occasional Local/ foreign
Asset, facilities in stock (physical, monetary, and expected duration to use)	
Volumes of ponds, tanks etc.	Type/ Main species
Water area occupied by aquaculture facilities	Type/ Main species
Land area occupied by aquaculture facilities	
Farmed stock	
Fish in growing phase	Origin/ Species
Brood stock	Origin/ Species
Others	
Feeds	Type
Chemicals	Type
Machinery	Type
Production in the previous unit period (physical and monetary)	
Seeds	Product type/ Species Destination (wild/ other farms/ exports)
Production for food	Product type/ Species Destination (household consumption/ sharing local/ domestic market/ exports)
Production for non-food use Ornamental Industrial use/ supplementary	Product type/ Species Destination (domestic market/ contracted plants/ exports)
Other inputs/ outputs (physical and monetary)	
Water	Abstraction per unit of time or turn over rate
Energy	Utilization per unit of time
Chemicals	Utilization per unit of time
Cost of water treatment	Cost per unit of time
Catastrophic loss in the previous unit period (physical and monetary)	
Loss of farmed fish stock by disease outbreak	Type/ main species
Loss of farmed fish stock by extreme events	Type/ main species
Loss of farming facilities by extreme events	
Community survey – Capture fishery – households and fishing companies	
Status Licensed/ registered (specify) Participation to cooperative associations	
Engagement [households] – individual member of household Members engaged in fishing activities Self-employment/ employee Time to be engaged	Gender/ Age group

Number of employees [companies] Management Technical Administrative clerks Labours	Gender/ Age group Full time/ part time/ occasional Local/ foreign
Engagement [households] – individual member of household Members engaged in fishing activities Self-employment/ employee Time to be engaged	Gender/ Age group
Number of employees [companies] Management Technical Administrative clerks Labours	Gender/ Age group Full time/ part time/ occasional Local/ foreign
Asset, facilities in stock (physical, monetary, expected duration of use)	
Fishing vessels Tonnage, powers, crews, origin Registration/ fishing licenses Operational status	Individual vessel
Fishing gears	Type/ Main target species
Land area occupied: Administrative building/ storage Landing/ processing area and facilities etc.	
Others	
Fuels	Type
Baits	Type
Vessel and gear maintenance materials	Type
Vehicles	Type
Ice plant/ cold storage	Type
Other machinery	Type
Fishing activities in the previous unit period (physical)	
Days at waters	Gears/ Vessel size
Areas fished	
Gross harvest (i.e. total extraction from water)	Species
Discarded catch	
Production in the previous unit period (physical and monetary)	
Production for food	Product type/ Species Destination (household consumption/ sharing local/ domestic market/ contracted plants/ exports)
Production for non-food use Fish oils/ fish meals Ornamental Industrial use/ supplementary	Product type/ Species Destination (domestic market/ contracted plants/ exports)
Other inputs/outputs (physical and monetary)	
Water	Abstraction per unit of time or turn over rate
Energy	Utilization per unit of time
Loss in the previous unit period (physical and monetary)	
Loss of gears	Type
Damage and loss of fishing vessels	Type/ cause
Loss of other facilities by extreme events	Type

Often, census could be the sole opportunity to obtain the information on activities that do not directly target cash earning, though such activities contributing significantly both in positive, e.g. in food security, and negative, e.g. pressure to fish resources, habitat degradation. On the other hand, the relative importance of fishery and aquaculture is not the same across the world. Although it is critical for all countries to disaggregate frame data of fishery and aquaculture, especially engagement, from agriculture, standard criteria to determine whether additional specific module surveys would be needed.

Another challenge is to ensure proper samplings of communities for the secondary module surveys. Fishery and aquaculture sectors may indicate quite a sporadic geographical distribution constrained by availability of access to appropriate accessibility to proper water bodies. This distribution could be quite different from the distribution pattern of other agricultural activities that may be dominant determinants of sample communities for secondary surveys. Pragmatic solutions to secure reasonable representativeness of sector information must be sought to ensure the effectiveness and utility of these module surveys in conjunction with the WCA.

4.2. Monitoring for fishery management and regular landing surveys

The primary goal of fishery and aquaculture management is ensuring sustainable development of the sector and the importance of timely and reliable information to support management has been repeatedly underlined with various instruments. In reality, while the fishing operations under international, regional, and multilateral fishery management arrangements are well monitored with detailed information even to an individual operational level, the monitoring practice becomes much less intensive and fragmented when applied to fishing operations occurring in coastal and inland waters. Nevertheless, wherever the management measures taken, data collection and monitoring are much more intense and frequent with multiple instruments of independent evaluations such as inspections, observers, consistency with modelling analysis and retrospective feedbacks.

In any case, this component covers a substantial part of national production and the quality of data is generally high. Often industrial fleets and coastal small-scale fleets harvest the same resources in the same area, indicating similar temporary trends in catch rates. In that case, small additional survey efforts on the latter may substantially improve accuracy of overall estimation.

I combined the components of regular data collection for fishery production statistics in the table, since the common framework is often served for management and statistical purposes simultaneously. In addition, many countries adopt sample based landing survey as a principle methodology to collect data for national production statistics but their sampling efforts are not necessarily evenly distributed. In general, landings closer to main production as well as main consumption centres are better covered than isolated scattered area as is often the case for inland and small coastal operations. Clearly recognising the existing sampling biases and holes by defining the area of coverage of existing surveys would be a useful initial step to develop national plan to correct under-representation of small scale operations. Therefore, the clear identification of coverage is utilized quite widely for collecting data to provide national production statistics.

Table 3 shows a typical set of information collected under monitoring scheme of fishing operations and/or regular data collection system of fishery production based on landing survey, only focusing the aspect of fishing operation.

Table 3: Typical data items available in monitoring for fishery management and regular sample based landing surveys.

Background information	
Objectives of management scheme Extent of target area Targeted species for management purpose Monitoring indicators, target and reference limit	To be determined according to the needs of individual cases; Should expand to incorporate additional management targets
Applied management tools Access limit/closed season and areas Gear restriction Effort control Catch control	Reference would be modified according to the monitoring indicators, in an agreed manner in advance

Items of regular data collection of fishery monitoring	
Fishing capacity	
Tonnage, power, flag, origins, main gears used	Individual vessel
Crews	Number/ nationality
Non-active vessels	Status/ Causes for individual vessel
Estimates of coverage	
Direct measurement	
Fishing operations (daily by boats or by cruise)	
Gear used/ main target species	Self-report/ inspection
Days at waters	Self-report/ Port entry records
Areas of operations	Self-report/ VMS/ observers
Estimated coverage	
Gross harvest (daily by boats or by cruise)	
Gross harvest by species	Self-report/ observers
Discarded catch by species	Observers/ Self-report
Additional biological information	Observers
Estimated coverage	
Landing (by trip)	
Quality and quantity of landings by main species	Market records/ self-report/ inspection
Size composition of main species	Sample survey at landing site
Detailed species composition of bycatch	Sample survey at landing site
Additional biological information	Sample survey at landing site
Estimated coverage	
Estimates based on random sampling	
Survey at landing (by segment)	
Daily catch by main species per boat	Sample survey at landing site / self-report
Sample coverage	
● Estimated days at waters by segment	
● Estimated harvest by main species by segment	
Additional information potentially useful	
Destination of harvests	
Domestic market	Market records
Export/ Landing at foreign ports	Custom
Fish meals/ fish oils	Market records/ Estimates by receiving plants/
Other processing plants	Self-report/ Estimates by receiving plants/ Aquaculture survey data
Inputs to aquaculture	
Self-consumption (including community share)	
Waste	
Fish consumption	Supply estimates/food consumption survey

Another, even more important component in this category would be the cases where local communities establish their participatory management scheme, preferably based on EAF approach. It is expected this would provide an opportunity to collect information from those segments totally different from those covered by national monitoring scheme, not only for fishing operations, but potentially also covering additional social, economic and environmental aspects, due to the management strategy adopted at relevant communities, when following EAF approach. In this case, the corresponding template table would need to be expanded to reflect the area of coverage.

Further, standard template data tables developed based on local communities' experiences would be helpful for those communities interesting in developing their own management scheme and facilitating the process of designing and developing their own management measures and corresponding monitoring indicators. The increased implementation of EAF will in turns lead to further enhancement of an integrated data collection framework.

4.3. Use of ad-hoc survey information

The final example of a data template is for ad-hoc survey information, including field projects, field surveys, case studies, and dedicated specialized ad-hoc surveys for an area of fisheries and aquaculture. Quite a large number of field projects and surveys have been continuously developed and implemented. Many of them, in fact, collect quite detailed information on specific aspects of certain communities. However, most of such information is left only in the form of a project report in isolation and is extremely rarely incorporated into national information systems. Unless integrated into a specific data system, it is not possible to effectively utilize this data.

Here, Table 4 only defines the template for background and frame information that would help to connect the information collected with the framework and core data frame. Actual data collection and reporting formats should follow those defined in censuses, as much as possible, with only relevant data items selected and expanded if necessary.

This data will not be able to provide statistics, but it can be a precious stepping stone to link and adjust statistics in non-survey time/areas, if a mechanism to integrate them together becomes available. In collaboration with the Memorial University of Newfoundland under their project to establish Information Network to support small scale fisheries, the more elaborated common template table(s) will be developed and the concept will be tested through utilization by field activities under the project.

5. Link with core data frame

This section shows possible examples of the standard compilation in the core data frame for cases where a census provides frame information without module surveys, in addition to regular landing and aquaculture production surveys oriented toward commercial activities. If a census is only collecting

Table 4: Background frame data to be collected commonly for any of ad-hoc survey to allow linkage with other data collected under the framework. For content data reporting, select relevant items in Table 2, in the same format and classifications as much as possible.

Background information -- Frame information on survey subject	
Total area Criteria defining survey subject area Total land area Total water area	Administrative data Remote sensing
Total population Gender/ Age group/ Main engagement	Administrative data
National, sub-regional, communal regulations Access limit/ closed season and areas Protected area Restriction on aquaculture	Administrative information
National, sub-regional, communal support Seeds production R & D/ research in technology Supporting facilities, e.g. cold storage, feeds plants Stocking/ habitat maintenance/ restoration Tax exemption/ subsidies etc.	Administrative information
Household consumption of fish Fish eaten in the previous unit period Type of products – fresh/ frozen/ salted/ dried/ processed/ canned/cooked plate Origin – self-produced, shared, purchased, restaurants	Supplemental survey if applicable to survey samples
Information defining compilation unit	
Information on samples – Sampling criteria/ strata to be covered Sample unit and sample size Estimated coverage/ representativeness	

the frame information, such as number of fishers, farmers, and aqua-farms, which would be the most probable case, the estimation should be done as a single stratum. In this case, in order to avoid substantial overestimation, any information, even if fragmented, should be used vigorously to adjust relative productivities among different segments should be vigorously used.

Table 5: Compilation example, where Xi and Ci indicating observation of i-th strata for regular survey at time t and census output, respectively.

I. Asset and use of aquatic living resources (physical/ monetary)	
1. Opening and closing stock of farmed stock	If covered by regular survey, surveyed cell: Xi, Non-surveyed cell (j): Xi*Cj/Ci If not, census data to be adjusted in proportion with data #6
2. Seeds and brood stock inputs from wild	Same as 1 above. Anecdotal information if available.
3. Import of seeds/ brood stock	Custom data, if not zero
4. Supply seeds to other farms	If covered by regular survey, same as 1 above. When no data available, zero.
5. Purchase of seeds from other farms	If covered by regular survey, same as 1 above. Public hatchery supply to farms (admin. rep). When no data available, zero.
6. Gross harvest of aquaculture	Regular survey: Xi Non-surveyed cell (j): Xi*Cj/Ci
7. Release to natural environment (e.g. stocking)	Public hatchery supply to farms (admin. rep). Additional private data if available
8. Catastrophic losses of farmed stock – diseases	Self-report, if any
9. Catastrophic losses in aquaculture - others	Self-report, if any
10. Number of aqua-farmers	Regular survey: Xi Non-surveyed cell (j): Xi*Cj/Ci
11. Other inputs to aquaculture – feeds, energy	Self-report: Xi Non-surveyed cell (j): Xi*Cj/Ci
12. Opening and closing stock of wild stocks	Calculated (methodology in development)
13a. Gross catch within national waters	Regular survey: Xi evaluated/adjusted with management data Non-surveyed cell (j): Xi*Cj/Ci
13b. Gross harvest outside national waters	Regular survey: Xi
14. Gross catch by foreign flag within national water	Administrative data
15. Fishing days	Regular survey: Xi evaluated/adjusted with management data Non-surveyed cell (j): Xi*Cj/Ci
16. Number and capacity of fishing boats	Administrative data: registry, license: Xi Non-surveyed cell (j): remote sensing if possible, Xi*Cj/Ci
17. Number of fishers	Administrative data: registry, license: Xi Non-surveyed cell (j): remote sensing if possible, Xi*Cj/Ci
18. Other fishery inputs – baits, fuels	Self-report, if any
II. Supply and use of fish and fish commodities (physical/ monetary)	
19. Import	Custom
20. Intermediate consumption	
21. Export	Custom
22. Household consumption	Specialized survey
23. Loss/ waste	
24. Production of fish food commodities	Market information
III. Land and water use (physical/ monetary)	
25. Land area used for aquaculture	Administrative data, Remote sensing if applicable: Xi Non-surveyed cell (j): Xi*Cj/Ci

26. Rice-fields with/without aquaculture	Rice fields from regular agri survey, remote sensing multiplied with pre-determined ratio with anecdotal information
27. Inland water bodies/ marine water (incl. EEZ)	Administrative data, remote sensing
27a. Occupied by aquaculture facilities	Administrative data, Remote sensing if applicable: Xi Non-surveyed cell (j): Xi*Cj/Ci
27b. Enhanced area (areas under management)	Administrative data
27c. Protected area (no access to fishing)	Administrative data
28. Water stock within aquaculture facilities	Administrative data, Remote sensing if applicable: Xi Non-surveyed cell (j): Xi*Cj/Ci
29. Turnover rate	Administrative data, self-reporting
30. Chemical inputs	Self-report: Xi Non-surveyed cell (j): Xi*Cj/Ci
31. Quality of returning water	Self-reporting, administrative data
32. Water area used by fishery	Self-reporting, administrative data
33. Fishing days/ fishing gears used	Regular survey: Xi evaluated/adjusted with management data Non-surveyed cell (j): Xi*Cj/Ci
34. Abandoned/ lost gears	Observer data: Xi Extrapolated with fishing days or gears used
35. Maximum/ minimum extent of water area	Remote sensing, if applicable, administrative records
36. Months accessible by fishery	Administrative data
37. Waters with ownership/ tenure/ access right	Administrative data

6. Further research needs

Following is a summary list required for further development.

First, as a general framework, it is necessary to develop further coherence and integration with the framework under the Global Strategy. In the SEEA implementation context, the standard methodology of compiling stock estimate based on catch rate information should be developed. Experimental compilation of SEEA with existing data for all fishery and aquaculture relevant items is currently under preparation in order to evaluate SEEA utility in fishery and aquaculture sector monitoring and management.

For development of the census and fishery and aquaculture survey module:

- Development of survey modules, questionnaires, and implementation guidance,
- Criteria to determine whether specified module surveys should be conducted,
- Methodologies to sample communities for module surveys,
- Procedure to define multi later stratification to be used in estimation of no-data cell, and
- Guideline to adjust sampling strategy based on census results.

It is also important to develop further collaboration with EAF/EAA. The first step is to translate many of existing implementation tools of EAF/EAA in the context of core data frame and examine whether it possible to establish common standard framework to be applied as facilitation tools in designing and developing individual EAF/EAA and corresponding indicators. The sharing collected information with the statistical framework should be relatively easy and straightforward.

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Endnotes

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Integrating Data from Different Sources: improved spatially-disaggregated livestock measures for Uganda[1]

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Abstract

Although livestock contributes to household livelihoods in a variety of ways -i.e., by providing cash income, food, manure, traction power, savings and insurance, and collateral for financial services- in this paper we focus on livestock as a source of income and food. Our focus is on Uganda, where agricultural data including livestock are relatively abundant, and the proportion of rural poor holding livestock is high - around 70%.

The objective of our study is twofold: on one side, to complement the analysis of Benson and Mugarura (2013) by using a suite of different methods to assessing the spatial density of livestock holdings; on the other, to show that combining different data sources -the latest Uganda National Panel Survey (UNPS) 2009/10 and National Livestock Census (NLC) 2008- and applying the Small Area Estimation (SAE) technique of Elbers, Lanjouw, Lanjouw (2003) can improve the spatial disaggregation of missing livestock measures in the Census. First, we combine our livestock number and density mapping results with those from the NLC. Second, we fit an estimation model of livestock income and share on the UNPS, and predict the missing information in the NLC, mapping livestock income and share at the local level. Our results suggest that the integrated use of multiple data sources, such as household surveys and censuses, satellite imagery and administrative data, together with spatial analysis techniques such as SAE can provide reliable, coherent, and location-specific insights to guide policy and investment. This work shows a useful way out that allows a reliable spatial livestock analysis whenever sectorial databases offer great coverage of the population of interest, but relatively fewer detailed information than specialized surveys. The method can be applied in all countries where there is a similar livestock information system, and common support between livestock census and households surveys with detailed agricultural/livestock modules. Cross-validation across data sources provides clearer insights into livestock-related farmer behavior and, in so doing, provides a better springboard for effective poverty-reduction policy action. Beyond policy-decision support, the results of the paper demonstrate how integration of different data sets can greatly enhance spatial analysis.

Keywords: Uganda; livestock; spatial analysis; data integration.

1. Introduction

The importance of livestock in the world economy has grown recently due to the "livestock revolution" -an increase in livestock consumption- in developing countries as population increases, becomes richer, moves to urban areas, and changes its dietary preferences (Fischer, 2003). Despite the ongoing livestock revolution, widespread recognition of the importance of the livestock sector in household livelihoods is yet to be achieved.

Given the benefits of livestock ownership and the growth of the livestock sector, there are multiple potential benefits from mapping aspects of livestock ownership. Mapping can aid in the targeting of livestock-sector policies and recommendations and can help demonstrate the impacts of policies over time. The ability to map variables of interest offers a way to present large amounts of data to the public and policy makers in a visually stimulating way.

However, the ability to generate maps is often limited due to a lack of information. The use of Small Area Estimation (SAE) techniques with the integration of survey and census data from Elbers, Lanjouw, Lanjouw (2003) is a possible mean to combine information from different data sources. Surveys are detailed but lack a sufficient sample size to be representative at lower levels of disaggregation to yield statistically reliable estimates. At the same time, census data have a large enough sample size but lack detailed information on income and consumption. Through the integration of survey and

census data, researchers benefit from the detailed information in the survey and the large sample size of the census to analyze variables at a higher spatial disaggregation than would be possible with the survey alone, allowing for higher spatially-disaggregated maps. While SAE has been predominantly used to impute measures of consumption or income into census data using estimates based on survey data, this technique could be especially beneficial in the analysis of livestock numbers and income from livestock activities to enhance knowledge at the local level of livestock owners for policy targeting.

2. Analytical Method

The SAE methodology for dataset-to-dataset prediction (Survey-to-Census in our case) comprises three steps or stages. The "stage 0" (according to Mistiaen, Özler, Razafimanantena, Razafindravonona, 2002) involves the selection of comparable information -in terms of how it was collected and the statistical distribution of variables- between the Census and the Survey. At this stage, means, standard deviations, and frequency distribution at the national and regional levels are compared across Survey and Census in order to check whether variables are equivalent.

In stage one, the dependent variable of interest is modeled as a function of the independent variables selected, using the equation

$$\ln y_{ch} = E(\ln y_{ch} \,|X_{ch}) + \mu_{ch} = X'_{ch}\beta + \mu_{ch} \quad (1)$$

where y_{ch} is the outcome variable for household h in cluster c; X is the vector of independent variables in both the Census and the Survey; and μ is the error term.

One of the most important aspects of this stage is the specification of the error term. The model above is first estimated by OLS weighted by Survey sampling weights. Residuals from this regression serve as estimates of overall disturbance, $\hat{\mu}_{ch}$. A portion of this disturbance is due to location-specific effects common to all households in a given cluster. Since not all clusters in the Census are sampled in the Survey, cluster fixed effects cannot be controlled for in stage one. Location effects must be accounted for in the error term, and as such residuals must be decomposed into location ("within-cluster means of overall residuals") and household ("overall residuals net of location components") elements (Mistiaen, Özler, Razafimanantena, Razafindravonona, 2002).

Incorporating the decomposition of the error term, the linear approximation of the model becomes

$$\ln y_{ch} = X'_{ch}\beta + \eta_c + \varepsilon_{ch} \quad (2)$$

Where η is cluster error and is applicable to all households in a cluster and ε is the household idiosyncratic error term. The two components of the error term are assumed to be uncorrelated with each other and independent of the regressors. The location component of the error term will allow for spatial autocorrelation and the possibility of heteroskedasticity of the household-specific error component (Simler and Nhate, 2005). Additionally, the μ error term -the unexplained location-specific component- is minimized, capturing as much variation as possible through the X vector, by incorporating cluster-level means from the Census into the Survey. This is done through estimation of Generalized Least Squares (GLS) model that takes heteroskedasticity of the household-specific error term into account.

In the final stage, parameter estimates of stage one and error terms of stage two are applied to the Census data. The disturbance term is accounted for by using bootstrapping re-sampling methods and converting from logarithms to levels, according to

$$\hat{y}_{ch} = e^{(x_{ch}*\tilde{\beta}+\tilde{\eta}_c+\tilde{\varepsilon}_{ch})}. \quad (3)$$

In each of the n simulations run (in our case we set n=100), parameter estimates are drawn from the multivariate normal distribution with the variance-covariance matrix and the two disturbance terms are drawn from the distributions described by the same parameters estimated in the first stage.

It should be noted that there are two sources of error that arise from the use of this method. First, there is model error due to the parameter estimates; second, there is idiosyncratic error from deviation of the actual y from the expected y (Alderman et al., 2002). Crucial assumptions of the model are presence of high spatial correlation between Enumeration Area and sub-county, and homogeneity of households within EAs. Yet, there could be unexplained effects that impact that error-term at the sub-county level (for instance, livestock prices) and at the more local EA level (for instance, disease) that are unaccounted for in the X_{ch} vector. It is important to consider that the model estimated is assumed to hold for all levels of disaggregation.

These two sources for errors could substantially impact the standard errors of the estimates under certain conditions, as proved by Tarozzi and Deaton (2009) through an empirical test using Monte-Carlo simulations. Nevertheless, if one is eager to accept the area homogeneity assumption, hence that "at

least some aspects of the conditional distribution of income be the same in the small area as in the larger area that is used to calibrate the imputation rule", then the bias in the standard errors calculated by the version of the SAE method (Elbers, Lanjouw, Lanjouw, 2003) used in this paper can be considered negligible, as in most empirical applications.

3. Data

Two datasets are used for this analysis. The 2009/2010 Uganda National Panel Survey (UNPS), representative at national level plus the strata of (*i*) Kampala City, (*ii*) Other Urban Areas, (*iii*) Central Rural, (*iv*) Eastern Rural, (*v*) Western Rural, and (*vi*) Northern Rural, collected information on 2,975 households from 322 Enumeration Areas (EA), although the sample is narrowed to 2, 375 households, as 45 households report incomplete information and 555 households had moved, of which 521 are urban.

The other dataset used, the 2008 Uganda National Livestock Census (UNLC), collected data from 964,690 rural holdings in all 80 districts of the country in a single visit. The UNLC is not a full enumeration Census but a sample-based one, and is representative at the district level, that is the level our results are presented. However, given that the average sample size at the sub-county level is adequately large (around 1,000 households), results are also reported at this lower geographic administrative level. Nonetheless, the limited amount of information collected in the 2008 UNLC is a constraint on the number of explanatory variables in the estimation model. The predictors used include: land size (separately by agricultural, pasture, and other land); number of livestock heads by type (disaggregated by indigenous and exotic bulls, cows and calves; poultry; small ruminants); average weekly egg and milk production; age and gender of the household head; whether the household hired agricultural labor; area covered by each agro-ecological zone and the NDVI[2] at the sub-county level.

4. Results

Three models are estimated on the 2009/10 UNPS and fitted. In the first model, the densities of large ruminants at the sub-county level are predicted and then compared to actual values in the census. This model is used to test the reliability of the prediction method used. In the second model, the dependent variable is the log of per capita livestock income (expressed in 2005 international Purchasing Power Parity -PPP- dollars); and, finally, the third dependent variable is the share of total household income from livestock. The latter two models are the core of the analysis, since they estimate dimensions (livestock income) not captured in the census but collected in the survey.

One of the main results of the analysis is that, by virtue of survey-to-census prediction, it is possible to draw higher spatially-disaggregated maps than using the survey alone. Figure 1 displays the actual densities (# of livestock/squared kilometer) of large ruminants from the survey and census, as well as the predicted density into the census. Some important elements emerge. First of all, what from the survey appear to be homogeneous regions, once disaggregated to the sub-county level through the census, becomes a more detailed and scattered picture. Second, the density range is wider in the census than in the survey, as in the latter the distribution is composed of four values, one for each region, as averages of sub-county values within each region. Third, and foremost, from a policy perspective the census map is more meaningful for targeting purposes.

The first model also tests the reliability of the methods used in conducting this analysis. Figure 2 witnesses that the actual as well as the predicted densities of large ruminants from the census is very close to the predicted one using the SAE method. This result offers an insight as to how SAE can be a viable and reliable method to estimate spatial distribution of missing information through prediction.

While the density of large ruminants in the census resembles closely the distribution from the Survey, the model fitted on the log of per capita livestock income in PPP is less able to predict missing information into the census. Figure 2 shows maps from the survey and the census for the estimated model.

Finally, the analysis of the predicted income share from livestock at the sub-county level yields surprising results (Figure 3). The predicted spatial distribution looks consistent regardless of the method used (maps not shown here), and this reinforces the argument that it is the lack of timely, reliable, and comprehensive survey and census data the constraining factor in addressing policy at the local level more than advancement in spatial methodology.

Conclusions

Our results suggest that the integrated use of multiple data sources, such as household surveys and censuses,

Figure 1: Density of Large Ruminants: Actual from Survey (left), Actual from Census (right), and Predicted from Census (below) at regional and district level.

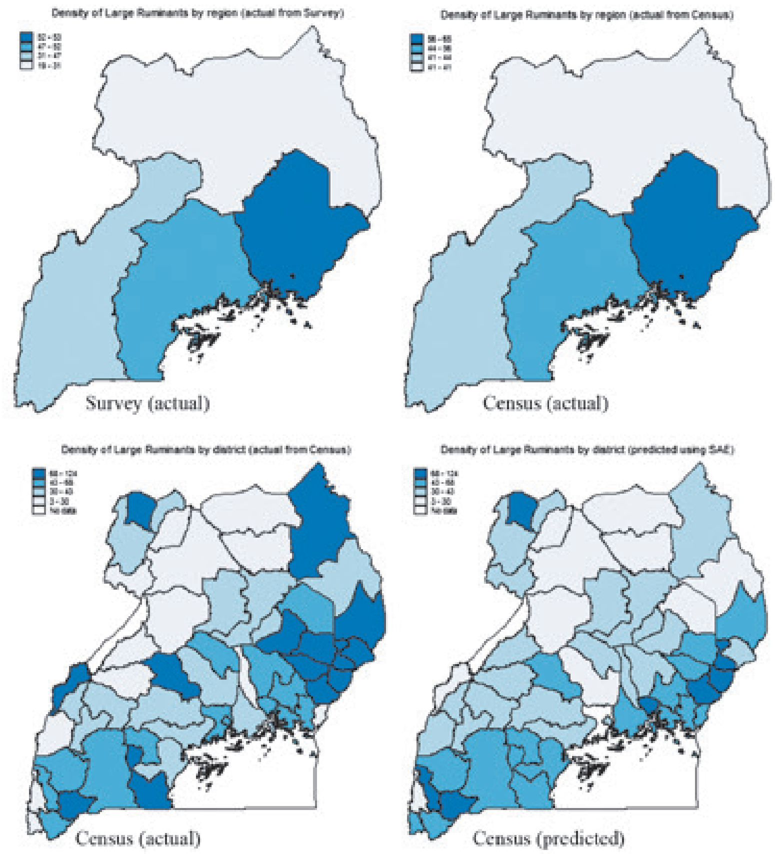


Figure 2: Per Capita Livestock Income (PPP): Actual from Survey and Predicted to Census.

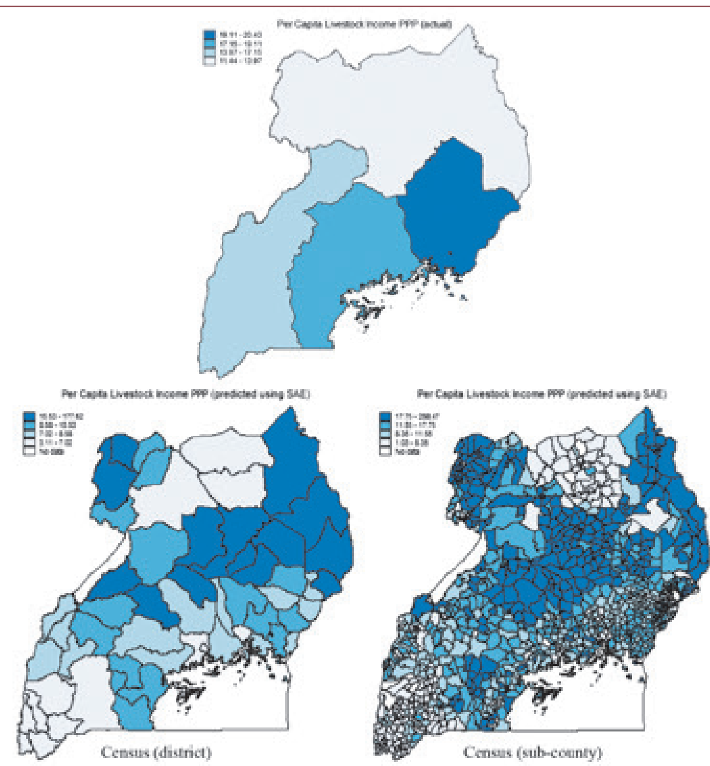
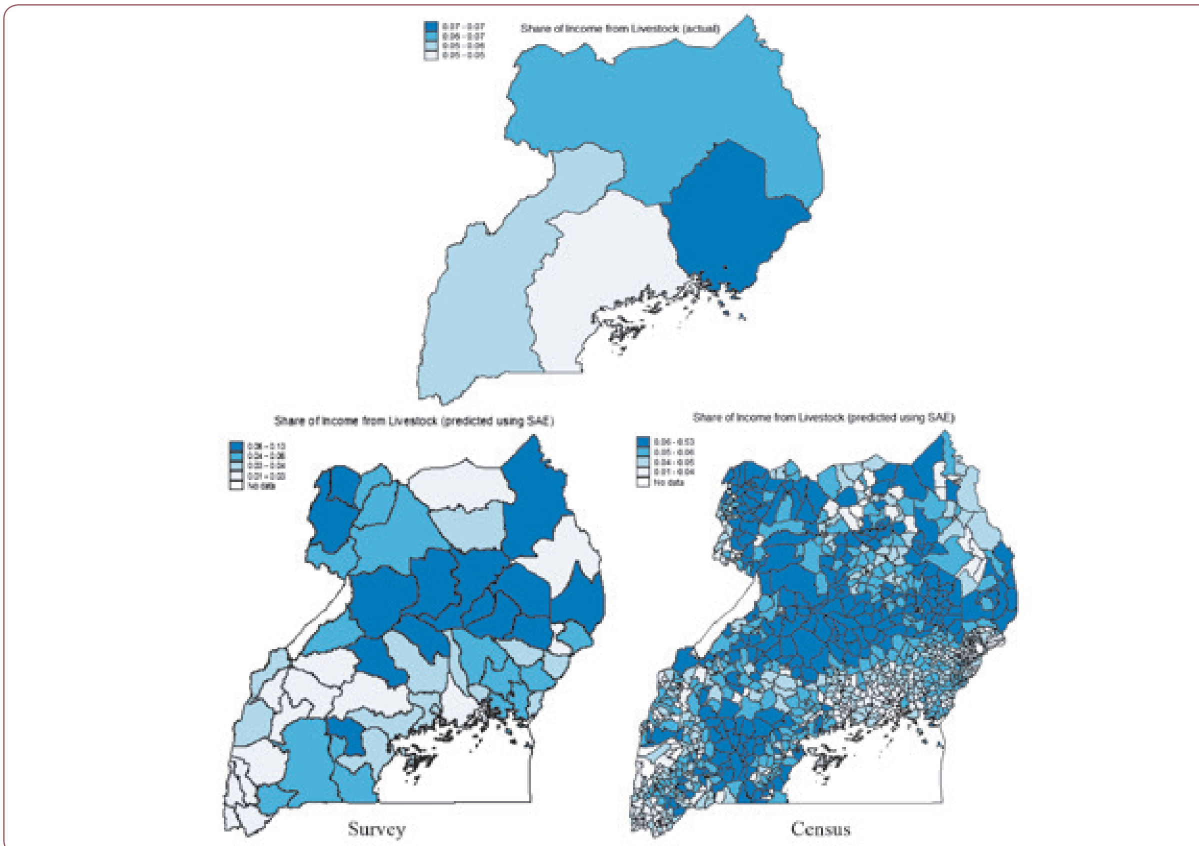


Figure 3: Share of Income from Livestock: Actual from Survey (left) and Predicted to Census (right).



satellite imagery and administrative data, together with spatial analysis techniques such as SAE and spatial allocation models, can provide reliable, coherent, and location-specific insights to guide policy and investment. Cross-validation across primary and secondary data sources provides clearer insights into livestock-related farmer behavior and, in so doing, provides a better springboard for effective poverty-reduction policy action.

By fitting accurate prediction models, there is the concrete possibility of combining multi-topic household surveys with specialized databases to estimate contribution of livestock to household livelihoods. Among the various econometric models tested, Small Area Estimation technique has been successfully used for targeting poverty programs in many countries worldwide, and the present work has shown that it could represent a potentially useful tool for informing livestock policy. Indeed, our work demonstrates that the integration between different data sources allows for finer spatial resolution, hence regional distributions looking homogeneous using the survey masks very diverse sub-county distributions using the census.

Our results are internally and externally consistent with the literature, strengthening reliability. The novelty of our approach is that it relies on micro-data and census, particularly important for policy targeting as it would greatly enhance the local relevance of policy interventions; in fact, there is the need to complement survey data with census information to provide more spatially-specific findings. In terms of external relevance and viability, our approach can be easily scaled-out to other countries with similar statistical data systems (e.g., those included in the LSMS-ISA).

Other possible refinements include using the enhanced livestock module developed in the UNPS 2011/12, and combining environmental and satellite data with household-level characteristics beyond agro-ecological zone and NDVI. Finally, a suggestion to national statistical agencies is to collect the Livestock Census regularly and with an adequate suite of information so as to allow a more effective integration of different databases. Expanding the topics covered in the census goes in this direction and would greatly refine the results.

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Endnotes

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2 It is a variable assessing the degree of live green vegetation in the observed area. Negative values of NDVI (approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Lastly, low, positive values represent shrub and grassland (approximately 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values approaching 1).

Questions that Count: a livestock module for multi-topic household surveys

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Abstract

The adequate inclusion of the major dimensions and determinants of livelihoods in multi-topic household surveys is essential for deriving appropriate measures of wellbeing and for effective investment design, implementation and evaluation. A review of existing Living Standards Measurement Study (LSMS) questionnaires reveals that livestock is largely neglected: this challenges the design and implementation of effective investments in the sector, despite about 60 percent of rural households in developing countries being fully or partly dependent on livestock for their livelihoods. This paper presents a short, a standard and an expanded version of a livestock module for multi-topic household surveys, jointly elaborated by the FAO, the ILRI (International Livestock Research Institute) and the World Bank. The standard version of the module consists of a set of questions that help quantify both livestock herd and the various contributions of farm animals to household livelihoods, including cash income, food, manure, draft power and hauling services, savings and insurance, and social capital. The expanded version provides additional details which, depending on the country, may or may not be included in the survey questionnaire. The short version consists of a minimum set of livestock-related questions, which is recommended be included in all multi-topic household surveys. Survey designers can adapt any of the three versions of the module to design a questionnaire that best suits their needs. The paper also draws preliminary lessons from experience in Niger, Tanzania and Uganda, where the livestock modules have been used to enhance the content of LSMS-type survey questionnaires.

Keywords: livestock; sub-Saharan Africa; household survey design.

1. Introduction

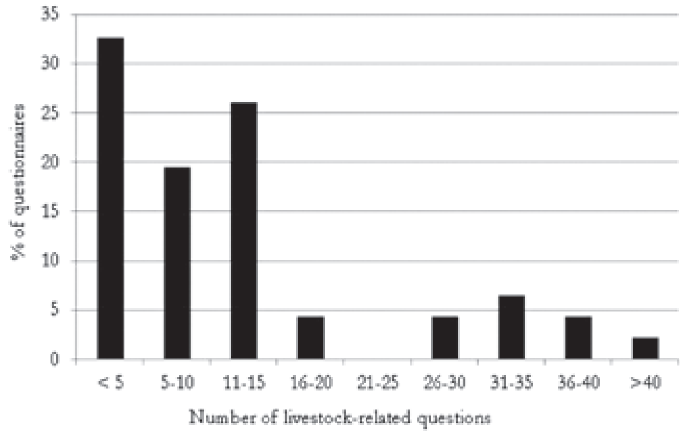
There is consensus that livestock sector development can contribute to poverty reduction and economic growth, as about 60 percent of rural households in developing countries are estimated to depend on livestock for all or part of their livelihoods; and population growth, urbanization and gains in real per capita income are fuelling a growing demand for high-value foods, including meat and dairy products (FAO, 2009). This provides good business opportunities for livestock producers. However, available household livestock data are hardly sufficient to appreciate the role of animals in the household economy, and the incentives and disincentives that guide households' livestock production and consumption decisions, thereby making it difficult to design and implement livestock investments that are both efficient and equitable (LDIP, 2012).

This paper presents a short, a medium and a standard version of a livestock module for multi-topic household surveys. The module aims to enhance the quantity and quality of livestock data available to decision makers, thereby facilitating the formulation and realization of successful interventions in the sector. It was jointly developed by the FAO, the ILRI and the World Bank as part of the implementation of the Livestock Data Innovation in Africa Project and the Living Standards Measurement Study - Integrated Surveys on Agriculture Project. The next section provides rationales for expanding the livestock content of existing multi-topic household surveys. Section three highlights the salient features of the livestock module for multi-topic household surveys, while section four presents lessons out of the implementation of the module in Niger, Tanzania and Uganda. Section five provides conclusions.

2. Why in multi-topic household surveys?

Reliable and up-to-date data from multi-topic household surveys are critical for governments to measure poverty, assess household wellbeing, and model household behaviour to evaluate ex-ante and ex-post outputs and impacts of public and private sector investments. The adequate inclusion of all

Figure 1: Number of livestock-related question in 'IHSN' multi-topic household survey questionnaires.



Source: Elaborated from www.ihsn.org.

dimensions and determinants of livelihoods in multi-topic household surveys is thus essential for deriving appropriate measures of wellbeing, and for effective investment design, implementation and evaluation.

Livestock keeping is a multi-functional activity in developing countries: farm animals generate food and income, are a store of wealth and act as a safety net in times of crisis. They provide draught power and hauling services, manure, fuel and building material; transform crop residues and food wastes in valuable protein and contribute to social capital (FAO, 2009). Rural households have thus a variety of incentives for keeping livestock and, indeed, data from 12 developing countries in Africa, Asia and Latin America show that between 46 to 85 percent of rural households keep farm animals, with a country average of about 60 percent (FAO, 2009). Many of them are poor, which implies that increasing the contribution of livestock to their livelihoods can directly contribute to the goal of reducing poverty worldwide.

A review of existing multi-topic household survey questionnaires, however, reveal that livestock is inadequately represented. The number of livestock-related questions (excluding those targeting consumption of animal-sourced foods) in a sample of 42 multi-topic household survey questionnaires available on the website of the International Household Survey Network (IHSN, www.ihsn.org), is a crude, yet revealing indicator of the limited availability of data to fully appreciate the role of livestock in the household economy. In almost 80 percent of the sample countries, the survey questionnaires include less than 15 livestock-related questions. Insights into investment opportunities are thus challenged by lack of adequate information on the role and use of livestock in the household economy.

3. A livestock module for multi-topic household surveys

With the objective to assist decision makers in formulating effective policies and investments in the livestock sector, the FAO-World Bank-ILRI Livestock Data Innovation in Africa Project (LDIP) and the Living Standards Measurement Study - Integrated Surveys on Agriculture Project of the World Bank (LSMS-ISA) developed a short, a standard and an expanded version of a livestock module for multi-topic household surveys. This builds on a variety of livestock survey questionnaires conducted in developing and transition countries, of which many by the International Livestock Research Institute (ILRI), as well as on interviews with expert informants and livestock practitioners. The three versions of the module vary by size, but have four common overarching goals:

- Generate basic statistics on key livestock-related variables, such as on livestock ownership and access to animal health services;
- Measuring the value of household's livestock, which are an important economic asset;
- Measuring the cash and in-kind income from livestock;
- Modelling household's livestock husbandry and production practices.

The module targets information in three major domains, including livestock ownership; livestock inputs, i.e. husbandry practices; and livestock outputs. Processing is omitted (but for one question) as it is a nonfarm enterprise activity that is typically included in other modules of the survey, or addressed in other types of surveys.

Table 1: Content of livestock module for multi-topic household surveys.

Livestock domain	Sections	Remarks
Livestock ownership	Number of animals Change in stock in past 12 months	Questions are asked for individual animals, often differentiated by age, gender and breeds (local/indigenous and improved/exotic), which helps to appreciate herd structure and inter-species composition.
Inputs and husbandry practices	Breeding Feeding Watering Animal health Housing	Questions are asked for major groups of animals (e.g. large ruminants, small ruminants, pigs, poultry birds, equines, other), as management practices usually do not differ between animals of the same species
Monetary and non monetary outputs	Meat production Egg production Milk production Animal power Dung	Questions are asked for major groups of animals, including both the monetary and non-monetary value of production

Short version

The short version of the module includes questions on livestock ownership by species (e.g. cattle) and type of animals within species (e.g. bulls, steers, cows, etc.), as well a question on the major purposes for keeping animals. It inquires about sales of animals by species over the reference period, which is 12 months for large and medium animals (e.g. cattle, sheep and goats) and 3 months for small animals, namely short cycle animals (e.g. chicken, ducks and rabbits). It includes some questions on meat, milk and egg production, and one only question on husbandry practices. The latter targets animal vaccination, which in most countries is provided for free or subsidized by the public sector.

The short version of the module allows quantifying with accuracy household's livestock wealth, and hence classifying households into different types; it also provides a rough measure of the cash income derived from livestock. This version comprises about 30 questions and is intended for use in surveys for which livestock is of minor interest.

Standard version

The standard version of the module collects a large amount of livestock-related information, including on ownership of animals, inputs and husbandry practices, and on livestock outputs by product, by-product and service, such as on milk, manure and draft power. As in the short version, questions on livestock ownership target species and types of animals; while all other questions only inquire about animal species, such as large ruminants, small ruminants and equines. Questions on change in animal stock over the reference period collect information on the causes of herd reduction / expansion, including purchases, sales, slaughters, gifts and loss of animals for different reasons (e.g. death due to disease; theft; etc.). Questions on inputs and husbandry practices target housing and breeding practices; access to and use of water and forage/feed; and animal health, including vaccination, deworming and treatment of sick animals. Finally, questions on outputs inquire not only about meat, milk and egg production, but also about the use of animal power (draft and transport services) and the production of dung, mainly but not only used as manure. Most sub-sections include questions on the use of family labour by gender, and on the non-family labour hired for raising animals.

The standard version of the module allows generating descriptive statistics for key livestock-related variables, for which nationally representative indicators are often unavailable. Examples include ownership of exotic breeds; prevailing breeding practices; and access to veterinary services. It also allows quantifying with accuracy not only household's livestock wealth, but also the contribution of livestock to household livelihoods, including both their monetary and non-monetary value. In addition, depending on the sample size and the species at hand, it can be used to estimate production functions using the animals as unit of observation, though specialized agricultural and livestock surveys better serve this purpose. The standard version of the module comprises about 95 questions.

Expanded version

The expanded version of the livestock module includes all the questions in the standard version and adds information in all sub-sections. In particular, it allows differentiating between animal ownership and animal keeping, as not all households owning livestock raise them on the farm; it includes questions on the providers of goods and services, such as the public and private sector, and NGOs; it asks more details about the role of family members in selling animals and livestock products, including about the control of the earnings.

The expanded version of the module allows generating key livestock statistics and undertaking analyses as with data from the standard version, but with higher accuracy. It's a long and heavy version and, as such, it should be seen as a rotational module that country governments implement only when they need comprehensive and detailed information on livestock, most likely for a specific sub-sample of the population (e.g. the cow keepers). In response to specific information needs, however, survey designers may wish include only one or selected sub-sections of the expanded version of the module in their multi-topic survey questionnaires, such as those on breeding and animal health.

4. Implementing the livestock module: lessons

The three versions of the livestock module for multi-topic household surveys are starting points for developing a module that fits the needs of the country. Survey designers are expected to build their own module that adapts the country livestock sector, including its structural and transitory features. Three sub-Saharan African countries have so far used the livestock module to improve the livestock content of their multi-topic survey questionnaires, including Niger (Enquête Nationale sur Les Conditions de Vie des Ménages 2011/12), Tanzania (National Panel Survey 2011/12) and Uganda (National Panel Survey 2011/12). Data from these surveys have not been yet officially released, but preliminary lessons from questionnaire administration can be drawn.

- The types of animals vary depending on the country. Survey designers should thus adjust the suggested list in the module, which is comprehensive, to be consistent with the prevailing livestock production systems. This could be done at three levels. First, some animals are simply not present in the country, such as yaks in Uganda, and should not be included in the survey questionnaire. Second, while the module allows separating local / indigenous from improved / exotic breeds, in many countries the diffusion of the latter is so minimal that it does make sense differentiating animals by breed only in the section on animal ownership. In the same vein, there are animals which are known not to be widely held by households, such as pigs in Niger. Again, in these circumstances, it could make sense to get only information on ownership of pigs to generate some basic statistics, but there's little value in asking details about inputs and outputs, as the sub-sample of pig producers is not large enough to generate data for robust descriptive statistics or causal analysis.
- Animal health / disease information is critical for country governments, particularly that pertaining to trans-boundary and zoonotic diseases. Following a standard approach, the module suggests asking direct questions about animal diseases, such as on brucellosis, ovine rinderpest (Peste des petits ruminants) and Newcastle disease in poultry. However, not all farmers are fully aware of the types of disease that affected their animals. Alternative options to collect information on animal health could be designed and tested. One possibility is to use a syndromic approach, which would imply asking questions on syndromes on the basis of clinical features (e.g. neurological, respiratory, dermatological and diarrhoeal syndromes); the collated data should be then interpreted jointly with local animal health authorities. A second possibility is to include questions on animal diseases not only in the household but also in the community questionnaire of the multi-topic surveys, along the lines of participatory epidemiology.
- Measuring labour is particularly challenging, and for two reasons. The first is that in many circumstances, with the possible exception of milking, the labour force performs the same task (e.g. feeding) simultaneously for all animals in the herd, and in particular for large and small ruminants (e.g. cattle and sheep). The second is that watering and feeding animals are often joint activities, with livestock taken to pastures where water sources are available. The implication is that attaching labour to a specific task or an

individual animal is challenging, which yet could be important as most households just keep few animals and of different species. The module presents one way to address the labour issue: it suggests first asking whether animals of different species are fed and watered jointly; and then questions on the time allocated to feed/water animals by family and non-family labour. Other options should be designed and tested.

- When collecting information on livestock production, the module proposes a different approach with respect to standard multi-topic household surveys. In particular, rather than directly asking information on meat, milk and egg production, the module asks a sequence of questions that link animals with production level. This apparently helps the interviewee to provide accurate information on production level. For milk, for instance, questions are included about the number of milked animals over a reference period; the number of months during which the animals were milked; whether suckling was allowed when the animals were milked; and on the average quantity of milk produced per day during the milking period. Similar flows of questions are suggested to get information on meat and egg production.

The above are some of the key lessons emerging from the administration of the livestock module for multi-topic household surveys in Niger, Tanzania and Uganda. Additional insights on strengths and weaknesses of the module will come clear as the country data are officially realised and available for analysis. In any case, the Niger, Uganda and Tanzania surveys are expected to generate the most comprehensive household-level livestock datasets available in sub-Saharan Africa, thus facilitating the analysis and documentation of the many connections between livestock and livelihoods. The coming insights are expected to significantly enhance our understanding of the role of livestock in the household economy.

5. Conclusions

Traditional multi-topic household surveys inadequately represent livestock, which is though a widely own asset among rural households in developing countries, including the less well-off. This challenges the design and implementation of equitable and efficient interventions in the sector.

This paper presented a short, a medium and a standard version of a livestock module for multi-topic household surveys, jointly developed by the FAO, the ILRI and the World Bank. The three versions of the module, with different level of details, aim at collecting data for the generation of statistics on key livestock-related variables; for measuring the value of household's livestock; measuring cash and in-kind income from livestock, and modelling household's livestock husbandry and production practices.

The three versions of the livestock module for multi-topic household surveys are starting points for developing country modules that fit the needs of the country at hand. Three sub-Saharan African countries have so far used the module to improve the livestock content of their multi-topic survey questionnaires, including Niger, for the Enquête Nationale sur Les Conditions de Vie des Ménages 2011/12, Uganda, for the National Panel Survey 2011/12, and Tanzania, for the National Panel Survey 2010/11. Lessons drawn out of the administration of the survey questionnaires indicate that major challenges relate to measuring labour and animal health/diseases. These represent areas for further research.

The short, standard and expanded versions of the livestock module for multi-topic household surveys are available from download from the website of the FAO-WB-ILRI Livestock Data Innovation in Africa Project, while the survey questionnaires for Niger, Tanzania and Uganda are available with the authors. The data from the livestock module implemented in Niger, Tanzania and Uganda will be freely available from download and use as soon as officially released by the statistical authorities in the countries.

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Milking the Data: measuring income from milk production in extensive livestock systems – experimental evidence from Niger

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Abstract

Data on milk production for human consumption are difficult to collect in household surveys for a number of reasons which make accurate recall challenging for the respondent. Milk can be produced daily but with seasonal patterns, and daily production potential varies depending on the lactation stage. Also, the extent of milking is a decision variable, not directly related to production potential: milk can be fed to calves, and productive animals may be present but not necessarily milked if markets for milk products are not available or production exceeds the household's own consumption needs. For these reasons, the quantification and valuation of milk production is particularly difficult in household surveys, introducing possibly severe biases in the computation of full household incomes and farm sales, as well as in the estimation of the contribution of livestock (specifically dairy) production in agricultural value added and in the livelihoods of rural households.

This paper presents results from a validation exercise implemented in Niger, where alternative survey instruments based on recall methods were administered to randomly selected households, and compared to a 12-month system of physical monitoring and recording of milk production. The results of the exercise show that reasonably accurate estimates via recall methods are possible, and provide a clear ranking of questionnaire design options that can inform future survey operations.

Keywords: livestock; household surveys; livelihoods; questionnaire design.

1. Introduction and background

Despite the importance of the agricultural sector and its critical role in meeting the MDGs, serious weaknesses in agricultural statistics persist. Of the 44 countries in Sub-Saharan Africa rated by the Food and Agriculture Organization, only two are considered to have high standards in data collection while standards in 21 countries remain low (FAO, 2008). The scope of coverage and completeness also varies widely (see for example, the four-country case studies by Kelly and Donovan, 2008). Knowledge about agriculture and its impact on welfare and equity is limited by the lack of available, high quality, and consistent data on rural households.

Against this backdrop of generally poor agricultural statistics in Africa, the statistics on the livestock sector stand out as an area in particular need for improvement. The neglect of the sector by policy makers and researchers in most African countries is both a cause and a consequence of the current state of affairs with statistical information on livestock. While it is well known that many poor and food insecure households depend on rearing animals for their livelihoods, the lack of high quality data on the sector hinders both advocacy and policy analysis efforts aimed at informing actions to support livestock-base livelihoods.

Besides the institutional and political neglect, there are important technical reasons that explain why livestock data are particularly scarce or of dubious quality. Collecting data on some major aspect of livestock activities is inherently difficult, because of peculiarities in the production and marketing processes, in the management of livestock assets, and also in the lifestyle of some population groups that are especially reliant on livestock for their livelihoods (e.g. pastoralists) that pose particular challenges to data collection.

Milk production data are difficult to collect in household surveys because: (a) Milk can be produced daily, but with seasonal patterns; (b) Milk production potential varies depending on the lactation stage; (c) Milk can be fed to calves; and (d) Productive/lactating animals may be present in the herd but not necessarily being milked. For these reasons,

the quantification and valuation of milk production is particularly difficult in household surveys, introducing possibly severe biases in the computation of full household incomes and farm sales. In this respect it is important to note upfront that this paper deals with milk produced/collected from the milked animals for human consumption, we are not concerned with quantifying the milk left to the calves or left on the animals.

The focus in the paper is on one specific family of household surveys, the Living Standard Measurement Study (LSMS). This is one prominent type of household survey widely implemented in developing countries to monitor and analyze poverty and livelihoods. While this is just one example of multitopic household survey for livelihood analysis, we maintain the lesson for questionnaire design that can be gauged with this exercise can be applied beyond LSMS surveys.

This paper presents results from a validation exercise implemented in Niger, where two alternative survey instruments were administered to randomly selected households and then compared to the results of a physical monitoring of milk production over a 12 month period. The objective of this work is to draw lessons for questionnaire design by selecting the best performing options and identifying outstanding issues.

The paper is organized as follows. The next section outlines the overall design of the validation exercise and the survey instruments being tested. Section 3 describes the data, and section 4 presents the results. The concluding section discusses the implications of this work for future data collection, and elaborates on ongoing next steps in furthering this line of work.

2. Testing alternative survey instruments

2.1 The context: Survey validation work in developing countries

In their primer on methods for testing and evaluating survey questions, Presser et al (2004a, p: 109) note how "pretesting's universally acknowledged importance has been honored more in the breach than in the practice". Even in countries with well-oiled and well-financed statistical systems, pretesting is often limited to a rehearsal of survey interviews, usually on a fairly limited number of cases, which are then qualitatively evaluated by the survey teams so as to draw lessons on questions that seemed to pose problems to interviewers or respondents. Sometimes this is complemented by a quantitative analysis of response frequencies and other basic statistics from the data collected during a pilot.

In most cases there is little that is systematic about these tests, despite the existence of techniques geared towards assessing the performance of survey instruments (see e.g. those reviewed in Presser et al., 2004b, and Iarossi, 2006), and very little documentation is provided to users of the data on the contents of such tests. The evaluation of what 'works' is mostly left to the judgment and experience of the survey team.

Increasingly, however, survey practitioners are paying attention to pre-tests as means towards improving data quality. Also, specific methods are being developed, tested and codified and applied in survey practice. The interested reader is referred to Presser et al (2004b) for an excellent review of methods such as cognitive interviews, behavior coding, response latency, vignette analysis, experiments, and statistical modeling. While the use of such methods, and their documentation, is more commonly found in OECD country surveys, their application is gaining grounds in low income countries, including in Africa.

Despite the fact that the quality of the data should be of interest to researchers as much as the quantity, it is surprising how little attention has the formal validation of household survey data collection received in the literature. Researchers' preoccupation with data quality results mostly in efforts to design and supervise survey work as well as possible, but very infrequently are the results of such efforts formally tested. There are some notable exceptions however, and our study aims to contribute to this small but growing strand of methodological literature.

Most of the existing literature on survey experiments and survey validation in the context of household surveys in developing countries refers to the measurement of household consumption. Beegle et al. (2012) test eight alternative methods of measuring household expenditure, comparing personal diary as the benchmark to other diary and recall formats. They find significant differences between resulting consumption measures, with the correlation between under-reporting and both illiteracy and urban households' status being particularly evident. In addition, Gibson et al. (2013) use data from the same survey experiment in Tanzania to obtain evidence on the nature of measurement errors, concluding that as expected errors have a negative correlation with the true value of consumption.

In the context of household consumption, another issue that has been analyzed is the extent to which the length of the lists of consumption items affect estimates of household expenditures. In a study in El Salvador, Joliffe (2001) shows that a more detailed consumption list, results in higher estimates of mean household expenditures (by around 30 percent). This finding has clear implications for the resulting poverty estimates.

The impact of the level of detail of the questionnaire on key indicators has also been investigated in the field of labour market statistics. Dillon et al. (2012) consider if this aspect, together with the type of respondent, can explain the existing widespread variation in measurement of child labour statistics.

Scott and Amenuvegbe (1990) conducted an experimental study on 135 households in Ghana. Each of them was interviewed 11 times at varying time intervals, asking to report expenditure on the 13 most frequently purchased items. In this study, each additional day of recall returns in a 3% decline of the reported daily expenditure.

The choice of reference period is also likely to have considerable impact in several domains. Beegle and Carletto (2011) test for recall bias in agricultural data, submitting questionnaires with different length of time between harvest and interviews for three African countries. An assessment of whether and how modalities of data collection in agricultural production may affect results is also provided by Carletto et al. (2012).

De Mel et al. (2007) find that firms under-report revenues by about 30 %, and significant impacts of account diaries on both revenues and expenses, but not on profits. More generally, they argue that questions on profits give more accurate measures than asking on revenues and expenses.

We are not aware of similar work done for livestock questionnaire design in the context of household surveys in low income countries, which is the reason that motivated a joint effort by FAO, ILRI, and the World Bank (as part of the LDIA and LSMS-ISA projects[1]) to start the survey validation work that is documented in this paper.

2.2 Milk production recall methods

As mentioned in the introductory section, LSMS surveys have typically lumped the collection of data on livestock products in one table listing the different products on the rows and a set of standard questions, common to all products and based on a 12-month recall period, on the columns. The module usually asks a variation on two rather simple questions: (1) "Number of production months in the last 12 months", and (2) "Average production per month during production months". Sometimes these questions are asked for milk as a homogeneous product, sometimes the product is broken down in different types of milk (cow, sheep, goat).

Because of the peculiarities of milk production recalled earlier (continuous production, seasonality, varying lactating capacity of animals over time among them) it is a well-known fact among practitioners that collecting reliable milk production data with such simple recall questions is likely subject to large errors, most likely in the way of underestimating annual production. This has led livestock researchers and livestock survey specialists to devise more complex strategies to collect more accurate milk production data as well as an expanding set of additional information useful to evaluate milk production systems.

Examples of these elaborate approaches include the 12_mo method developed by researchers in France's CIRAD (see Lesnoff et al., 2010) which relies on the monitoring/recording of production over extended periods of time, as well as techniques which while based on recall approaches, try and prompt the respondent more in depth about the milk production system hoping that this will help increase the accuracy of the responses. In developing new survey approaches to be integrated in LSMS-type surveys that include an expanded agricultural focus, these approaches are useful, but need to be adapted to conform to both the objective of the survey as well as to the survey operations. The only way to assess whether a change in approach results in an actual improvement in data quality is to validate the new method via fieldwork, ideally in an experimental setting, while reproducing as closely as possible real survey conditions.

It is beyond the scope of the LSMS, in terms of both objective and logistics, the possibility to collect milk production data over extensive time periods, or in a way that allows calculating the complex milk productivity parameters often required by livestock sector specialists. The main goal of LSMS-type surveys is to generate information on household living standards and livelihoods, in this case jointly with information on the productivity, profitability and returns to different activities households may be engaged in. The LSMS survey logistics are organized with mobile teams, that normally reside in each enumeration area for 3-4 days, and need to complete the survey operations in that location in that given time. It is therefore beyond the scope of the LSMS, in terms of both objective and logistics, the

possibility to collect milk production data over extensive time periods, or in a way that allows calculating the complex milk productivity parameters often required by livestock sector specialists. The objective of an LSMS needs to be more modest, and limited to collecting a reliable measure of milk production that can accurately portray the role that milk production has in the overall household livelihood strategy.

At the same time, LSMS-type surveys aim to look at the heterogeneity across households, so methods that rely on the application of technical production factors from the literature (e.g. average milk production per animal in a certain environment) to variables that may be easier to measure in a survey (such a number of animals milked by the household) may result in accurate 'average' estimates, but may artificially reduce the observed differences in milk production (both in physical and value terms) across households. For most of the analysis performed with LSMS data, the analysis of the dispersion of the distribution is often as if not more important than the analysis of the measures of central tendency (means, medians). For these reasons, competing data collection methods will need to be evaluated not only on the basis of their ability to yield an accurate point estimate of, say, mean milk production, but also on their ability to return a distribution of observations that resembles as much as possible the 'true' distribution.

In view of these considerations, in developing the Niger survey validation we looked at two methods that are often applied in livestock sector surveys, but also seemed to hold promise of being adaptable to both the questionnaire design and logistics of LSMS survey operations. In what follows we will refer to these two methods as the "Average Milk per Day" (AMD) and the "Lactation Curve" (LC) methods.

The two questionnaires are identical, except for one question milk production. Both questionnaires are asked at the level of each animal type (bovines, sheep, goats, camels), and start off by prompting the respondents about the number of months during which animals where milked for human consumption, and how many animals were milked on average during each of those months. The questionnaires then differ in that the AMD asks for the average quantity per day produced during the reference period[2], whereas the LC questionnaire asks about the amount of milk produced on average by each animal at three (four) different points in time: one week, one month, and three (and four) months after parturition. The two modules then continue asking the same set of questions on issues of whether calves/lambs/kids were allowed to suckle, about the distance between parturitions, and about the disposition of milk production (sales, consumption, transformation into dairy products).

Annual household milk production can be calculated from both questionnaires. In the AMD this is done by simply multiplying the average daily production by 30 days (to get to monthly production per animal), then by the number of production months and by the number of animals milked. In the LC methods things are a little more complicated, and annual production is calculated as the area under each animal's lactation curve, or rather milk production/off-take curve. This is not immediately intuitive and requires some explanation.

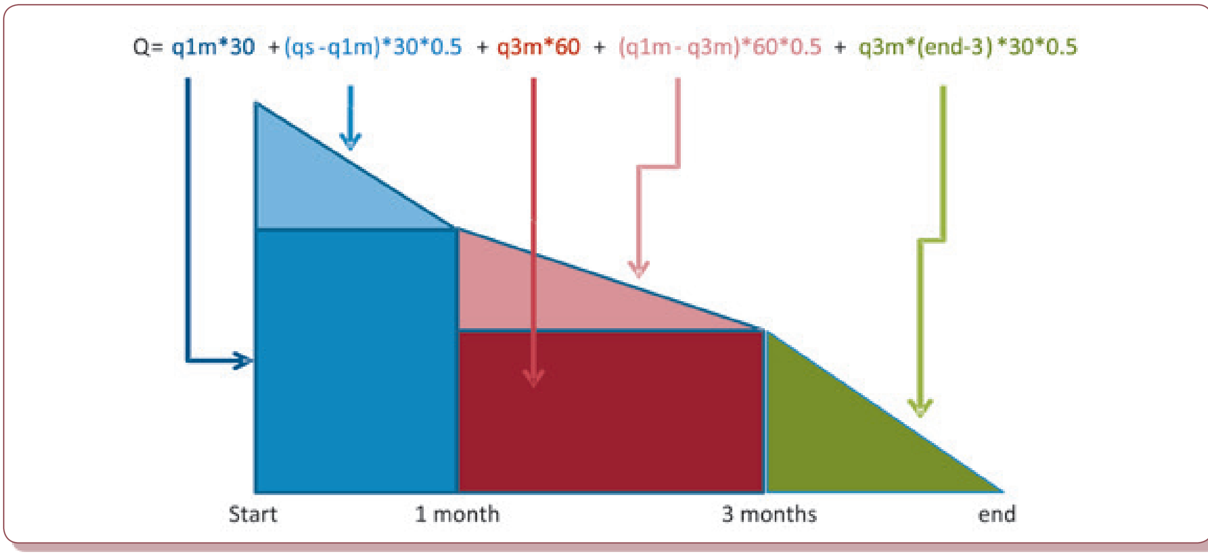
All mammals have a pattern in the lactating period with lactation starting shortly after parturition, a peak in lactation reached early in the lactation period, and then a slow decline in lactation to the end of the lactation period. The timing of these periods and the overall length of the lactation vary by animal species, and by breeds, and with climatic, grazing, watering and a host of other factors. Besides that, what the survey measures is not lactation as such, but the amount of milk that is taken off for human consumption, which is a decision variable for the farmer.

Total milk off-take can therefore be approximated, assuming a constant value of off-take between the last point in time for which recall is asked and that of the end of the milking period[3], as the area under a curve such as the one depicted in Figure 1. In the most general case of four monitoring points, the corresponding formula can be written as:

$$Q= q1m*30+(qs-q1m)*30*0.5+q3m*60+(q1m-q3m)*60*0.5+q6m*90+(q3m-q6m)*90*0.5+q6m*(end-6)*30.$$

Where *Q* is the total milk off-take per animal in one lactation, *qs* is the average daily quantity of milk off-taken per animal at the start of the lactating period (one week after parturition in the Niger LC module), *q1m, q3m* and *q6m* are respectively the off-take one month, three and six months after parturition, and *end* is the average number of months of milk off-take per animal. For animals with shorter lactation periods such as ewes, and goats, more parturitions (and hence lactating periods) may fall within the 12 months of the survey reference period. In such cases, the presence of a question on the average interval between parturitions allows attributing a quota of the second lactation to the survey reference period (Njiuki et al., 2011). In this paper we focus on cattle milk over a 12 months reference period, which rules out the possibility of multiple lactations for any one animal as the calving interval for cattle is longer than 12 months.

Figure 1: Computing milk consumption using the LC method.



With the LC method respondents are asked to recall more information (milk production at different points in the lactation) but to only average out this information across the animals they have milked. In the AMD method, respondents are required to report only one figure, but to obtain that via an implicit process of averaging not only across animals but also across the lactation period. What process is easier for the respondent and more likely to return an estimate closer to the 'true' value is an empirical question, and the main question this papers aims to address. Whether it is easier for respondents to respond to questions about an average animal or about the entire herd is also an empirical question. In Niger it was felt, after some piloting in the field, that respondents found it easier to report about production per herd, as the milk is collected for all animals into one container, once or twice a day.

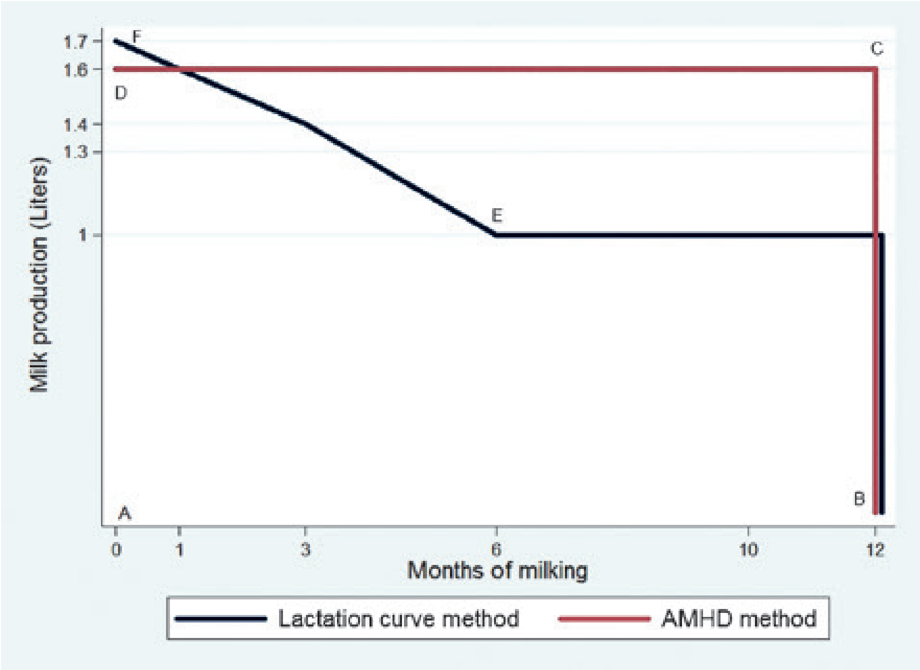
Some livestock survey practitioners suggest that the response given to the AMD question may result in an overestimate of the quantity of milk collected as the response patterns may lead to estimating the area under a rectangle that will largely be above the lactation curve triangle. Figure 2 illustrates the point, using hypothetical values not too dissimilar from the data in our Niger cattle milk off-take study. In calculating total milk off-take from the AMD method one is essentially computing the area of the rectangle ABCD, where AB is the number of months milk was collected and BC is the monthly quantity (in liters) collected milk[4]. Suppose the true shape of the off-take curve for the respondent was equal to the polygon ABEF and it becomes evident how AMD would result in an overestimate of milk production.

The AMD method can be administered for different recall periods, as it is often argued that shorter recall can improve data quality. This is especially true for variables that are characterized by seasonal patterns, which is the case for milk production. In the case of the LC method this is not feasible as a, say, six-month recall period would likely be shorter than the lactation/off-take period, thus complicating the task of the respondent as some of the points in the off-take curve may fall outside of the recall period.

It is also often found that additional questions related to the main object of the recall can be useful in aiding the recall by the respondent. For that reason, in the exercise we describe in this paper, we also experimented in combining the AMD with the LC questions. The idea is that if a respondent is first invited to recall average milk production at different point in times over the milk production period, she may then be able to provide a more accurate answer when asked to estimate the average production of her herd (or per animal) than if asked to provide that figure directly.

In the exercise we report on here we compare the following methods: (a) the LC method; (b) the AMHD method with a 12 month recall; (c) the AMHD method with a 12 month recall and linked to the LC method questions; (d) the AMHD method with a 6 month recall. All are compared against a benchmark constructed by the physical monitoring of milk production over a 12 month period. We also provide some evidence on the performance of the AMAD variant of the AMD method. Before discussing the results of these comparisons, we now turn to describing how the data used in the paper were generated.

Figure 2: Comparison of recall methods.



3. Data

The main dataset used in the analysis in this paper is based on validation exercise we report on in this paper. It comes from fieldwork that took place in the Dantiandou district in Niger, between April 2012 and June 2013. The fieldwork was managed by two experienced enumerators, and coordinated by ICRISAT Niamey (Hiernaux et al., 2013 – from which the description below is taken almost verbatim). The team monitored the milk off-take of 300 families over 12 months, as well as associated livestock management, and family consumption and sale of dairy products. The team also administered 6 month recall questionnaires on 200 families, and 12 months recall questionnaires to 400 families.

The first 200 family farms were randomly sampled among the 835 family farms documented in 2009 and 2010 for the Livestock Climate and Society (ECliS) project. These 835 families live in 13 villages and associated camps within the district (commune and canton) of Dantiandou (80 km East of Niamey). A large data base is available on the composition of the family, its economic activities (including cropping, breeding livestock, forestry, and off farm), the composition and number of livestock, milking practice, consumption and sale of dairy products. This data base was used to stratify the families based on the type of dwelling (either village or camp), which largely matches with socio-ethnic affiliation (Jerma/Fulani), and on the size of the herd (less than 5, 5 to 15 and more than 15 adult females). The additional 100 families were selected in additional 13 villages from the district of Dantiandou (5340 families and 45 village in total), based on the national census.

The monitoring method targeted the assessment of the daily milk off-take in each of the 300 sampled families. For each sampled family herd, the milk off-take was measured one day every fortnight adding morning and evening milking when applicable. At each milking, the total milk off-take of the herd was poured in a transparent plastic pot devoted to that measure. The level reached by the milk was marked on the outside of the pot with a marker by the herder. To assess milk volume the research assistant weighted the plastic pots empty and when filled with water up to the mark done on the side of the pot. The pot weights were recorded on the herd recording form together with the number of lactating females, and the number of lactating females milked re-actualized at each visit. Equipped with a motorbike, each of the two enumerators monitored about ten farms per day (one or two visits depending on milking practices), with revisits every two weeks.

Camp families involved in dairy farming are endowed larger cattle herd in average than Jerma families (7.2 vs 4.4), both however are managing quite small herds and mean number of lactating cows in the course of the year is 3.4 vs 1.8. Then, only a fraction of the lactating females are actually milked in average 1.9 vs 1.3. Resulting mean milk off-take are low at 2.1 liters per day in camps and 1.3 liters per day in village farms. There are large seasonal variations, the wet season and first part of the dry season ('cool' season) contrasting with the late dry season, with milk yield in a factor 2 in camp farm and factor 1.5 in village farms. These seasonal variations are explained by the reproductive cycle of the cows (peak of birth in early wet season), better quality of grazing resources, but these reasons are mediated by the herder decision (share of the lactating cows actually milked, milking in the morning/evening or both, volume off-take). It appears for example that the volume milked (0.8 to 0.9 liters per

Table 1: Summary statistics for different randomly selected sub-samples.

		Avg. raised cows	Avg. lactating cows	Months of milking	Avg. cows milked	Length of previous lactation	Gap in last two births	Age of cow at first birth	Number of births	Age of cow	
Lactation Curve Quest.	Obs.	172	170	168	168	176	155	168	169	168	
	Mean	5.64	2.73	11.07*	2.02	12.35	22.17	52.23	3.04	10.55	
	Median	4	2	12	2	12	24	60	3	10	
	Std. Dev.	5.09	1.84	2.31	1.19	4.35	5.31	24.46	1.39	3.14	
	Min	1	1	2	1	4	12	4	1	5	
	Max	31	10	12	7	30	36	108	7	19	
Avg. / Herd / Day (AMHD) Quest.	Obs.	168	164	163	163	157	154	164	165	164	
	Mean	5.88	2.76	10.51*	2.02	12.61	22.30	52.23	2.98	10.27	
	Median	4	2	12	2	12	24	60	3	10	
	Std. Dev.	5.51	2.08	2.99	1.18	4.85	5.43	23.98	1.45	3.04	
	Min	1	1	1	1	3	12	3	1	5	
	Max	35	12	13	7	28	36	96	9	18	
Physical Monitoring Subsample	Obs.	290	286	286	286	284	264	287	287	287	
	Mean	5.86	2.75	10.97***	2.03	12.51	22.26	51.94	2.97	10.22***	
	Median	4	2	12	2	12	24	60	3	10	
	Std. Dev.	5.36	1.95	2.45	1.16	4.51	5.35	23.35	1.41	3.06	
	Min	1	1	1	1	3	12	4	1	5	
	Max	35	12	13	7	30	36	96	9	19	
Subsample Not Monitored	Obs.	50	48	45	45	49	45	45	47	45	
	Mean	5.16	2.73	9.69***	1.98	12.29	22.09	54.09	3.26	11.67***	
	Median	3.5	2	12	2	12	22	60	3	11	
	Std. Dev.	4.90	2.03	3.66	1.31	5.06	5.50	29.19	1.42	3.05	
	Min	1	1	1	1	4	12	3	1	6	
	Max	20	10	12	5	24	36	108	7	17	
Lactation Curve Quest.	Obs.	144	142	142	142	148	130	143	143	143	Monitored
	Mean	5.89	2.80	11.23*	2.06	12.44	22.32	51.78	3.03	10.36	
	Median	4	2	12	2	12	24	60	3	10	
	Std. Dev.	5.28	1.86	2.10	1.19	4.28	5.30	23.59	1.37	3.12	
	Min	1	1	2	1	5	12	4	1	5	
	Max	31	10	12	7	30	36	96	7	19	
Avg. / Herd / Day (AMHD) Quest.	Obs.	146	144	144	144	136	134	144	144	144	
	Mean	5.83	2.70	10.71*	1.99	12.58	22.20	52.09	2.92	10.08	
	Median	4	2	12	2	12	24	60	2	10	
	Std. Dev.	5.46	2.04	2.73	1.14	4.76	5.41	23.19	1.46	3.00	
	Min	1	1	1	1	3	12	4	1	5	
	Max	35	12	13	7	28	36	96	9	18	
Lactation Curve Quest.	Obs.	28	28	26	26	28	25	25	26	25	Not monitored
	Mean	4.36	2.39	10.19	1.77	11.89	21.40	54.80	3.12	11.64	
	Median	3	2	12	1	12	21	60	3	11	
	Std. Dev.	3.79	1.71	3.12	1.18	4.76	5.39	29.35	1.51	3.13	
	Min	1	1	2	1	4	13	5	1	6	
	Max	15	6	12	5	24	34	108	7	17	
Avg. / Herd / Day (AMHD) Quest.	Obs.	22	20	19	19	21	20	20	21	20	
	Mean	6.18	3.20	9.00	2.26	12.81	22.95	53.20	3.43	11.70	
	Median	4	2	12	2	12	23.5	60	3	11.5	
	Std. Dev.	5.97	2.38	4.28	1.45	5.52	5.65	29.73	1.33	3.03	
	Min	1	1	1	1	5	12	3	1	7	
	Max	20	10	12	5	24	36	96	7	17	

Source: Authors' calculation based on data collected for the experiment. Significance levels: * 10%; ** 5%; *** 1%.

cow and per milking) does not vary with farm type, morning or evening milking, position along the lactating curve. Sparing milk for the calves drives the practice of milk off-take especially in camp farms.

Recall questionnaires were asked to 200 farms (141 of which had also been monitored) in December 2012, and to 400 farms (269 of which had also been monitored) in May-June 2013. The December survey included a 6 month recall AMHD questionnaire. The 400 households interviewed for the 2013 survey were randomly split into two groups, with one being administered a 12 month AMHD recall, and the other a LC module, where the LC questions where followed by an AMHD question. We are therefore able to compute recall measures based on the four measures described above (6 month recall, which we also annualize by multiplying it by 2), LC curve, 12 month AMHD, and 12 month AMHD cum LC recall aid.

The objective of the physical monitoring was to be able to construct a measure that could be used as a benchmark against which to compare the different recall methods. Earlier in the project, an LC questionnaire and a 12-month AMAD recall had been included in the national ECVMA survey implemented in 2011 by the Institute Nationale de la Statistique (INS) of Niger, with technical assistance from the World Bank and the Minister de l'Elevage, on a nationally representative sample of 3,968 households, of which 2,430 are rural and 1,538 urban. While it was not possible to construct a benchmark for this large nationally representative survey, the results of the comparison between the two recall methods can be interpreted in the light of the conclusions emerging from the Dantiandou survey and monitoring.

While the standard LSMS-type livestock product module was not used in these surveys, a smaller scale pilot that was run in February 2011 on about 60 households provide qualitative confirmation of the expectation that the standard LSMS module tends to understate milk production compared to other recall methods.

Of importance to the design of the study, we observe no significant differences between the two groups in which our sample was randomly split. That provides confidence in that the random design on which the survey is based worked, and that the groups being compared have no systematic difference other than the fact that they have been asked different questions. Table 1 summarizes the descriptive statistics for the key groups in which the sample has been split for the fieldwork and the analysis. Or only two variables we do find statistically significant differences (months of milking and age of cows) which are mostly driven by differences between the monitored and non-monitored households. However, within the group of households that were only administered the recall questionnaire (i.e. non-monitored) there are no differences between those who responded to the LC or to the AMD questionnaires. Most of the comparisons we will base our conclusions will however be based on the monitored households only, so that even there was any bias in the selection of the households to monitor, that would not affect the households not being monitored. The non-monitored households were mainly added to the sample to obtain some more power in the comparison of means.

4. Results

The expectation going into the exercise was that the LC method could provide an improvement over the AMD, which we expected to overestimate production. The key results from the validation exercise carried out as part of the ICRISAT-led fieldwork in Dantiandou are reported in Table 2.

The first rather surprising result is that the AMD recall methods do in fact perform much better than was expected, and appear to be superior to the LC methods. The deviation of the median values from the median of the milk monitoring is surprisingly close to the value obtained via the physical monitoring with a difference of just 21 liters (or about 3 percent). The deviations for the mean values are somewhat larger but still acceptable at 30 liters (3 percent of the monitoring value for the 6-month recall, up to 6 percent for the other variants).

Secondly, for the LC Method the results are less satisfactory. Deviations from the 'gold standard' represented by the physical monitoring range between 'acceptable' levels at 6 and 10 percent, when median values are considered (for the 4 and 3 points measures, respectively). If one considers deviations from the average value of the monitoring, however, differences increase to 13 percent for the 4-point LC method and 37 percent for the 3-point LC method. In general, the 4-points method appears to perform significantly better, thus justifying the extra question required of the respondent.

Thirdly, the results show that a major feature common to both the AMD and LC methods is how they over-estimate the dispersion around the mean (as measured by the standard deviation), and particularly so for the LC method. Among the AMD variants, the highest standard deviation is 1.4 times the standard deviation of the monitoring. For the LC method the ratio is 1.8.

Within the AMD methods, shortening the recall period to 6 months appears to perform as well as the

12 month recall, without any major improvement in accuracy. In this particular sample the 6 month recall survey did not generate any large extreme value, which happened for the 12 month survey, but it is hard to generalize this result, as it is linked to the performance of a few respondents[5]. We will however return to this matter when we discuss other measures we use to assess the relative accuracy of the various methods.

Another result that is interesting to note is how the AMD method, when integrated with the LC questions, returned substantially more accurate results than when the LC questions were not included. It appears, but again this is based on few observations in the left hand tail of the distribution, that introducing LC as a recall aid did help respondents to average out to values closer to the 'true' value, which we approximate here with the monitoring. This is particularly true for camp household, which are characterized by both higher production values, and deeper seasonal fluctuations.

Importantly, very similar findings regarding the differences between the estimates obtained via the AMD and LC methods are observed in the data collected via the national ECVMA survey, which did not include a benchmark measure as did the Dantlait survey. Figure 3 reports the mean, median and standard deviation measures of milk production per cow in both data sets. The patterns, in terms of differences between the LC (based on 3 points) and AMD methods, are very similar in the two surveys. This is consistent with the idea that the Dantlait survey results can be extrapolated to a sample of households in other parts of Niger, conducted as part of a larger scale, national survey operation conducted by the national statistical office.

It is important to note, however, that the Dantlait survey was limited to cattle. Small ruminants have shorter lactating periods, and the same results may very well not apply to them. In the ECVMA data, for instance, milk off-take from ewes and goats[6] is substantially higher when estimated with the AMD method compared to the 3-point lactation curve method, which is the opposite of what happens for cattle in the same sample. Unfortunately, as discussed earlier, the ECVMA did not include a benchmark that allows assessing the precision of these estimates, and the Dantlait survey only collected data on cattle. Throughout the paper, therefore, we will be referring only to estimate of cattle milk off-take.

Figure 3: Comparison of mean, median and standard deviation measures of milk off-take estimates from AMD and LC methods in Dantlait and ECVMA surveys (liters).

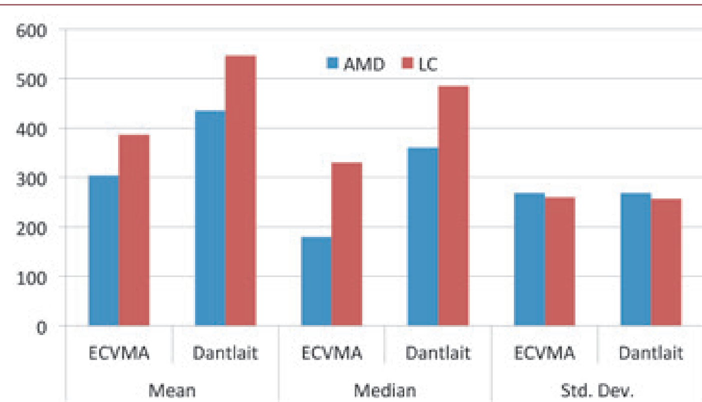


Table 2: Household milk off-take (liters). Comparison of monitoring and recall data, various methods (annual and 6 months).

	TOTAL						VILLAGE						CAMP					
	Obs.	Mean	Median	Std. Dev.	Min	Max	Obs.	Mean	Median	Std. Dev.	Min	Max	Obs.	Mean	Median	Std. Dev.	Min	Max
Physical monitoring																		
Monitoring at 12 months	300	877	741	631	10	3291	129	605	512	465	10	2484	171	1083	971	662	45	3291
Recall on 12 months																		
6 months recall - annualized	171	847	720	699	8	3600	63	569	360	534	8	3240	78	1089	1080	640	180	2880
Avg. / Herd / Day (AMHD) - LC module	167	934	720	870	43	5400	55	684	557	591	43	2229	79	1072	929	845	130	4458
Avg. / Herd / Day (AMHD) - All	330	926	720	863	9	6687	111	759	557	692	9	3960	157	1049	743	880	130	6687
Avg. / Herd / Day (AMHD) - 12 months recall	163	918	720	859	9	6687	56	832	549	777	9	3960	78	1027	743	920	130	6687
Lactation curve - 3 points	167	1200	818	1146	132	6900	56	1091	600	1140	132	6037	79	1284	913	1229	201	6900
Lactation curve - 4 points	167	990	693	934	87	6037	56	915	480	1010	87	6037	79	1055	855	954	174	5263
Note: 330 sample of households with not null milk production.																		
Monitoring at 6 months	300	471	386	323	10	1825	129	334	267	230	10	1321	171	574	509	345	45	1825
Recall at 6 months	171	424	360	350	4	1800	63	284	180	267	4	1620	78	545	540	320	90	1440
Note: 300 monitored hhs (152 with LC quest. / 148 with AMHD quest.).																		
Source: Authors' calculation based on Dantlait survey data.																		

Besides getting at reasonable average estimates, however, LSMS-type surveys are geared towards depicting the heterogeneity in household's livelihoods and productivity. To that end, looking at how different indicators perform along the entire distribution, and understanding how well they can estimate the position of each household along the distribution is as, if not more, important as obtaining an accurate central tendency measure. For these reasons it is worth analyzing also the correlation and regression coefficients between the different recall methods and the monitoring benchmark (Table 3), and the box plots for the different measures (Figure 4).

Looking at Table 3, it is comforting to observe that the implicit ranking of the different recall methods observed for central tendency (Table 2) is also confirmed when one looks at the overall correlation between the measures resulting from different recall methods. The annualized 6 month (AMD, top row) and the straight 6 month recall (bottom row)[7] display the highest coefficients and R2, followed by the other 12 month recall methods in the order in which they appear in the table, and again pointing to a better performance of the 4-point compared to the 3-point LC variant.

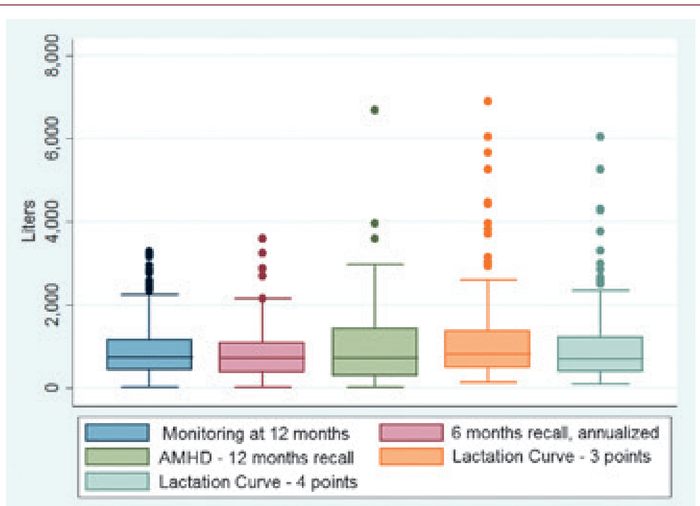
The box-plots (Figure 4) provide further support to these results. To improve readability we have only graphed five indicators, the monitoring, 6 month recall annualized, 12 months recall, and 3 or 4-points lactation curve. As in the statistics shown in tables 2 and 3, the 6 month recall method shows a little more dispersion than the monitoring, but in terms of median and overall distribution the fit is overall very good. The dispersion at the top end of the distribution increases with the less precise AMD methods, but remains broadly acceptable (even though it is of course hard and to some extent subjective to define 'acceptable' in this case), and becomes substantially higher for both variants of the lactation curve method.

Table 3: Correlation and regression (Ordinary Least Squares, OLS) coefficients between monitoring and recall methods.

	Correlation coefficient	OLS no constant		OLS		OLS (logs)		N
Correlation with 12 months monitoring		Coeff	R2	Coeff	R2	Coeff	R2	
6 months recall - annualized	0.71	0.91	0.81	0.68	0.50	0.76	0.63	141
Avg. / Herd / Day (AMHD) - LC module	0.61	0.79	0.72	0.51	0.38	0.57	0.48	134
Avg. / Herd / Day (AMHD) - All	0.52	0.73	0.66	0.41	0.27	0.58	0.44	268
Avg. / Herd / Day (AMHD) - 12 months recall	0.44	0.69	0.60	0.33	0.19	0.58	0.41	134
Lactation curve - 3 points	0.35	0.47	0.52	0.19	0.12	0.47	0.21	135
Lactation curve - 4 points	0.36	0.57	0.53	0.24	0.13	0.49	0.24	135
Correlation with 6 months monitoring								
Recall at 6 months	0.67	0.97	0.78	0.69	0.44	0.76	0.63	141

Source: Authors' calculation based on Dantlait survey data.

Figure 4: Box plots of mean household daily milk off-take (liters): Monitoring and recall.



Then, to look more closely into the correspondence between the different measures for the individual households, we have plotted scatter plots of the different recall measures against the result of the milk monitoring. Results are reported in Figure 5, where the green line represent the line of equality between the two measures (this would be a 45 degree line if the axes had the same scale), whereas the blue line is based on a linear fit.

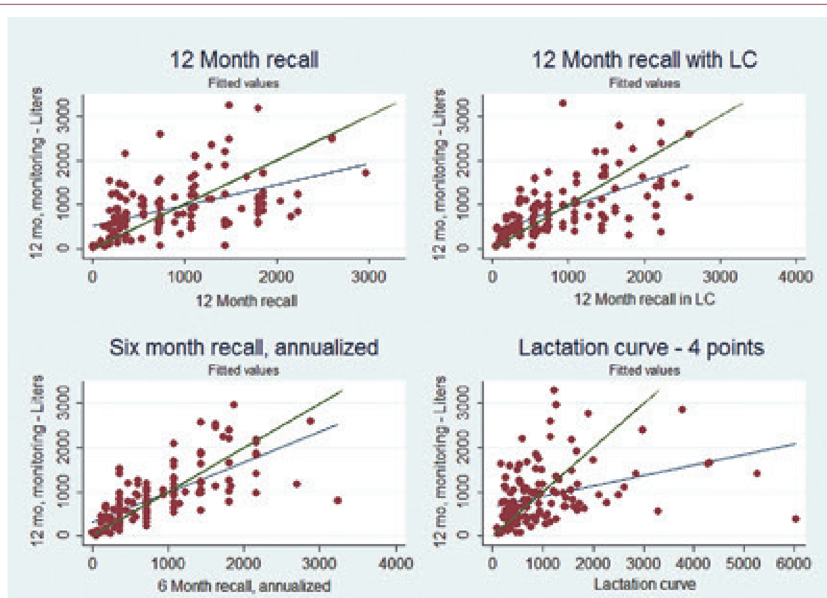
A few things are notable from these graphs. First, the methods that perform better when judged on the synthetic measures we have analyzed so far, also perform better when we look at individual household observations. The cloud is a lot more scattered in the case of the LC method than it is for the six month recall or the 12 month recall with the LC aid. Second, a fair amount of measurement error remains[8]. More importantly, at this visual inspection the error does not seem to be randomly distributed, but tends to be negatively correlated to 'actual' (i.e. monitored) milk production. Respondents are more likely to under-report milk production if they produce larger quantities of milk, and they are more likely to over-report production when they produce smaller quantities. This is clearly a matter of concern for the analyst, and something we plan to investigate further as the next step in this research project.

5. Conclusions

Agriculture plays a key role in the livelihoods of poor households through the developing world, and particularly so in Sub-Saharan Africa. Livestock accounts for an increasing share of food consumption, offering increasing opportunities for value addition and income generation. For many poor households, livestock ownership is a major contributor to satisfying the needs for cash as well as proteins. For the households more prone to climatic stresses, such as those in arid areas, it is often the main - if not the only- source of livelihoods. Milk in particular offers a marketable product that is available throughout the year and that can play an important role for nutrition, particularly for children.

While there has been a renewed interested in the research over the nexus between agriculture, poverty and nutrition in recent years, associated with the increase in international food prices, this has not been matched by an improvement in the state of agricultural statistics. In Africa the availability and quality of agricultural sector data leave much to be desired, and that is particularly so for the livestock sub-sector. In terms of methods, livestock statistics offer peculiar challenges that are exemplified by the difficulties of collecting accurate milk off-take data at the household level. However, of the small investments in livestock statistics, hardly any goes into methodological validation. The work documented in this paper takes the motivation from this state of affairs, and the belief that given the abysmally low level of attention to this type of work, effort to improve data quality can have substantial marginal returns and multiplier effects on research and policy analysis.

Figure 5: Household milk production: Scatter plots of recall against monitoring method.



There are some clear messages we take away from work implemented in Niger to test different recall methods to capture household level milk off-take data, against a gold-standard of physical monitoring over a 12-month period.

The first is that even though there is a substantial amount of measurement error in the way even the best recall methods we tested perform in capturing household milk off-take, some methods do in fact perform fairly accurately, and much more accurately than what we expected when we designed this exercise. In particular, the methods do a reasonable job at estimating the more common central tendency measures (mean and median), as well as the distribution of milk production across sample households.

The methods that rank consistently better among those we compared are the 6 month AMD recall, and a 12 month AMD recall coupled with a lactation curve recall aid. The lactation curve method, on the other hand was consistently the worst performer, with differing patterns depending on the number of data points used to estimate the off-take level at different points in the lactation. Within the AMD method, the shorter recall period appears to significantly improve the estimates, even though it is uncertain the extent to which this result would hold if the 6-month recall interview were to be moved to another point in time, given the seasonality of milk production.

In terms of future research agenda, our priorities will be to look closer into the determinants of the measurement error we observe. Candidates are herd and production system characteristics (including seasonality, herd size, number of milkings per day), household and respondent characteristics (education, age, gender, importance of livestock for the household), as well as factors such as the tendency of respondents to round up numbers in the responses.

While we plan to pursue this analysis in the near future using this dataset (and possibly additional similar experiments in different geographical settings) we do maintain our findings are strong enough to be already taken up in future questionnaire design.

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Endnotes

1 For information on the two projects see www.africalivestockdata.org and www.worldbank.org/lsms-isa.

2 In fact there are two variants of the AMD method, one that asks about Average Milk per Animal per Day (AMAD), and one that asks about Average Milk per Herd per Day (AMHD). Our results refer mainly to the latter even though – as we explain in what follows – we used both at different points in our fieldwork.

3 An alternative way of computing milk production is to assume a monotonic decline in lactation from a peak after a week from parturition, to zero at the end of the lactation (milk production) period.

4 Note that the area of the rectangle ABCD depends on the mean milk off-take by animal by day (BC) but also of the mean duration of milking (AB). The latter is much more variable and depends on factors such as individual, parity, season, and it could reflect a progressive reduction of milking frequency.

5 One possible reason is that the 6 month recall survey occurred at the end of the wet season, so that the average milk offtake was mostly based on the high milk off-take during wet season while the 12 month survey occurred at the end of the dry season, requiring for the herder a more difficult averaging exercise between low milk off-take in the last months and higher off-take in the former months.

6 Data not reported, but available from the authors upon request.

7 The annualized 6 month recall is just the 6 month recall times 2. What really changes in the comparison between the two is the benchmark data, which is the full 12 months of monitoring in the former case, and the first 6 months of monitoring in the latter.

8 It should be noted that while we treat milk monitoring as the benchmark this measure is also, as any measure, affected by some degree of error.

SPP 6
Census and Dissemination

Organizers: Susana Pérez Cadena, Mauricio Rebolledo Loaiza, INEGI

Chair: Arturo Blancas Espejo, INEGI

In many countries, the economic and agricultural censuses are carried out through a comprehensive enumeration of the observation units, with which directories are conformed, being the basis for the subsequent collection of census data.

Generally, the enumeration activities for the Economic Census and for the Agricultural Census are done separately and independently, meaning that in many occasions the same areas are roamed by different interviewers and at different times, but with the same objective: capture observation units that perform economic or agricultural activities. The above cause high costs, over burden on respondents and frames built at different times are obtained.

The objective of the session is to understand the efforts that countries are making to build a unique directory with observation units dedicated to the economic and agricultural activities under the same enumerating operation, as well as its link with the Population Census.

Possible topics for papers in this session include:

1. Comprehensive enumeration of the agricultural and forestry production units, as well as those dedicated to the production of goods, trading of goods and service providers in the country.
2. Construction of a Master Sampling Frame for economic and agricultural units.
3. Link between the Population, Agricultural and Economic Censuses.

Dissemination

In a more globalized and interconnected world, it is of vital importance to share information that allows knowing and disseminating information related to the agricultural statistics generating process, since this will enables all countries to go on a same direction, taking advantage of the experiences jointly acquired in the seek for a common objective: produce complete and accurate agricultural statistics with the maximum level of geographical and sectorial disaggregation possible, using the lowest quantity of resources.

To achieve the above, it is necessary to advance in the promotion of the “Free access to data” philosophy, understood as a practice that requires that certain data be available for everyone without copyright

restrictions, patent nor other control mechanisms, following the principles of confidentiality that each institution and country are required to respect according to the legal frameworks.

The information that is apt for dissemination embraces all the agricultural statistics production process, from the birth of projects to the dissemination of the results, so that the experiences acquired through various activities of the process may be shared.

It is clear, that to obtain the above, considerable effort and time is required. To date, there are different advances that have been made in that sense, so the proposed approach for the Sixth International Conference on Agricultural Statistics circumscribes the following topics:

- Dissemination of methodologies, good practices, a minimum set of core data, indicators and advanced technology for the agricultural statistics production process.
- Design and use of products that combine statistics, geography and informatics for the dissemination of the agricultural statistics results.
- Dissemination of projects that integrate economics, agricultural and population information in a unique geographic consultation product.
- Work schemes that allow fully satisfying our information users, following the principles of confidentiality. User´s demand for data confidentiality is growing every day, our interest, is to know the way in which different countries are fulfilling these demands without violating the confidentiality principles that they are required to follow.

Papers:

- Edmund Kibuuka, Moses Mnyaka (South Africa), "Agricultural Censuses: importance, challenges and opportunities in the developing world"
- Jerzy Banski (Poland), "The Atlas of Polish Agriculture as an Example of the Use of Statistics for Decision-Making"
- Filippo Gheri, Amy Heyman (FAO), "Efficiency and Effectiveness: the FAO Statistical Yearbook"
- Salih Hamza Abu-El-Yamen (Sudan), "Towards Bridging the Gap between Data Production and Data Utilization"
- Mauricio Rebolledo Loaiza (Mexico), "Agricultural Geo-Statistical Information Query System"

Agricultural Censuses: importance, challenges and opportunities in the developing world

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Abstract

Agricultural censuses although not in existence for as long as population censuses, have been around for a while. Agricultural censuses are designed to measure the extent of agricultural activity in any given country. Agricultural censuses are important to both the developed and developing world economies. The significance of agricultural censuses, however, is more pronounced in the developing world, in which agriculture is the source of livelihood to the majority of population and is usually the largest contributor to national gross domestic product. In the developing world, therefore, the importance of agricultural censuses cannot be divorced from that of the agricultural sector, which the censuses are designed to measure.

The challenges of conducting an agricultural census in the developing world are immense, but a number of opportunities do exist for these regions. In recent years, agricultural censuses have progressed from collecting information traditionally classified as farming to forestry, fisheries, rural and environmental statistics, complicating the situation further for developing regions already struggling with resources for this purpose.

This paper is an attempt to unpack the importance, challenges and opportunities for agricultural censuses with specific reference to the developing world. The paper further explores the opportunities behind the integration of agriculture and rural statistics into the population census and reports on the South African experience.

Keywords: agriculture; population; census; developing world; statistics.

1. Introdcution

Most constituents of the developing world are located in Africa, South Eastern Asia and South America.

The importance of agricultural statistics in the developing economies of the world can never be over emphasized. Agriculture in many developing countries of the world contributes the greatest portion of the gross national product (GDP), is the single largest employer and the source of livelihood for the majority of people. Since the majority of the population in these countries live in rural areas, the importance of agriculture and its potential in uplifting the standard of living of the rural poor is difficult to overlook. In Uganda for example, agriculture provides employment and livelihood to about 80% of the population. A similar picture is to be expected in most countries in the region.

It should be mentioned, however, that agriculture may not always be the leading contributor to GDP in developing economies. Depending on country specifics, mining and tourism may take centre stage in some countries.

The Food and Agriculture Organisation (FAO), has in the past decades, spearheaded a number of initiatives to guide and drive agricultural statistics, such as the Global Strategy for the improvement of agricultural and rural statistics (FAO, 2010). These initiatives have contributed greatly towards addressing the challenges faced by the developing world.

2. Importance of agricultural censuses to the developing world

The importance of agricultural censuses cannot be divorced from that of the agricultural sector at large. Thoroughness and promptness are important in the measurement of the largest and most important sector in any the country. In addition, the importance of the sector dictates that the censuses are conducted at a regular frequency. For the reason that they collect more accurate and detailed information, agricultural censuses are of additional importance in these economies.

Briefly, agricultural censuses are important for the following reasons:

- In addition to the number of people/households/entities involved in agriculture, agricultural censuses provide accurate information on the structure of agriculture and farming practices in a country;
- Provide value of production (and also income), pricing and input use in agriculture; and
- Agricultural censuses provide country production information for crops, livestock, forestry and fish products also land and water use, degradation and conservation.

All the above information is critical for policy and informed decision making for private and public sector alike.

3. Challenges facing the developing world

Developing countries are exposed to a number of challenges. Most of these challenges are related to the political, economic and political circumstances, unique to these economies. Some countries in Africa, for example have not been able to conduct any comprehensive agricultural census due to political upheavals in part of their territories.

Most governments in these regions prefer to invest in projects with maximum political visibility, which agricultural censuses do not possess. Lack of political visibility unfortunately leads to low political will to conduct agricultural censuses. Other challenges are listed below:

Limited funding for agricultural Censuses

Developing countries run on constrained budgets, yet the agricultural censuses they are required to conduct are very costly exercises. The censuses in these economies have to compete with a number of other developmental priorities for funding such as health (HIV and malaria), educational and other campaigns, which are usually perceived more pressing than agricultural censuses. There is simply not enough money to go around. Budgetary constraints usually relegate agricultural censuses to external/donor funding. The usual practice, in light of budgetary constraints, is to limit coverage by geographic detail and variables collected (Marshall, 2010).

Skills shortage

After limited funding, the shortage of agricultural statistics skills is perhaps the biggest challenges facing the developing world. Skill shortage directly impacts on the countries' capacity to generate quality statistics. It all stems from the kind of training provided in the countries under discussion. The training offered provides little in terms of linkage between agriculture and statistics. Ideally, an agricultural statistician should be a professional appropriately versed in the biological, statistical and economic[1] aspects of agriculture. The professional should in summary be an agriculturalist with deep knowledge of applied statistics.

Also related, but separate from skill shortage, is the low overall level of literacy in these regions. This implies that applications like self-enumeration in agricultural census questionnaires become redundant. Enumeration costs per questionnaire escalate because most farmers have to be visited for the completion of questionnaires.

Infrastructural challenges

The developing world is faced with numerous infrastructural challenges. Most are linked to the under development of road infrastructure due to lack of resources and neglect. Whatever the underlying reasons, the consequences are absence and/or impassable roads in the rural areas, where the agricultural households are located.

Although, mobile phone and internet connections have in the recent decades, greatly improved telecommunication in the rural areas of the developing world, many are still to be covered. Internet access and usage remains low in developing countries. Low internet access coupled with low literacy rates, dictate that questionnaires have to be posted and field visits are unavoidable.

A number of these countries are rapidly broadening electricity supply to rural areas, but the task at hand is enormous. Since most census equipment requires electric power for charging and operation. A large number of census personnel, in these regions, are often left with no option but to commute to and fro a major urban centre and the field, further inflating the cost of agricultural censuses.

Changing national and global trends in the demands for agricultural statistics

The demand for agricultural and rural statistics has changed over the years. There are new demands there were not there before. As the world changes, new demands emerge e.g. environmental degradation and the need for statistics to track water and soil degradation. In addition, the definition of agricultural statistics has broadened to include forestry and fisheries. Gender issues and minority populations are also increasingly becoming frontline issues in agriculture and rural development. The changing trends in the demand of agricultural and rural statistics are stretching budgetary and skills requirements of the institutions involved to levels never experienced before.

Respondent fatigue

Most governments in the developing world now recognize the importance of statistics for informed

policy formulation, administration, monitoring and evaluation. However, collection of these statistics has inevitably created untold burden to respondents that on some occasions are required to participate in up to four (4) surveys a year. The result is low response rates in agricultural censuses.

Various approaches to improve public awareness can be utilised in addressing this challenge. In the South African for example, there is a dedicated publicity team to for agricultural censuses and surveys. The publicity team conveys sponsorship, attends and addresses organized agriculture meetings and congresses. Print and electronic media are also used in the team's stakeholder outreach programmes. Increased awareness campaigns improve respondent and public appreciation for agricultural statistics. The opportunity here is improved response rates.

Also equally beneficial, is the integration of agricultural statistics modules into other survey areas. For example, the process of the integration of agricultural and rural statistics, in South Africa, started with the population census in 2011. The following questions were included in the population census questionnaire of 2011:

1. What kind of agricultural activity is the household involved in?
2. How many animals (by category) do you household own?
3. Where does the household conduct its agricultural activities?

By integrating agriculture into the population census, a household frame of agricultural activity in the country can be compiled. This process eliminates duplication of costs, since a single budget, manpower and other resources are used. Finally, by integrating agriculture or any other survey into another survey area, the number of questionnaires and therefore the burden on respondents is reduced.

Lack of Master sampling frames (and in some cases lack of an agricultural statistics strategy)

The structure of the agricultural sector in these countries is mainly composed of commercial and household based farming units. It is unusual for a country to display an equal distribution, by number, between commercial and household based farming units. The common scenario is dominancy of one component over the other. In South Africa, the household based farming units dominate over the commercial units (in number) despite the fact that the latter are more organized and resourced. This is the most likely scenario in most regions of the developing world.

On average, due to their small proportion, the sampling frame for commercial farming units is usually comprehensive. The challenge usually arises from compiling the household based frame. Including an agricultural module in the population census questionnaire, identifies these households and usually resolves this challenge. Without the integration of agriculture into the population census, the frame development exercise would be exorbitant, for any of these countries to afford.

It can safely be said that most of the challenges mentioned above may be linked to the absence of a national agricultural statistics strategy. The implications can be far reaching for an agricultural census or survey. The consequence is low quality statistics, collected in an uncoordinated and costly manner.

A brief discussion of South Africa's experience is provided under the recommendation section.

4. Opportunities

The following opportunities do exist for agricultural censuses in the developing world:

Improved political will and donor funding

Increasing empirical evidence, in favour of agriculture's potential in uplifting the livelihood of the rural poor, is drawing increasing political attention for the need to measure the sector. There is improved political will and increased international donor funding for agricultural censuses in developing countries.

Technological advancements

Technological innovations such as satellite technology (imaging, collection, transmission, measurement, communication and data sharing), GIS, GPS, analytical computer packages, mobile phones and internet are improving accuracy, communication, and access to previously inaccessible rural areas. The benefits are shorter 'turn around times' and better quality data for agricultural censuses.

Additionally, innovations in information technology have increased the opportunity to 'share and learn from others'. The opportunity, for agricultural censuses, lies in cost reduction and data quality improvement associated with information sharing. These regions are now able to avoid costly mistakes by learning from the experience from other countries.

Technological innovations, such as satellite imaging, are also paving way for less intrusive data collection methodologies.

Integrated approach

The opportunities availed by linking the agricultural census to the population census or integration into other surveys have been discussed in the preceding section of this paper. The highlight in this section is cost reduction (by eliminating duplication), improved depth, width and versatility of agricultural statistics.

5. Recommendations

A lot still has to be done towards raising awareness and educating the general public about the importance of agricultural statistics and other statistics. Public awareness campaigns need to be stepped up. Awareness campaigns should be targeted in nature-towards different categories of respondents.

As mentioned earlier, low literacy rates reduce farmers' ability to complete questionnaires on their own. Programmes designed to improve literacy in rural areas are also recommended.

National and possibly regional investment in rural infrastructure improves access to rural areas and in the long run reduces the cost of running agricultural censuses and surveys.

Finally, countries in these regions are advised to develop and implement national agricultural statistics strategies designed to address most of the inherent challenges mentioned earlier. National agricultural statistics strategies are able to address:

- Poor capacity in agricultural statistics;
- Data quality (gaps, depth and width);
- Poor coordination and efficiency use of resources within the sector; and
- To guide quality assurance, standardisation and certification in the agricultural statistics.

For improved synergies, a regional approach is recommended for training agricultural statisticians.

5.1 Recommended steps strategy formulation process

The following discussion is based on the South African experience, which is anchored on the Action plan for Africa 2011-2012 for improving statistics for food security, sustainable agriculture and rural development (AfDB & FAO.2011). The agricultural strategy development process in South Africa is based on the following steps:

5.1.1 Research

A study to analyse all the aspects concerning the provision of agricultural statistics in a country should be conducted. In this study, data gaps, producers, users, and skill gaps etc. should identified. It is highly advisable that this research involves both a desk and field study. Investigations on international best practice should form a major component of the desk top study. This study should culminate into a report/ discussion document.

5.1.2 Stakeholder meeting to discuss study findings

A stakeholder meeting to discuss and derive consensus on both challenges and recommendations is suggested. In this meeting, the actual specifics regarding the country's core and supplementary modules are agreed upon. Recommendations to address challenges such as definitions, data quality and skills shortages are coined. It is proposed that this meeting is constituted of the most important stakeholders in the sector, both at the data producer and user levels. Depending on the complexity of the country's agricultural sector, several consultative meetings may be required to reach consensus. This stage culminates into a document specifying agreed definitions, variables and collection frequencies required.

5.1.3 Formation of a national agricultural statistical subsystem (NASS)

This stage deals with the coordination, assignment of roles and designing a regulatory frame work for agricultural statistics in a country. Data producers and users are organized and coordinated into the NASS. The phase usually involves the formation of the National Agricultural Statistics Steering Committee (NASSC). The NASSC[2] coordinates agricultural data producers and users and provides research and advisory functions to the NASS and agricultural statistics in a country. The NASS forms one of the building blocks of the South African National Statistics System (SANSS) discussed in the next section.

5.1.4 Integration of NASS into the national statistical system (NSS)

The first step in the integration of agriculture and rural statistics into the NSS is the incorporation of some agricultural module into the population census. This process, for South Africa, has been discussed in detail in previous sections of this paper.

Integration of the NASS into SANSS subjects NASS, and other statistical subsystems to the following:

Certification and quality assurance of statistics

All statistics generated under any subsystem under the SANSS is subject and evaluated according to the stipulations of the South African Statistical Quality Assessment Framework (SASQAF) before they are granted the official statistics status. Statistics South Africa is the only entity in the country mandated to evaluate and certify statistics produced by any public or private entity and to confer the official statistics status.

Standards

Standards are set to promote consistency in the methods and results of surveys and censuses. This involves the development of sector, national and internationally agreed classifications, concepts and definitions.

Coordination

All generation of agricultural statistics, and indeed other statistics, in the country are governed by the Statistics Act[3]. Legal agreements in form of Memoranda of understanding or Service level agreements are designed to enforce compliance.

6. Conclusion

Although the challenges facing agricultural censuses and surveys in the developing world are numerous, they are not insurmountable. Innovation is creating opportunities which should vigorously be exploited. Other opportunities to be exploited include improved political will and donor funding, technological advancement and integrated survey approaches for agricultural statistics.

While the development of an agricultural statistics strategy should be every country's first step in addressing the challenges afflicting agricultural censuses and surveys, the strategy in itself cannot and will never address all the challenges faced by agricultural census and statistics as whole.

FAO's initiatives have contributed greatly towards addressing the challenges faced by agricultural censuses in the developing world. However, addressing these challenges (e.g. low capacity) will continue to demand a lot in terms of resources, scarcity of which is the main reason these countries are in this situation in the first place.

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Endnotes

1 Biological aspects such production potentials of various crops, trees and livestock. Statistical aspects such imputation, outliers etc. Economical aspects such production possibilities and prices.

2 Proposed composition for South Africa: Departments of Agriculture Forestry and Fisheries, Rural Development and Land Reform, Water and Environmental Affairs, South Africa; The Office of the President of the Republic of South Africa; Universities; and Provincial nominees.

3 Statistics Act, 1999.

The Atlas of Polish Agriculture as an Example of the Use of Statistics for Decision-Making

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Abstract

We often refer to the spatial differentiation of farming in the study of agricultural economy, or, when we analyse a problem on the scale of a region, we try to show the place of this region against the background of other areas of the country. This is supported by various kinds of cartographic renditions on the basis of statistical data.

The present *Atlas of Polish Agriculture* is also meant to serve such a purpose. Yet, it also goes beyond the standards set for similar elaborates. Side by side with rich cartographic content, it provides a synthetic description of the most important phenomena, complemented with numerous tables, diagrams and photographs. Thereby, it constitutes a complete image of the state of Polish agricultural economy in spatial setting on various scales (local, regional and national). The Atlas analyses a wide spectrum of issues: *the role of agriculture in Polish economy, environmental conditions of agriculture, development of agriculture in Poland, Agricultural population, agricultural land use, land structure, technical facilities and production goods, plants cultivation, farm livestock, agricultural production, agritourism and organic farming, science, education and agricultural service.*

The *Atlas of Polish Agriculture* was prepared in 2010 by the Department of Rural Geography and Local Development at the Institute of Geography and Spatial Organisation of the Polish Academy of Sciences. This is the very first such ample cartographic and statistic report on Polish farming.

The present *Atlas* can be made use of by the scientific and practitioners community and the spatial planning bureaus, as the basis for analytic studies and expert assessments. It can also be used as a source of information for diverse institutions of public administration, as well as social and economic organisations. Wide use of the Atlas in the teaching process at the university level is expected, as well.

Keywords: atlas; agriculture; statistics; Poland; regional analysis.

1. Introduction

The new era that came with the end of the communist system in 1989 brought important transformations in Polish society, politics and the economy. These changes were the result of replacing the over-40-year-old socialist system with a democratic one featuring an economy based on the free market. These transformations were particularly visible in agriculture, which to this day retains a leading role in the economic activity of the countryside, one often identified in Polish society with food production. Agriculture paid the highest price as a result of the transformative processes of the time. However, recent years have brought increasing benefits and positive changes for the countryside and agriculture, most notably following the accession of Poland to the European Union; indeed, contrary to skeptical expectations on the ability of Polish agriculture to rival Western European standards, this form of activity is becoming more and more competitive and profitable for those that exercise it.

The dynamic changes occurring in agriculture require a diagnosis and an assessment from a spatial perspective, and the results obtained as well as the conclusions we draw from them are a foundation for planning development and strategic action in the food production sector. It was with these goals in mind that the *Atlas of Polish Agriculture* was conceived, as a contemporary snapshot of Polish agriculture based on a rich database of statistical information compiled by the Central Statistical Office in 1988, 1996 and 2002. A basic hindrance here was the lack of homogeneity in the manner of compiling data, which is different for every wave. The comparability of statistical information is the "Achilles tendon" of statistics worldwide. The *Atlas* was published by the Department of Rural Geography and Local Development at the Institute of Geography and Spatial Organization of the Polish Academy of Sciences in 2010.

Theme-based agricultural information atlases are common and popular as compendia of data, and are highly useful in practice. They can be physically printed as books or published electronically, with

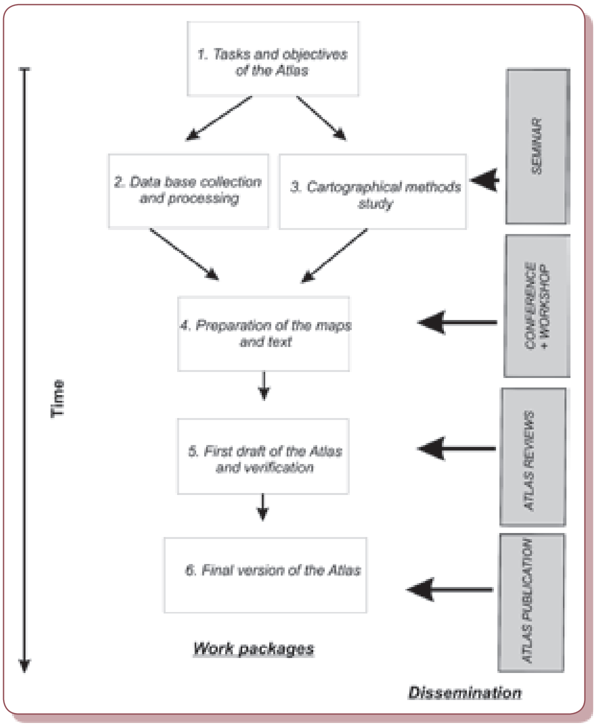
access given to users through the Internet. Some of the oldest initiatives of this kind include: the Soviet *Atlas siel'skogo choziajstwa SSSR* (1960) and the *Agricultural Atlas of England and Wales* (Coppock 1964). Some of the most intriguing printed publications among those released recently include *Agriculture*, published as part of the *National Atlas of Sweden* (1992). It is an exemplary case of a standardized thematic atlas. In 2011, Sweden published a new atlas entitled *Agriculture and Forestry in Sweden since 1900* (Jansson *et al.* 2011). Other national atlases also include volumes dealing specifically with agriculture, including the *Atlas de France*, Vol. 8: *L'Espace rural* (1998).

Noteworthy interactive, electronically published atlases include the *Agricultural Atlas of the United States*, first made available in 1997 and offering over 300 maps focusing on different aspects of the territory, as well as the *Agricultural Atlas (England)*, assembled based on current national censuses. National atlases of agriculture have also been published in Nigeria, Yemen and South Africa. Finally, general atlases of world agriculture such as the International Association of Agricultural Economics' *World Atlas of Agriculture* (1969) or the FAO's *Food and Agriculture Atlas* have also been released. The content of these atlases, however, is very general, and refers to entire countries as the smallest unit of analysis against a global background.

2. Methodological Premises of the Atlas

The process of preparing the *Atlas* involved 6 steps (Figure 1). The first of these was defining the topics to be included in the atlas and drawing up a plan of tasks and objectives. The second step was collecting and processing diverse databases and written material (articles, books, notes). The cumulative statistical data made up a new database, which in turn helped the authors devise indicators that were subsequently used as guidelines for the preparation of maps. At the same time, studies on cartographic methods were conducted to determine the best presentation framework and design for each topic referenced in the atlas. The fourth task was the actual preparation of content, comprising both the creation and arrangement of text, maps and other graphical components. This step was accompanied by workshops and conferences whose goal was the final development of the theoretical and methodological foundations of the atlas. A group of advisors was enlisted to supervise the creation of content across the board. The fifth task consisted of creating the first draft of the *Atlas* and subsequently submitting it for assessment by a panel of reviewers. The comments and recommendations that resulted from this were used to verify and fine-tune both content and graphics. The final task was to draft the final version of the work, make all the necessary technical preparations for electronic publication in two forms (on a CD and on the official website of the Institute of Geography and Spatial Organization) as well as for a printed publication.

Figure 1: The drafting and publishing process of the Atlas.



The *Atlas* was drafted based on a homogenous set of statistical data collected by and large for the purposes of the agricultural census carried out by the Central Statistical Office in 2002 and annual statistical reports prepared for the Local Data Bank in the years 1995-2010. This made it possible to use the same spatial units throughout the atlas; the basic points of reference were territorial units, including the *gmina* (commune, NTS 5), the *powiat* (county, NTS 4) and the *województwo* (voivodeship, NTS 2). Each level of disaggregation corresponded to a scale on the map, which ranged from 1:4,500,00 to 1:7,500,000. Throughout the atlas, one specific type of equal-area projection was used, in accordance with the standards for statistical maps.

The homogenous character of the final product also holds true for the graphical side. Several color scales were prepared and consistently used in all of the publication's graphical components. With respect

to cartographic methods, the premise was to use basic cartographic methodology, depending on the character of the source data and the purpose of the map. However, consideration was given to the wide audience the product could potentially reach, and therefore it was decided that simple and most perceptually intuitive methodological solutions would be most effective (Muller 1979; Dobson 1980; Maddock, Crassini 1980). Due to the nature of the statistical material in the way in which it was aggregated, quantitative methods prevail, particularly the cartogram and the dot method.

The cartogram method, true to its namesake, is used to illustrate the numerical distribution of different variables in spatial terms. In this method, the information is coded cartographically using contrast, with e.g. lower densities represented by lighter colors (Figure 2). The dot method was used in maps that seek primarily to illustrate the spatial distribution of a variable and numerical values or density are of lesser importance (Figure 3). Dot distribution maps also make it possible to identify the numerical characteristics of a variable or phenomenon, as each

Figure 2: Example of a cartogram: Share of arable lands in total area of agricultural lands, 2005.

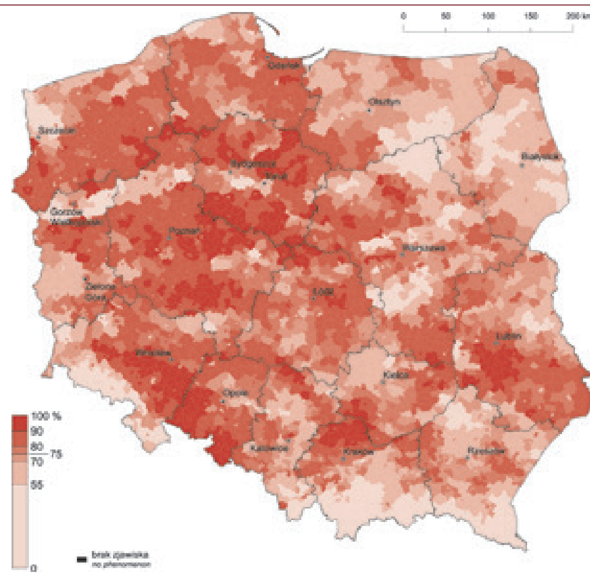
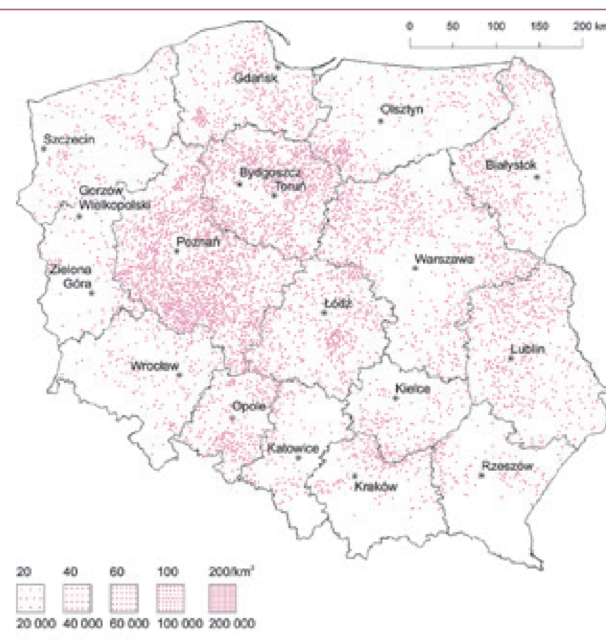


Figure 3: Example of a dot distribution map: Population of pigs, 2002.



dot possesses a constant value, although decoding such information for larger areas is rather difficult.

Other methods were used to illustrate specific points, including the proportional symbol technique, isolines (contour lines), the signature method and the ranges method. The proportional symbol technique was used to illustrate the spatial distribution of the absolute values of a phenomenon and the synthetic image of its internal structure. The size of the effect is directly proportional to the size (area) of the graphical marker. The isolines (contour lines) method traces lines that connect points with identical values on a given variable. This was used to visualize natural phenomena, e.g. to illustrate the climatic conditions in which Polish agriculture develops. The signature and ranges methods mostly find utility in synthetic maps that display the results of more advanced studies in a simplified way. One example of using the ranges method for this purpose is a map showing the extent of "problem areas" in agriculture or areas of food security, in an illustration derived several complex analyses of data condensed into a single map. The atlas is graphically enriched by a large number of photographs, graphs, charts, diagrams, tables, other illustrations and text (in both Polish and English) that discusses the various topics tackled in the *Atlas* (Figure 4).

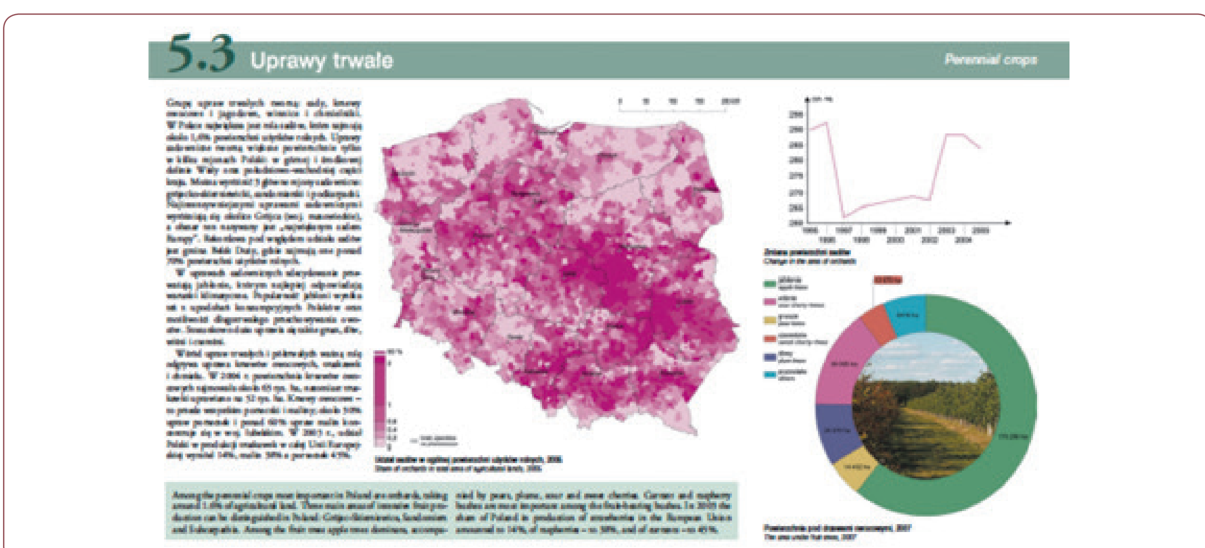
3. Content Structure

The content of the atlas is both diverse and comprehensive, covering all of the crucial topics related to the agricultural sector, condensed into twelve thematic chapters:

1. The Role of Agriculture in the Polish Economy
2. Environmental Conditions of Agriculture
3. Development of Agriculture in Poland
4. Agricultural Population
5. Agricultural Land Use
6. Land Structure
7. Technical Facilities and Production Goods
8. Cultivation of Plants
9. Livestock
10. Agricultural Production
11. Agritourism and Organic Farming
12. Science, Education and Agricultural Services

The *Atlas* begins by discussing the importance of agriculture in the overall structure of the Polish economy as well as its position relative to other countries of the European Union and of the world. Next, it covers the natural conditions in which agriculture is embedded, comprising mainly a typology of soils, weather conditions, availability and quality of water and the relief. Special attention is given to assessing the quality of the agricultural production space. The third chapter is dedicated to the history of agriculture on Polish lands; this section guides the reader through successive historical periods – from pre-feudalism to the socialist era – that had the greatest impact on the directions of development of food policy and management in what today is the Republic of Poland. The next chapter details the agricultural population of the country; maps show employment rates in agriculture and the spatial distribution of farmers' education throughout the country.

Figure 4: Sample page from the Atlas of Polish Agriculture.



The bulk of the *Atlas* is dedicated to issues related to agricultural land use and land structure. Thanks to a detailed set of statistical material, it was possible to display the share of land dedicated to specific agricultural functions at the level of the commune; these functions include arable land, meadows, pastures, fields and orchards. Furthermore, arable lands were subdivided into plots of land where different cereals (wheat, rye, oat, barley), industrial plants (sugar beet, rapeseed, agrimony), fodder plants (maize, various blends of cereals and others), and vegetables and other crops (leguminous plants, potatoes, greenhouse plants). The maps and graphs also present a detailed overview of the forms and structure of land ownership as well as the size of different agricultural holdings, including technical infrastructure, machinery and machine-powered farming tools, types of farm buildings, as well as fertilization of soil and plant protection.

The ninth chapter is a very expansive panorama of livestock in Poland. Maps show the distribution of cattle, pigs, chickens, sheep, goats and other animals (horses, rabbits, game and other species raised for their fur) as well as the industrial production associated with each. Next, several maps synthesize the production (both global and commodity), productivity and yield of agricultural output. Chapter 11 discusses the rapidly evolving touristic functions of agriculture (agritourism) and ecological agriculture. The final part of the *Atlas* is devoted to agricultural studies and education in the field at different educational levels as well as the provision of agricultural services, which is of even greater importance following Poland's accession to the European Union.

4. Role of the Atlas

While conducting research on agriculture, we often refer to its spatial heterogeneity; or, when examining an issue on a regional scale, we attempt to frame it within the context of the other regions of the country. Cartographic solutions often turn out to be the solution to our problems, as they are usually graphical reflections of statistical material that has been reconfigured into a diverse set of social and economic indicators. Their basic drawback is the discrepancy in reference scale between maps, disjointed forms of presentation and significant flexibility in content. We then come upon different hurdles that end up hampering our analysis. Atlases are usually free of such shortcomings, as they strive to present the most complete information possible about the processes that take place within a given topic. The *Atlas of Polish Agriculture* is one such complete and fleshed-out illustration of the state of agriculture and agricultural planning on a national level. Thanks to this, the publication serves the specific needs of scientists and practitioners well.

Another advantage of the approach taken in the *Atlas* is the dynamic analysis of selected issues. The most important of these (rural land use, agricultural production, livestock raising etc.) are inspected for a time bracket that goes back well over a dozen years. This allows us to evaluate the most significant processes and phenomena that took place in agriculture in the period of transformation and the first years following the accession of Poland to the EU.

The *Atlas* constitutes a basic reference source for a plethora of governmental, social and economic institutions that are in some way connected to agriculture (Ministry of Agriculture and Rural Development, Ministry of Regional Development, Agricultural Advisory Centers, Agency for the Restructuring and Modernization of Agriculture etc.). The *Atlas*, whose entirety is based on the newest available statistical data, is also a basic source for studies and expert reports on the agricultural sector in the economy, regional development and spatial planning, particularly for rural regions. Further, it is the starting point for the work of geographers, rural economists, planning experts, sociologists of the countryside and representatives of other scientific fields interested in the topic of agriculture. Thanks to the bilingual version of the *Atlas*, the study can also be tapped as a source by foreign scientists and experts.

The *Atlas of Polish Agriculture* goes beyond the approaches traditionally found in atlases in that it does not limit itself to a rich and diverse assortment of cartographic content; instead, it enriches said content through synthesized descriptions of the most important socio-economic trends and processes associated with the visualizations, providing an important descriptive dimensions that is further supplemented by numerous tables, graphs and photographs. Its straightforward, coherent and comprehensible choice of graphics and composition makes it easy to use even for non-experts and on different levels of public administration and government. It is invaluable as a tool of support in planning rural and agricultural development, as well as in drafting strategic documents. Some of the maps in the *Atlas* were used as a blueprint for important research papers on the subject, and found their way into documents outlining national planning initiatives for spatial development (e.g. the National Spatial Development Concept, the National Strategy of Regional Development) and the agricultural economy (Strategy for the Balanced Development of Countryside, Agriculture and Fishing for 2012-202).

Figure 5: Example of a map used in the National Spatial Development Concept: *Main food-producing areas.*

5. Conclusions

The *Atlas of Polish Agriculture* exemplifies studies whose main goal is to transform a collected set of statistical data into graphical form. Thanks to this, an initially undecipherable set of statistical values was organized and re-imagined from a spatial perspective on a map or in the form of processed indicators on a graph. This allows us to assign the right values to individual territorial units and evaluate the spatial or temporal changeability and heterogeneity of the data. Such an approach is of major importance, both scientifically and practically, as it effectively broadens and deepens our knowledge about socio-economic processes and phenomena that take place within the rural economy, but also finds much use in diagnosing the current state of land use and development on different levels of planning – from the local all the way up to the national.

The unique role of the *Atlas* is a result of its complex approach to topics pertaining to agriculture. It is a highly complete snapshot of Polish agriculture as it stands after the first decade of the 21st century – a snapshot that is It is a highly complete snapshot of Polish agriculture as it stands after the first decade of the 21st century – a snapshot that is an important component in the process of planning and making strategic decision about the future of Poland's "food economy".

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Efficiency and Effectiveness: the FAO Statistical Yearbook

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Abstract

Compiling hundreds of statistics from different sources with a traditional approach, such as manual preparation of Excel tables, can be very labour intensive and prone to error. Furthermore, knowledge and expertise is difficult to transmit, thus resulting in inconsistent results and treatment over time. Therefore the Statistics Division of FAO implemented the use R and LaTeX as the new architecture for a sustainable and cost-effective way to produce its Statistical Yearbook. The R packages include all of the steps of the process: retrieving and merging data, conducting computations, and creating visualizations. On the other side, LaTeX provides the layout structure. Because all steps are well documented, this approach increases the longevity and coherence of the publication. The combined power of R and LaTeX makes this a new data publication in line with the open data philosophy. And the use of open source software and the availability of the package – therefore total transparency – make the entire procedure – and the possibility of using the technology to produce other publications – available to anybody.

Keywords: dissemination; FAO; R.

1. Overview

1.1 The FAO Statistical Yearbook series

The FAO Statistical Yearbook series[1] started in 2004, consolidating and replacing four previous FAO publications – the FAO Bulletin of Statistics, and the FAO Production, Trade and Fertilizer Yearbooks. The purpose was to provide the users with a selection of indicators on food and agriculture by country. The data were taken from FAOSTAT[2], the Organization's corporate statistical database, as well as from several other FAO divisions and sources, mainly within the UN system.

In 2012, the Statistics Division launched a Statistical Yearbook (SYB), which presented a very new look and feel. The publication now presents a visual synthesis of the major trends and factors shaping the global food and agricultural landscape and their interplay with broader environmental, social and economic dimensions. In doing so, it strives to serve as a unique reference point on the state of world food and agriculture for policy-makers, donor agencies, researchers and analysts as well as the general public. Thus far, two global and two regional Yearbooks have been released. Five more regional Yearbooks will be launched during the first half of 2014. A Pocketbook, which is a reduced version of the Yearbook but presented instead by country, has also been designed.

The novelty of the Yearbook is not only the content, which fills a global gap of presenting up-to-date information on agriculture and food security, but also the efficient method of production, which sets a precedent for dissemination. The publication is generated with the statistical software R[3] in combination with the typesetting program LaTeX[4]. And both are open source softwares. The two programs work in concert to provide a seamless process in generating data publications and therefore more efficient dissemination tools. The way of working within the team has also changed. The use of open-source software like GitHub[5], SVN[6] and Dropbox[7] provides continuous tracking of all changes to documents and to be able to simultaneously work on documents.

1.2 Motivation of using an open-source programming language

The idea of using an open-source programming language for the SYB is two-fold: the first involves the use open-source software and the second the programming language. Following the GNU definition[8], "'free software' means software that respects users' freedom and community. Roughly, the user has the freedom to run, copy, distribute, study, change, and improve the software. With these freedoms, the users (both individually and collectively) control the program and what it does for them". This means that moving from proprietary to open-source software first reduces the increasing license costs. It also makes the process completely transparent, which is particularly important because

it allows other researchers to understand how the program works, thus giving them the possibility to improve the work.

The second reason concerns the use of a programming language. The most important advantage is reproducibility, which is a standard within academia. In order to achieve reproducibility, access to the code is a precondition. This property allows one to verify, improve and reproduce research for future use. This has tremendous potential for the user and, in this case, for FAO. Furthermore, since the methodology and codes are available publicly, the active community can also provide extremely valuable feedback to improve the overall system.

Other advantages involve automation, the text based source, and communication. The high level of automation significantly reduces manual operations, which are often subject to errors, and saves significant time in updating data. Moreover, the fact that a programming language is essentially text makes it possible to easily keep track of all of the changes through version/revision control systems, to simply print out the code and store it in the long term, and to copy and paste sections that could be reused for other purposes. Finally, code permits reproducible examples so that problems can then be shared within the community, therefore increasing the chances to solve issues and, at the same time, providing assistance to other users.

Therefore, this approach increases the sustainability, transparency and coherence of the publication because all data manipulation and treatment are recorded within the code. Transparency in this type of publication is crucial. The philosophy of the new SYB, which publishes country-level data and aggregates, should be examined under the same standard. It is important to publish these figures as well as the methodology used to prepare the data. This type of feedback can also lead to a greater harmonized framework.

1.3 Motivation of using R and LaTeX

R is often defined as a free software environment for statistical computing and graphics. However, rather than a domain specific language for statistics, R is more precisely a domain specific language with broad functionality. As an open-source software, R is quite flexible. The very active R community, which also serves to solve challenges from within, has developed more than 4,000 documented packages that span several fields of science. The freedom to study how the specific functions work allows the user to adapt the algorithms to specific needs and therefore to continuously improve packages. And finally, the high connectivity to other languages and software makes R a flexible tool that responds to a variety of users' needs.

The major downside of using R is the steep learning curve. In addition, the speed is sometimes slow, especially for exceptionally large datasets. And, given its data analysis focus, the programming infrastructure is not very well developed. As a result, the benefits of this tool apply primarily to those who use it on a daily basis.

In the SYB process, R is used for data processing, analysis and dissemination. More specifically, R automatically downloads variables, imports datasets, merges datasets with different standards, constructs new variables, computes aggregations. It also disseminates data through charts, tables, and maps, which are automatically translated into LaTeX code.

LaTeX is an open-source high-quality typesetting system that includes features designed for the production of technical and scientific documentation. As with R, LaTeX is open source and therefore has no licence costs. Moreover, LaTeX is a mark-up language that shares the advantages of programming languages. Compared to other word processing programs like MS Word or LibreOffice Writer, LaTeX accommodates mathematical notation easily, controls sectioning, cross-references, tables and figures, and automatically generates bibliographies and indexes. It separates content and style, and therefore the user can write the document without having to also changeformat. It allows multi-lingual typesetting and guarantees perfect consistency throughout a document/book (e.g. in the management of the colours), thus facilitating enormously the printing step without intervention from graphic designers. And finally, LaTeX also moves seamlessly from print to web version with one click. The challenge, however, is that there is also a steep learning curve, even though new open source document processors, which can be used together with LaTeX, are facilitating use.

LaTeX is used to typeset the entire SYB publication. The dissemination objects translated into LaTeX code by R are automatically included and formatted within the publication through the specific class *faoyearbook*. This package defines all of the needed commands to delineate the structure and build the publication. The package is geared towards the Yearbook, but can easily be adapted to create other

publications. This makes the process completely exportable/applicable with a relatively small amount of time needed to design the book layout.

1.4 Revision control systems

A revision control system is a way of managing changes to files. This software is essential for developers and, although they differ in terms of functionalities, they usually have similar advantages. First of all, a revision control system allows users to revert to previous versions of a document and to track all the modifications within the file. Secondly, users can work simultaneously on the same files on multiple computers, even if people are offline. The merging operation solves possible conflicts or, if this operation is not available, the file locking method prevents concurrent access simply by locking the specific file. Third, it gives the possibility of creating branches of a project and identifying a snapshot of this through tags.

It is usually very difficult to manage binary files (e.g. Excel spreadsheet) with revision control systems, and it is even more challenging to run some basic operations, like merging, when a conflict arises. R and LaTeX are essentially scripts. This means that all of the changes are automatically tracked and documented and that all team members are informed about the activity. Moreover, the possibility of creating different branches for a single project leads to one stable version. This is essential in monitoring the development of the project as well as, on the practical side, keeping separate what has already been tested from what is under development.

In the SYB process, Dropbox, SVN, and GitHub are used for different purposes. All of the files that require an immediate update and that are usually used by just one member of the team are stored in Dropbox. GitHub houses the R packages that are publicly available, while SVN is used for the LaTeX package and the final output that is not publicly available.

2. SYB production

The construction of the SYB revolves mainly around processing, analysis and dissemination steps, which are described by the Generic Statistical Business Process Model[9]. Processing and analysis are done entirely with R, while data dissemination occurs with both R and LaTex. More specifically, two R packages have been created. The FAOSTAT package hosts a list of functions to download, manipulate, construct and aggregate agricultural statistics, while the FAOSYB package includes functions to disseminate these statistics.

2.1 Data retrieval

Data retrieval involves all operations to import variables from different databases. The simplest way is by querying a database. When this option is not possible, the user must manually import the indicators. The FAOSTAT package provides the functions to automatically download variables from the FAOSTAT[10] and the World Data Bank[11] databases as well as the algorithms needed to manually import specific sets of data. It would also be possible to retrieve data through SDMX with R.

2.1.1 Download data from FAOSTAT and World Data Bank

The function *getFAOtoSYB* collects data using *getFAO* and processes these in order to retrieve the dataset in an easily manageable format. *getFAO* provides access to FAOSTAT data through the FAOSTAT API. The user is facilitated in the construction of the API by the function *FAOsearch*, which, with very few steps, gives users needed codes to build the query. Similarly *getWDI* and *getWDItoSYB* are functions to download the World Development Indicators.

2.1.2 Import data manually

Importing datasets with different structures and *ad hoc* variables in various formats requires a flexible programming language that can dialogue with different software. Nevertheless, in most cases, this is not enough. First, organizations often have different constructions of the world and do not have a common classification system. Nor are they necessarily harmonized across countries and borders. Therefore all of the (frequent) exceptions made by organization to the reference country classification system should be taken into account on a regular basis. Only then is it possible to accurately design the software to address these issues.

Aggregates can therefore not be imported unless the definitions match exactly, which often is not the case. In the Yearbook production, these aggregates are not discarded but are used to check the aggregates computed for potential errors in the methodology and/or weighting variables.

There are three main issues in attempting to combine different country classification systems. The first is differences in the country definitions, which are generally due to varying legal entities. The second is changes in the country composition over

time. China is one such example. The World Bank disseminates China (excluding Taiwan), Hong Kong and Macao. Until recently, FAOSTAT disseminated only China (including Taiwan, Hong Kong, and Macao). It is clear that, in the two cases, "China" represents three different realities. The second aspect then complicates this problem by adding the time dimension. South Sudan was recognized by the United Nations on the 9 July 2011. However, statistics reported by the Sudan during the same year can also include data for South Sudan, therefore leading to double counting. Finally, the analysis is further complicated by disputed territories and economic unions, such as Ilemi Triangle, which do not have representation under most of the country coding systems.

A precise matching is thus essential. The SYB uses the M49 country classification system[12] following the idea of a needed convergence to a common international standard. However, for internal purposes the FAOSTAT country coding system is used. The reason is that this coding system is disaggregated enough to allow maximized matching. The functions *fillCountryCode* and *translateCountryCode* provided by the FAOSTAT package help respectively in filling and translating the country code when just country names are provided. Nevertheless, a perfect matching is not always possible. If the country classification used considers the dissemination of China (including Taiwan), Hong Kong, and Macao but the time series includes just China (including Taiwan, Hong Kong, and Macao), then it is impossible to disaggregate the data, and a footnote is needed.

2.2 Merging datasets

Merging is a typical data manipulation step in daily work – albeit non-trivial – especially when working with different data sources. Within the FAOSTAT package, the built-in *mergeSYB* merges data from different sources as long as the country coding system is identified. A precondition for this operation is the correct structure of the manually imported datasets following the rules described in the previous paragraph.

2.3 Scaling

In theory, data should be processed and stored in the base unit (e.g. kilograms) and, if needed, disseminated with an attached multiplier (e.g. thousand kilograms) or with a different scale of the same measure (e.g. tonnes). Nevertheless, very often this is not the case and, as a result, they need to be rescaled. Both of these operations are done with functions external to the FAOSTAT package because of the way of treating measurement units by different users, both in terms of different coding/naming system used and results to be obtained. This heterogeneity would imply a complex matching of different systems that, for the moment, has not been developed.

2.4 Construction of new variables

The FAOSTAT package can automatically construct new variables, including growth rates, shares, indices and relative changes. Two types of shares can be computed. If just one variable is used, the "share of total" option checks the weight of a specific country/aggregate vis-à-vis the total. There are also two types of growth rates within the package: the least squares and the geometric growth rates. The least squares growth rate is used when the time series is of sufficient length. The default is at least five useable observations. However, if the time series is sparse and more than 50 percent of the data are missing, then the robust regression is used. Furthermore, for a specific time series, both index number and relative change can be computed. The first one requires a base year, while the second the year interval.

2.5 Aggregation

Aggregation is another data manipulation step that is commonly overlooked, especially when data are taken from different sources. In most of cases the already computed aggregates cannot be used because a) a different country classification system is used; and/or b) the change in the country composition over time is treated differently. For the same reasons, it is difficult to get exactly the same results and address missing values in a harmonized manner.

At this point of the process, the user must a) converge with a specific country classification system, and b) generate consistent and comparable aggregates. In the specific case of the SYB, the M49 list is used. This problem has been addressed in the SYB by a two-step aggregation process.

2.5.1 Country level

The starting point in the aggregation process is a set of countries that, in our case, is as disaggregated as possible through the FAOSTAT coding system. The objective is then to match the information with the M49 country level definition. Therefore, in the first aggregation step, we merge together the countries

that go together following the M49 system. One such example would be combining Tanzania and Zanzibar. The *aggCountry* function aggregates territory entries into countries or higher level classifications based on the relationship specified. It is clearly important to operationalize the method and weighting variable, otherwise the aggregate will produce erroneous output. Nevertheless, no aggregation rules are applied at this step.

2.5.2 Geographic and economic level

In order to compute geographical, economic, and political aggregates, a further aggregation step is necessary. The first problem is that a hierarchical approach cannot be used. It would be a logical step to compute the aggregations starting from the set of countries obtained after the first aggregation. However, this cannot be done for two reasons. In primis, while the first step exclusively follows a political criterion, the second could follow other rules, such as geography. External territories are a perfect example. They could politically belong to countries that are geographically on the other side of the globe. These territories are incorporated into the "mother" countries in the first step, but they do not follow the "mother" country in the second. The first implication is that the countries of a specific region would therefore not sum up to the regional aggregate. One such example is Reunion, which is part of France yet is located close to Africa.

Second, following a hierarchical approach would risk excluding the time dimension into consideration, and therefore the historical evolution of the country composition. This would violate the comparability over time. Clearly, the final country list reflects the last updated world composition, so there are no challenges for a current year. However, given that we are interested in computing aggregates for past years, we need to consider how the world composition has evolved over time. If we want to compute an aggregate for Africa in 2013, we need to include South Sudan and Sudan. On the other hand, this rule would not be valid in 2010, when South Sudan and the Sudan were a single country. For this reason, the aggregate for Africa can only be computed consistently by including South Sudan, Sudan and Sudan (former). The presence of data for all the three Sudans would imply a double counting. Therefore the hierarchical approach does not apply. The strong assumption that should be verified is that data are mutually exclusive.

This means that the second aggregation step also begins from the big set of countries and needs a partially different relationship. In this case further specifications are also needed in order to address the problem of missing values, which can render the aggregates incomparable. Two rules are implemented to ensure that the aggregates computed are meaningful and comparable: first, a minimum threshold (default 65 percent) in which data must be present; and second, the number of reporting entities must be similar over the years (therefore the country composition can change during a specified period by up to 15 countries) because it does not make sense to compare aggregates for two different years if the number of reporting countries vastly differ. Both of these rules are automatically applied by the function *aggRegion*.

2.6 Analysis

Exploratory data analysis is fundamental before conducting any modelling operations and data dissemination. In a publication, this type of analysis is crucial in order to understand the main messages behind the data and to decide the central idea to be passed on to the user through a specific object, sub-section and section. It should help clarify what a specific dissemination object is trying to communicate, how this message fits within the sub-section idea and how it is linked to the other messages.

Dealing with international datasets has the risk of not having enough data to calculate many aggregates due to data sparsity. The *sparsityHeatMap* function provided by the FAOSTAT package checks data sparsity for all variables, across country and time. The function generates a plot grouped into four panels. The first three panels group the country by their value, while the last shows countries with no values.

Another tool within the FAOSTAT package is the *tsPanel*. The advantage of the plot generated by this function is to identify the behavior of a specific variable, in particular if one was to build models or carry out imputation. The characteristics that govern the variable and the transferability of country information determine what type of model is available.

2.7 Dissemination

While the R FAOSTAT package focuses on data processing and analysis, the R FAOSYB package supports the user in the dissemination phase. The functions *theme_syb* and *plot_color* define a style and a set of colors to be applied across the publication in order to ensure consistency across the book. *plot_data* and *plot_dictionary* help the user to create predetermined types of charts that come from the R package *ggplot2*.

Furthermore, the functions *GAULspatialPolygon*, *map_breaks* and *plot_map* help use maps in *ggplot2* and the shape files provided by the GAUL project[13]. Tables are generated using internal codes have not yet been added to the package due to their complexity. However, what is important is that charts, maps, tables and mini tables are essentially R code, and, for this reason are easily reproducible and updatable. In the end, these objects, captions, sources and metadata are automatically translated into LaTeX code.

2.8 Typesetting

The typesetting of the publication is then entirely done with LaTeX. Dissemination objects, captions, sources, text, bullet points and metadata are assembled together by the SYB specific class *faoyearbook*. Automatically, LaTeX controls sectioning, cross-references, and indexes. The bibliography is done with BibTeX[14] and it is read automatically by LaTeX.

3. Conclusion

Up until now, many statistical yearbooks have been produced with a fairly large team that manually downloads data and inputs the information. This process, however, is prone to error and expensive. FAO, through the production of its Statistical Yearbook, offers an alternative. Two open source software, R and LaTeX, are used in all steps of the process: retrieving and merging data, conducting computations (including aggregations and growth rates), creating visualizations and managing the layout structure. All steps are documented with code and are therefore well-documented and transparent. And they can be used by anybody for production of other publications. The R package *faoyearbook* defines all of the needed commands to delineate the structure and build the publication.

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Endnotes

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Towards Bridging the Gap between Data Production and Data Utilization

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Abstract

The general topic of this paper concern with all types of data collected through censuses and surveys. It could be population, agriculture or any other statistical census or survey; however, an example of one of the subjects touched is devoted to the integration between population and agricultural censuses or surveys.

The objective of the paper is to initiate steps to measure and bridge the gap between production and utilization of data obtained from censuses and surveys. In most or some of developing countries two contradicted situations of existence of data are observed: the first one is the lack of data in general, or on specific socioeconomic sector; the second one is the miss-planning of data production processes where some of the data produced at some of the process stages would not be used or utilized. The first situation is well known and often addressed in the scientific forums; the second situation, however, did not find a considerable focus in this respect though it costs money, labor, and time in addition to its effect on the quality of the data expected to be utilized. The paper is meant to open a door for researchers to cater for this issue with some guide lines to address the problem with respect to scope, measurement, causes, and solutions.

The follow chart of data production and utilization processes go through data collection, data entry, data processing, data dissemination, data usage and data utilization. Between each of these stages some of the data lag behind and not proceed to the next stage; not because of inertial errors but because of some technical, awareness, coordination, political and other factors that would be confined and discussed in the paper. This, results in partial gaps in the size of data forwarded or utilized between the subsequent stages. The accumulation of the partial gaps between different stages constitutes the final gap between data production and data utilization; that is the gap between data collected and data utilized. The paper tries to measure this gap and find the partial gaps of considerable contribution to the resultant gap, and the possible solutions to bridge this gap.

Apart from the factors that reduce the degree of utilization of the outcome data is the lack of integration between different types of statistical censuses or surveys. There are some interrelationships between the different sectoral data; and, the calculation of some sectoral indicators depends on other sectoral data. So, the data produced for specific sector would not be fully utilized by other sector if the specific requirements in this respect are not considered by the data producing agency. The paper includes in this regard an example of the integration between population censuses or surveys and agricultural censuses or surveys.

1. Introduction

The objective of this paper is to initiate steps to measure and bridge the gap between production and utilization of data obtained from censuses and surveys. The ideas and propositions stated in the paper in this respect are derived from the experience of statistical censuses and surveys conducted in Sudan, which I believe to be similar to experiences of most or some of the developing countries. In Sudan and most likely in most or some of developing countries two contradicted situations of existence of data are observed: the first one is the lack of data in general, or on specific socioeconomic sector; the second one is the miss-planning of data production processes where some of the data produced at some of the process stages would not be proceeded to the next stage, used or utilized. The first situation is well known and often addressed in the scientific forums; the second situation, however, did not find a considerable focus in this respect though it costs money, labor, and time in addition to its effect on the quality of data expected to be utilized. The paper is meant to open a door for researchers to cater for this issue with some guide lines to address the problem with respect to scope, measurement, causes, and solutions.

The paper consists of 8 sections. Section 1 is the introduction. Section 2 is a general review of types and concepts of data forwarded through different stages of statistical census/survey. In Section 3 and Section 4 we discuss the factors contribute to retardation of data through production stages and dissemination stages. Section 5 we present a general framework

of integration between a subject survey agency and other data producers/users agencies. Section 6 is an example of the application of the framework on the integration between population and agricultural censuses/surveys. In section 7 we present proposed steps to measure the gaps in data between different stages and the resultant gap between data collection and data utilization stages. Finally Section 8 is about bridging the gap in which we summarize the important factors we believe to be responsible for the different gaps and the imperative actions that should be taken to solve the encountered problems.

2. Types of data through the production & dissemination stages

The flow chart of data production and utilization processes goes through data collection, data entry, data processing, data dissemination, data usage, and data utilization. The first three stages constitute Data Production stages; the second three stages constitute Data Dissemination stages. The shape, definition and concepts of produced and utilized data differ between different stages. In the collection stage the data is raw data of textual or numerical type that reflect the characteristics of individual objects. The definition of data in this stage is subject to the definition described by the survey agency. The data in this stage might not have any meaning to the survey agency; it is articulated, conceptualized and collected to give the maximum yield of information as desired by the survey agency. In the data entry stage the data is also a raw data for the same individual objects but the shape would be changed to codes, mostly numerical codes, for entry and processing purposes. The ideal situation in this regard is to transform the data to this stage taking with it all the definitions and concepts as described by the researcher or the survey agency. In the processing stage the type of data is significantly different. The outcome is of aggregate type in form of tabulations or indicators. A very huge amount, likely infinite number, of cross tabulation or indicators could be emerged from the data in this stage, but only a part of this potential production would be of important meaning to the survey agency depending on the proposed tabulations and indicators previously fixed in this respect. Other part of this potential might also be of important meaning to other researchers or agencies who did not participate in the survey.

With respect to the Data Utilization stages the type of data is the same type as come from the processing stage (Tabulations and indicators). In the dissemination stage the ideal situation is to take all the produced information including its descriptive metadata to the hand of the concerned users in the required time. The data usage and data utilization stages intersect with each other; and they are somewhat different from previous stages in that they are not defined by fixed time; their periods elapse when the usage or utilization of the data at hand expire. In these two stages the major actors are the data users who considered as data recipients who use and utilize the data and interpret it according to their level of knowledge and to the size of metadata provided with the received information. The major difference between the two stages is that in the usage stage the data might not be used correctly, or not fully utilized because of insufficient descriptions of the metadata or of the modest knowledge of users to understand the definition and concepts of indicators & the tabulated information. The utilization stage is the final stage, considered as the strategic goal of the survey. The degree of utilization of the survey data reflects the level of the success of the survey (see Figure 1).

3. Data Production gaps

The previous section is a general perspective of the transformation of data with its conceptual definitions from stage to stage. Between each of these stages some of the data or some of its utilization lag behind and not proceed to the next stage; not because of inertial errors but because of some other factors. In this section we are going to discuss the gaps in the data flow through the production stages i.e. data collection, entry and processing. During these stages the loss is the diminishing of data itself whereas during the utilization stages the loss is in the retardation of the utilization of the produced data.

To start with collection-entry stages we put the following proposition “not all of the data produced during the collection stage would be entered in the computer for processing”. There are some factors rather than entry errors which prohibit some data from proceeding to the entry stage. The most important of these are: the “questionnaire design” and “the coding process”. With respect to “questionnaire design” we argue that “some constructions of questions in the questionnaire would come with responses that could not be easily coded and entered

in the computer". The questionnaire design includes open questions, closed questions, single answer questions, multiple answer questions and different procedures to construct these types of questions. If the construction of different types of questions do not meet the processing procedures requirements the responses of these questions either be impossible to be coded and entered as required or it would be of complicated and tiresome procedures. So, these responses would be either completely discarded or they lose some important required details. The main reason of this factor is the lack of coordination between questionnaire designers and computer programmers. With respect to the other factor "coding process" the main point is the grouping of different detailed responses of the questionnaire into one code. This likely happens in coding the occupational and economic activity responses; for example to use the major group or sub-major code of the skilled agricultural and fishery workers specified in the International Standard Classification of Occupations document instead of the minor or unit groups where the questionnaire include data down to these levels. This mainly results from miss-planning of the program of the survey which may be due to lack of knowledge of the coding process subsequences or due to unrealistic ambition.

As for the entry-processing stages we also say that "not all of the data entered in the computer are tabulated or produced as indicators". As noted in Section 2, unlimited number of tables of information and indicators could be produced form the data entered in the previous stage. But the actual produced information is usually far lower than the potential possibilities. Three main factors could be identified in this regard which are, "the needs of the concerned survey agency", "the financial capabilities" and "the miss-coordination with other sectors". With respect to first factor the problem is the miss-identification of needs of the survey agency which results in residuals of row data that is not needed, or at least not needed at present time. With respect to the next factor the survey agency does collect needed information but would have not anticipated properly the expected costs. As for the third factor, some potential information might not be of interest to the survey agency but of interest to other agencies not participated in the survey or not aware of the survey potentials of data; this part of information could have been used if there was some kind of coordination or integration between the concerned survey agency and other sectors agencies; we will discuss in this paper an example of integration between population and agricultural surveys in Section 5 and Sections 6. However, though there is loss of live data between these two stages but there is a possibility to produce more information from it using some other procedures through the dissemination stage as we will see in the next section. There is some neglected information, the same as information produced for high administrative levels, could be produced for some small administrative levels; we mean by that the sample areas selected to represent some high levels of administration. Though these sample areas are surveyed to represent collectively some of the high administrative levels, their data could also be processed for individual areas whether a village or quarter. This information is likely to be ignored since it is not available for all the units of the specified small levels. (see Figure 1 and Figure 2).

4. Data Utilization gaps

The Data Utilization stages consist of data dissemination stage, data usage stage and data utilization stage. We noted in Section 2 the characteristics of these stages and the conceptual difference between dissemination, usage and utilization stages. Also we noted above that the loss during these stages is represented by the retardation of utilization of the produced data rather than the production itself. In this section we are going to discuss the flow of information through the three stages.

The Data Utilization stages include three gaps "Processing-Dissemination", "Dissemination-Usage" and "Usage-Utilization". We start with "Processing-Dissemination" gap by saying that "not all processed data (produced information) would be disseminated"; three possible reasons for that are: "financial problems", "political issues" and "unavailability of will". The financial problems arise mainly form planning or execution draw backs; in some cases no sufficient budget is allocated to dissemination stage; in other cases since the dissemination stage comes in the last part of survey stages the shortage of money in previous stages would be solved from the dissemination budget. With respect to "political issues" some or all of the produced information might be prohibited from dissemination because of some political reasons. With respect to the "will" factor the survey agency might not be keen to disseminate the information because it believes

that users should come to take their needs from its center or for any other reason. It is worthwhile to draw attention here that to maximize the utilization of data dissemination should include both statistical information and row data; it would be more beneficial if the row data disseminated in the NET through processing software such as REDATAM software to provide chances for researchers to produce their own information.

With respect to the "Dissemination-Usage" gap we continue to say that "not all disseminated data are used". Three reasons could be indicated in this respect; the first one is the unawareness of some users of the importance of statistical data to support evidence-based planning or evidence-based decision; the second one is the lack of adequate knowledge of ICT for some users to retrieve their required information; the third one returns to the user institutions' database system where the user would not be able to access to the disseminated statistical products, either because there is no database in the user's institution or the database does not properly work.

Finally we come to the last gap to say that "not all used disseminated data are properly used". The statistical data would be fully utilized only if it is used with its maximum validity and precision. Otherwise, the degree of utilization decreases gradually to come down even to the negative direction where it would be a misleading tool rather than enlightening tool. Three factors can be nominated to maintain maximum utilization of disseminated data two of which return to the data produce agency and the other to the users. With respect to the producer agency first, the socioeconomic indicators should be calculated properly using the most reliable methodologies; second, the disseminated data should be accompanied with all necessary definitions and concepts that describe the full meaning of the information. As for the users they should be trained on all fields of statistical data applications (see Figure 1 and Figure 2).

5. Frame work of integration between census/survey agencies

Integration between sectoral censuses and surveys maximizes the utilization of data produced through these censuses and surveys as discussed in Section 3. It also improves the cost-benefit criteria of the survey to obtain high benefits with low costs for both or all integrated survey agencies. Before discussing the integration between population and agricultural censuses and surveys in the next section we introduce here a general module to explain the different possible levels of integration. Generally speaking the information included in any census/survey could be classified into four types as follows:

1. Some of the information emerged from the census/survey could be of interest of other sectors not participated in the census/survey.
2. Some of the data included in the census/survey, that is not of interest of the survey subject might not be processed or tabulated; this information might be of interest of other sectors.
3. Some of the data included in the census/survey could be of interest of other sector if the questions leading to it would have been modified.
4. The whole data included concerned only with the survey agency and could not be used by any other sector.

According to the above classification we classify the integration between sectoral censuses and surveys into four levels as follows:

1. In censuses/surveys with classification type 1 where some information concerned with some sectors originally considered by the census/survey agency no need for integration with these sectors if the information obtained meet all their needs.
2. In censuses/surveys with classification type 2 there is a need for some integration between the census/survey agency and concerned sectors. This integration would be of small extra cost since the information is already there but needs extra processing so we call this **Level I Integration.**
3. Censuses/surveys with classification type 3 needs some prerequisite coordination arrangements between the subject agency and the integrated agency so we call it **Level II Integration.**
4. Censuses/surveys with classification 4 needs further coordination between the census/survey agency and the integrated agency to add new information required by the integrated agency to the survey according to two situations:
   a. The required information to be added to the census/survey is also of interest to the subject agency.

b. The required information to be added to the census/survey concerned solely with the integrated sector.

5. In situation a. the addition of new required information to the census/survey adds more burden to the census/survey and it would benefit both the subject agency and the integrated agency so we call it **Level III Integration.**

6. In situation b. the addition of new required information adds more burden to the census/ survey and it needs considerable coordination between the subject agency and the integrated agency so we call it **Level IV Integration .**

6. Integration between population/ household and agricultural censuses and surveys

To begin with we first clarify that when we say integration we mean part of the information required from agricultural census or survey could be obtained from other censuses and surveys, and not all of the information, for it is rather not possible to undertake two full censuses or surveys in one time; second, the agricultural agency should be aware of all the information expected to be produced by the census/ survey agency before the integration decision; third, the integration at any level should start from the planning stages of the census/survey and not form subsequent stages.

The information obtained from agricultural census or survey can be classified into three main groups: 1 - social and economic characteristics of agricultural workers, 2 - costs and consumption of agricultural products, 3 - agricultural production, land use and investment in agriculture. According to the classification of types of information and levels of integration discussed in the previous section the first group of information is likely to be included in all population censuses and households surveys, especially in population censuses. But, it may need Level I integration to ensure that the proposed tabulation by the subject census/survey agency includes all information required by the agricultural sector agency, or otherwise to cater for extra information that could be processed easily from the row data. Sometimes some information concerned the agricultural sector exists in the row data but not included in the tabulation plan of the subject agency. The processing of such information may need sophisticated operations; for example, as we noted earlier, to obtain information down to minor or unit groups of occupation specifically for agricultural workers might need complicated arrangements in the coding and programming procedures; so this may be considered as Level II integration. If there is a need to have new information on the socioeconomic characteristics of agricultural labors then this may also inter in Level II integration; for examples in 1993 of population and household census in Sudan a question was included in the questionnaire about agricultural land tenure to be used as frame for agricultural surveys.

With respect to the second group of agricultural information, "costs and consumptions of agricultural products", most of information of this kind included in poverty and household budget surveys. The same steps of integration discussed with the first group could also be applied here. The third group of information "agricultural production, land use and investment in agriculture" is the core of agricultural data which obtained mainly from agricultural censuses and surveys. However, part of this information; especially that concerned with individual or house hold unit of analysis; might be obtained by integration with population censuses and household surveys at Level III and Level IV integration levels indicated in the previous section.

7. The challenges of measurement

It is rather a challenge to design reliable indicators to measure the gaps in data between the different stages discussed above and to come with an index to measure the whole gap between data collection and data utilization. The difficulty lies especially on the measurement of data dissemination gaps and on the combination of these gaps with the data production gaps to come with a single indicator for the whole collection-dissemination gap. However, we would present here a theoretical frame with broad outlines for measurement and to leave the details and practical work for interested researchers to proceed for the development and the practical applications of the module.

7.1 Measurements of data gaps between different stages

7.1.1 Data collection-entry gap

- The digital size of a record in questionnaire with all possible details of responses assumed to be coded = S_n
- The digital size of the record of entered data = Sx

- The total number of records before entry = T
- The total number of entered records = R
- The collection-entry gap = Ge:

$$Ge = 1 - (Sx*R)/(Sn*T) \quad (1)$$

7.1.2 Data entry-processing gap

- The number of all variables of the entered data = Vt
- The number of variables used in output tabulations or in calculation of output indicators = Vu
- The entry-processing gap = Gp:

$$Gp = 1 - Vu/Vt \quad (2)$$

7.1.3 Data processing-dissemination gap

- Number of variables in disseminated tables of indicators = Vd
- The processing-dissemination gap = Gd:

$$Gd = 1 - Vd/Vu \quad (3)$$

7.1.4 Data dissemination-usage and data usage-utilization gaps

In these two stages the data usage rate and data utilization rate are calculated from information to be collected through a survey of N user respondents in which a questionnaire is designed with questions leading to the number of users believed to use the data (Y) and utilize it (X)

- The dissemination-usage gap = Gu:

$$Gu = 1 - Y/N \quad (4)$$

- Usage-utilization gap = Gz:

$$Gz = 1 - X/Y \quad (5)$$

7.1.5 The overall data collection-utilization gap

We define this gap as the proportion of number of digits of data in variables not entered in any of the tables or indicators utilized by at least one user from the number of digits of data in all variables of information collected through the questionnaire that is coded or possible to be coded. It can be estimated as follows:

- The estimated number of variables used by at least one user = U:

$$U = (Y/N)*Vu \quad (6)$$

- The estimated number of variables utilized by at least one user = Z:

$$Z = (X/Y)*U \quad (7)$$

- The number of all variables in the questionnaire = Vq
- The average number of digits in all variables of the collected data whether coded or possible to be coded = A:

$$A = (Sn*T)/Vq \quad (8)$$

- The estimated number of digits in variables utilized by at least one user = D:

$$D = A*Z \quad (9)$$

- The overall collection-utilization gap = O:

$$O = 1 - D/(Sn*T) \quad (10)$$

7.1.6 The maximum and minimum values of the gap measurement indicators

According to the above equations the maximum value of the gap indicator between different stages is one (1); it would be reached when not any data/information transferred to the next stage with respect to the data production stages, or not any data/information is used or utilized in the data utilization stages. The minimum value is zero (0); it would be reached when all data/information transferred, used or utilized to or in the next stage of the production or utilization stages. The resultant gap indictor also varies between one (1) and zero (0).

8. Bridging the gap

To bridge the gap between data collection and data utilization first we have to identify the most important problems then to find solutions for them. From the above discussion we list here 6 points introduced through the different stages we believe to be most the important contributors to the gap. These are:

1. Lack of coordination between survey agency and other sectors agencies.
2. Lack of participation of computer specialists in the design of questionnaires.
3. Poor planning and results-based management.
4. Lack of adequate financial support.
5. Lack of political will.
6. Lack of adequate capacity building in the fields of statistics and information and communication technology for non-specialized cadres in statistical and the ICT fields.

To address the above issues it is imperative first, to establish an effective National Statistical System; second, to develop a sound National Strategy for Development of Statistics. The presence of

effective NSS and sound NSDS would solve all the six points stated above. Coordination between different statistical sectors and agencies is the core objective of the NSS. A well prepared strategy would grantee the identification of actual user needs, participation of all concerned technical staff in the different statistical operations and provision of capacity building programs in the fields of statistics and ICT. Governments' will would also be stimulated through these two entities to be more encouraged and to provide considerable financial support to statistical work.

Figure 1: Graphical representation of data gaps between different stages.

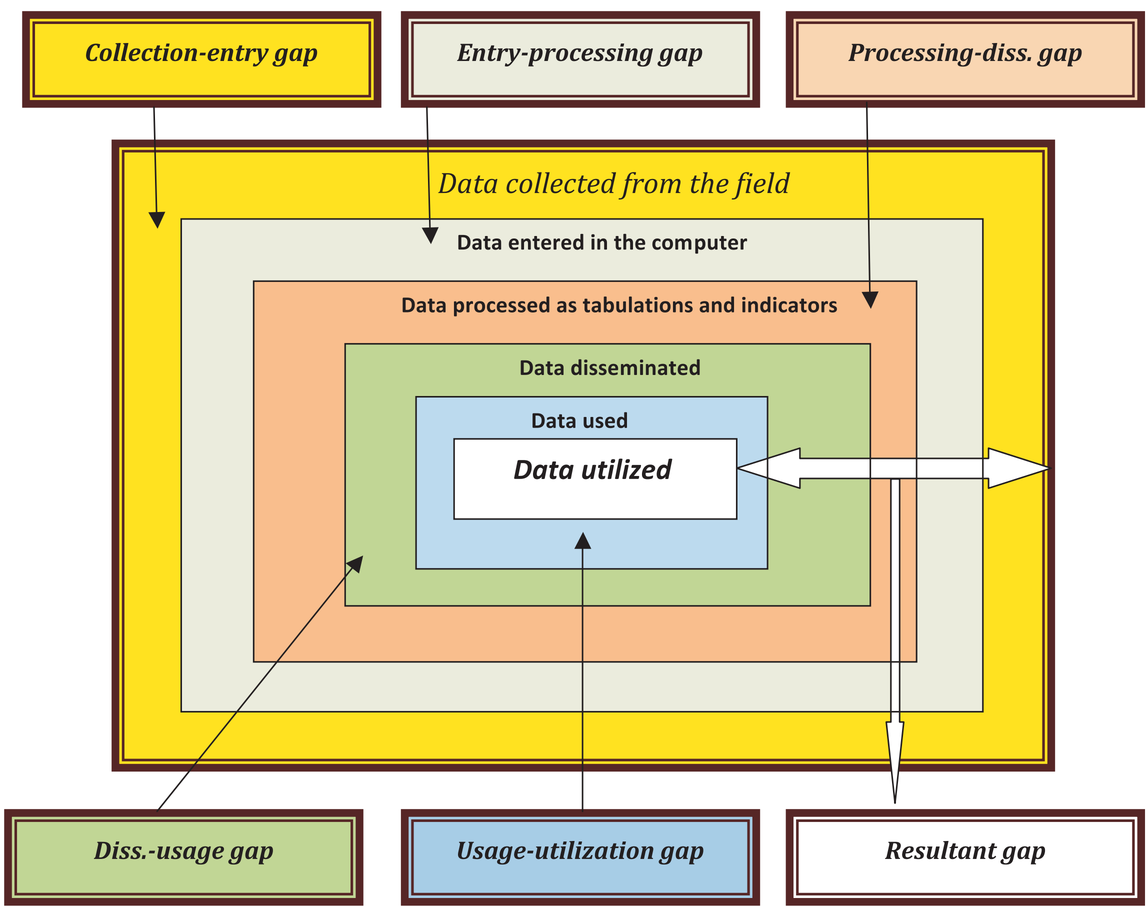
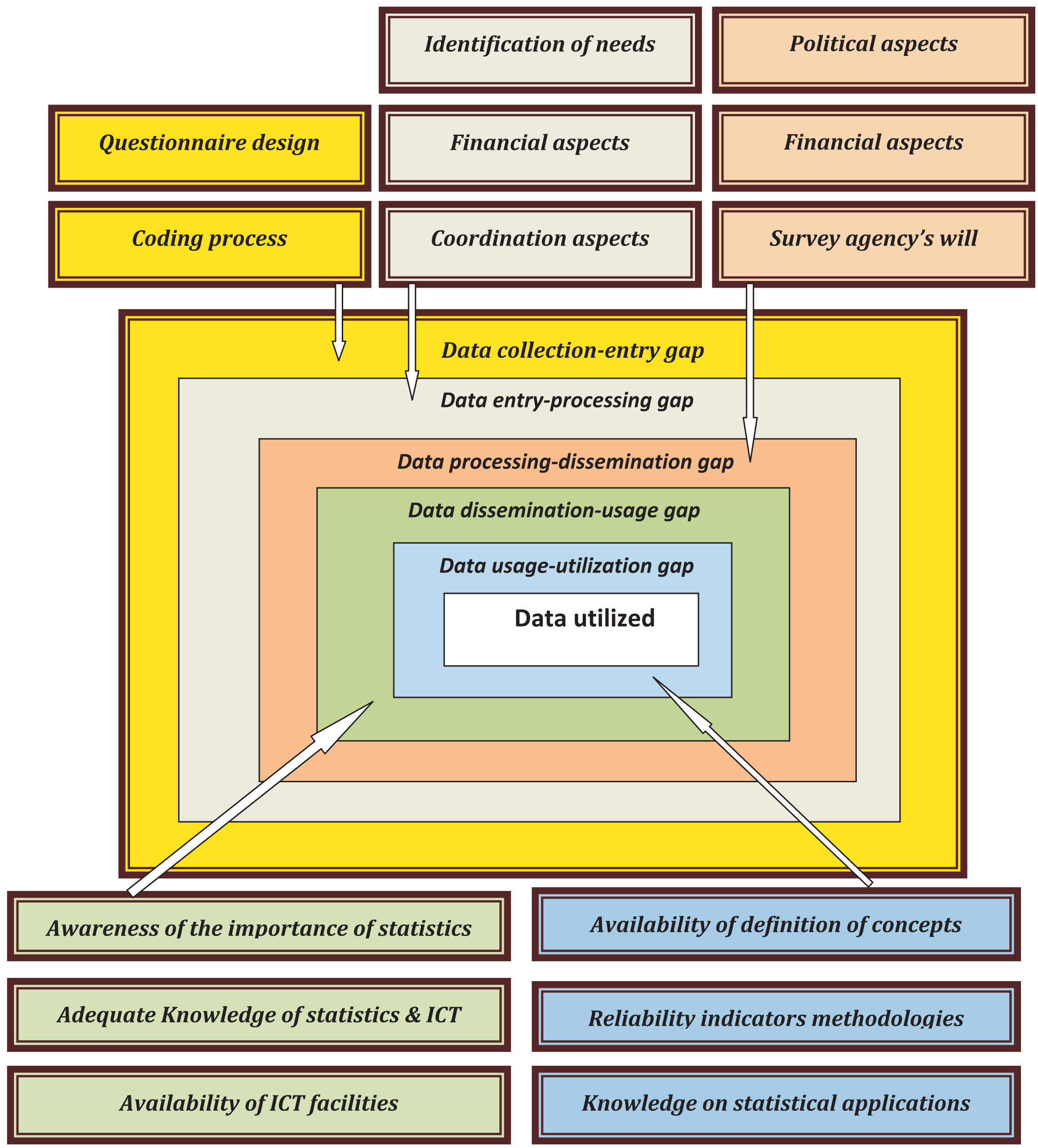


Figure 2: Graphical representation of factors affecting gaps in different production and dissemination stages.



Agricultural Geo-Statistical Information Query System

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Abstract

The need to make data consultation accessible and for the users to have interaction with it has led to creating new ways of presenting statistical results. One of them is through graphic consultation systems, which relate the statistical data with the geographic space in which it takes place. In Mexico, like in many other parts of the world, this trend has also been followed; The National Institute of Statistics and Geography (INEGI), has taken on the task of preparing information from different statistical events for its integration in applications like the Geographical Information System (GIS). This is the case for the Agricultural Geo-statistical Information Query System (SCIGA), which presents part of the results from the VIII 2007 Agricultural Census, organized by economic activity according to the North American Industrial Classification System (NAICS) in its 2007 version.

This work is focused on showing the institutional efforts made for integrating and preparing the information for the VIII 2007 Agricultural Census, without affecting the principle of confidentiality on personal information governing in Mexico; as well as the efforts made to present the results on a safe platform and with proven quality such as the Digital Map of Mexico, in its internet version, which is a GIS developed at INEGI.

It is concluded that this first SCIGA´s version provides users with information at different level of detail, for users with basic knowledge as well as those that have higher management of statistical information. This first version can be improved in some functions to make its use friendlier and be able to export the tabular data it contains; it is expected to incorporate these and other improvements in the System soon.

Keywords: census; agriculture; system; consultation.

1. Introduction

INEGI is an institution that constantly produces and publishes statistical information, collects the Population and housing Census and Counting, the Economic and Agricultural Censuses, additionally, during the year performs numerous surveys of socio-demographic nature as well as on different economic sectors.

For data dissemination the Institute has traditionally used the presentation on tabulations. But at the same time, throughout the last 20 years, it has constantly evolved to the point of combining tabulates with the results of geographic presentations. For example, they are the Census Information Query System, SCINCE (INEGI, 2002), and the National Statistical Directory of Economic Units, DENUE (INEGI, 2012), to name the main ones.

In the case of agricultural statistics, the main background on presenting data in a different format to tabulates, date back to the Agricultural Censuses performed in 1991, and with those results the informatics system denominated "State Carpets" was prepared in 1994, it allowed visualizing the tabulate as worksheets, but without the possibility of performing operations with the information. In that same year the compact disk "Agricultural Sector" was published, it integrated the state carpets and contained a cartographic section with information by municipality. This product was the first to present statistical information from the primary sector related with the geographical space, even though the representation scope went as far as municipality level. In 1996 the AGROS system was published, it displayed graphical information on thematic maps at municipality fraction level denominated Rural Basic Geo-statistical Areas. It also allowed obtaining results for the intersection of two variables.

The development of these systems was based on the MS-DOS platform. The systems required to be installed in a personal computer to enable access to the information, and this made them restrictive,

if we consider that in that time there was little computer equipment.

After 16 years, an agricultural census was again conducted in Mexico in 2007. The progress in the development of information technologies that occurred in that long period allowed reverting to the goal of creating an automated system for presenting Agricultural Censuses' results in 2009; some test versions were made but they only worked for internal use. It was not until late 2010 when the databases were worked on again, with the objective of creating a query system; that is how the "Agricultural Geo-statistical Information Query System" (SCIGA) was created, and was made publicly available in August 2010, through INEGI´s web-page.

2. Material and methods

SCIGA was created based on the idea of disseminating the results of the VIII 2007 Agricultural Census to a larger number of users and for the information to be visualized in the exact geographic place where the activity is developed. The first element that was integrated in the SCIGA were the National Geo-statistical Framework vector files, which is the territory subdivision in geographic units that correspond to the 31 states and the Federal District, to the 2,456 municipalities that existed in 2007 and to the 17,200 rural geographic subdivisions defined by the INEGI for statistical purposes denominated Basic Geo-statistical Areas (AGEB), as well as to the 280,000 Control Areas, smaller subdivisions that were originally created for the control of the collecting activities on field, but for the SCIGA they were used for the presentation of results at a more detailed geographical breakdown (more detailed than the municipality and the AGEB).

The processes performed with the ArcGIS software for validating the consistency of the vector files of the Geo-statistical Frame allowed identifying and solving overlapping or gap problems between the different layers of information.

The second element that was integrated into SCIGA was the census questionnaire variables, which were selected from 800 contained in the questionnaire and should be classified according to the North American Industrial Classification System (NAICS) that has the agricultural, animal breeding and exploitation and forestry harnessing activities registered.

In Mexico like in many other parts of the world, there are production units engaged to more than one activity; for example, they have animal breeding and exploitation and at the same time they cultivate an agricultural product. For this reason, it was necessary to identify the main activity in every production unit, thus classifying them once and not duplicating them. This process was done taking into account the products and sales prices reported by the producer during the census.

After defining the questionnaire variables that were to be incorporated into the system, the extraction of information from the 2007 Agricultural Census data-base was done. During the extraction of the production units, those that did not have a plot for the development of their activity were left out, which are mainly in urban areas and carry out their activities in their backyard.

The last element that was considered was the identification of those control areas that contained plots with only one or two production units inside it, since no information on them would be presented to keep the confidentiality principle required by the Mexican law, marking them in the data-base, not displaying those production unit´s information in the system and instead making them appear hatch patterned and with a note allusive to confidentiality.

All the elements obtained in the Census were integrated and uploaded to the institutional digital cartographic platform Digital Map of Mexico, which was also developed by INEGI. The Digital Map of Mexico has common tools and information layers, so when someone has used a product developed in this platform, it facilitates the learning of new products. Also, additional tools were integrated into the SCIGA for managing and presenting information, making the system sturdier.

3. Results

The result was materialized in the Agricultural Geo-statistical Information Query System, which runs in the institutional platform Digital Map of Mexico or MDM in its version for internet. SCIGA can be accessed through INEGI´s web-page www.inegi.org.mx clicking the Statistics tab, in the data Bank column (figure 1):

Figure 1: INEGI´s web-page, Access to SCIGA.

This option guarantees free access to the system to practically anyone, it is not necessary to have a personal computer since you can do it from any public establishment that provides the access to internet. When a user enters SCIGA, he has Access to a tutorial and to the paper. What is the SCIGA? Both are supporting elements for the user to know the system´s generalities and learn how to make data consultations in it. The system´s handling is very user friendly and intuitive.

The SCIGA allows making two types of consultations: *thematic maps and detailed consultations*. The *thematic map* allows selecting the economic activity wished to consult and defines the type of map that will be presented. Different to the detailed consultation, the thematic map is a pre-elaborated map and it presents the results on national maps and with the stratified information in four big groups (figure 2). This consultation allows having a first overview of the activity of interest and then performs detailed consultations. For example, to geographically locate where a crop is produced, the crop is selected and the type of map you wish to see is solicited, it could be the percentage of production units engaged to the selected crop or the percentage of area engaged to this crop; any of the two consultations display the results at control area level.

In the detailed consultations the user must select three variables (Figure 3): the first is the economic activity; more than one may be selected, but be careful of precisely knowing what is wished to consult and what the expected results are. The second variable to be defined is the size of the production unit wished to consult (the size in terms of employed personnel). The third variable is the geographic area of interest that could be the whole country or only consult certain states and municipalities.

The result will present the list of control areas located within the selected geographic area that comply with the activity and size selected (figure 4). The system allows consulting the details of the production

Figure 2: Thematic map consultation.

Figure 3: Definition of elements for the detailed consultation.

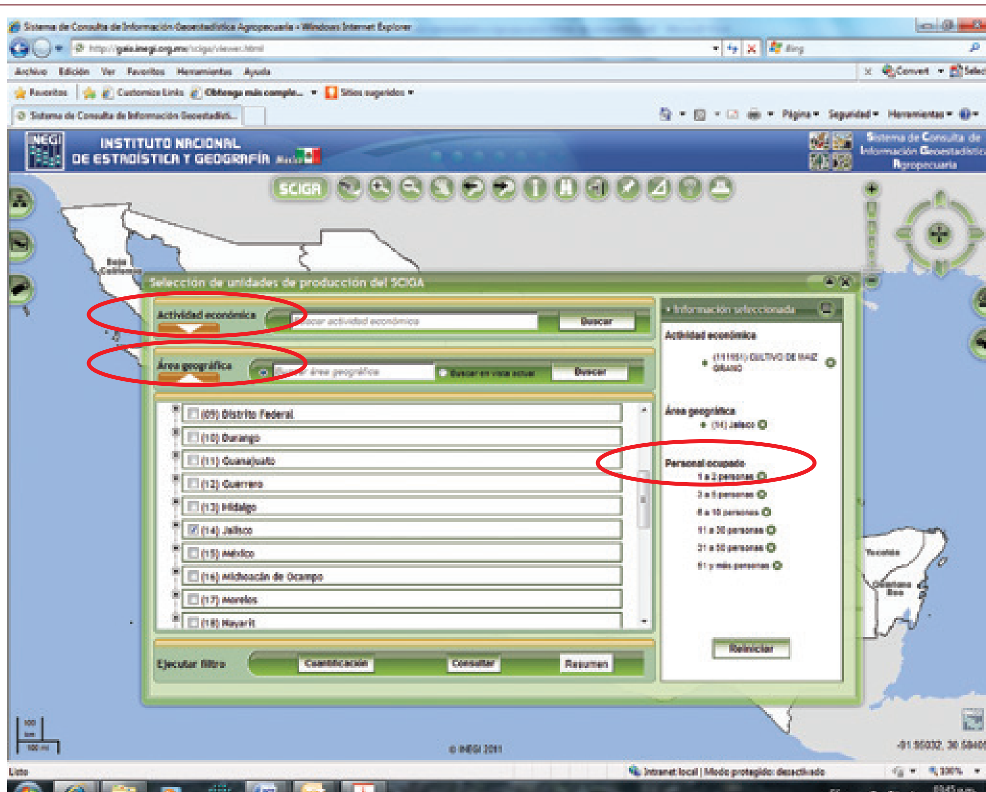


Figure 4: Result of the detailed consultation.

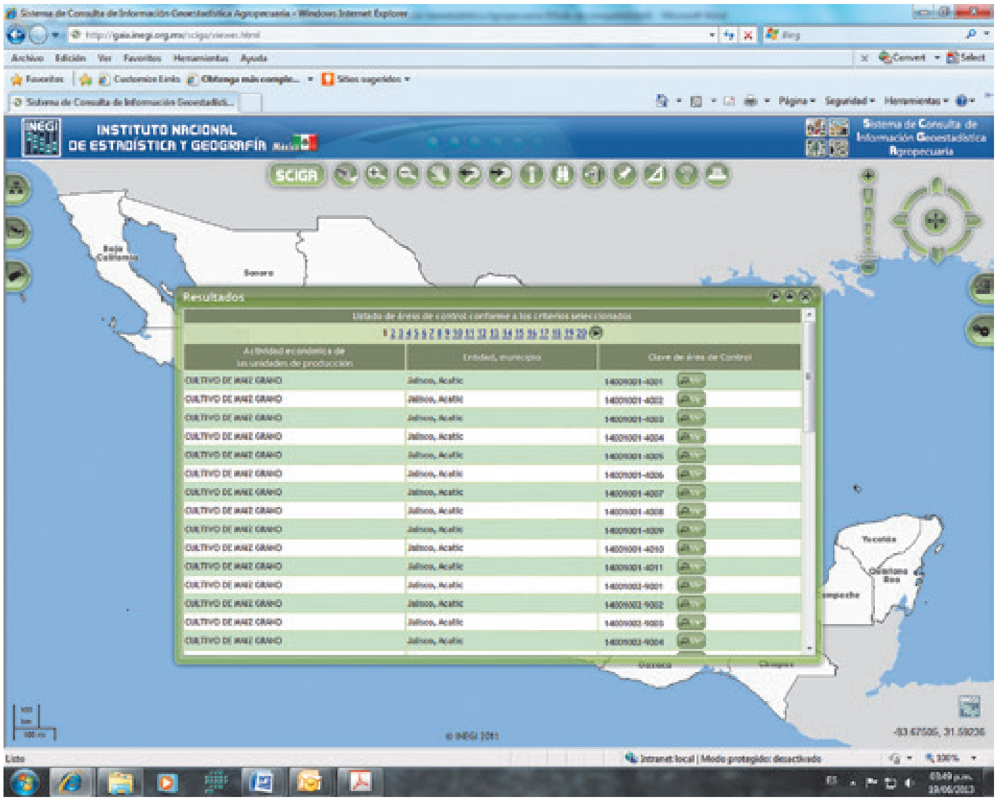
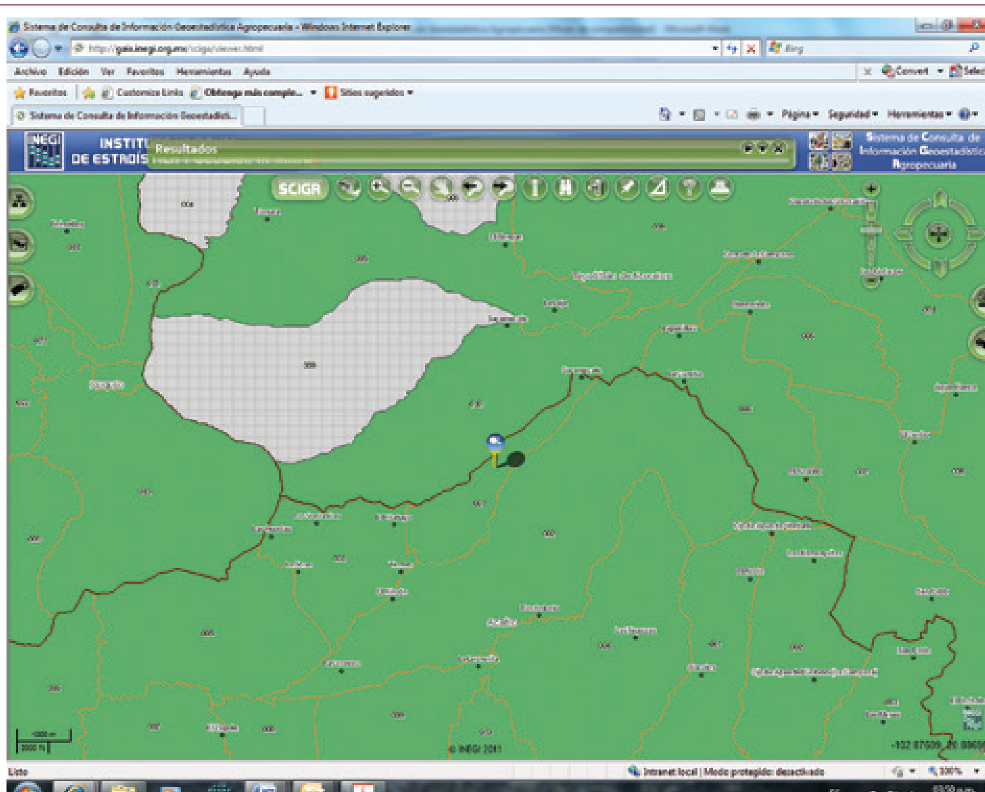


Figure 5: Control areas that comply with the consultation.



units that appear on the list in the consultation results box and then goes to the space where the production units have their plots (figure 5). The system also allows relating the producers with the locality where they live.

The system also has preloaded information that serves for complementing the census information; such as orography data, hydraulic infrastructure, urban and rural localities from 2007 and urban localities from 2010, geographical names for the present elements, hydrographic features, communication routes, and natural resources, cartographic frame and ortho-photo.

The tabular information the system presents can be copied and pasted in Excel sheets for its handling.

A little over a year, after the publication of SCIGA, several workshops on its handling and application have been provided to different users, such as agronomy college students up to FAO representatives and researchers from state governments related to the agricultural sector.

4. Conclusions and discussion

This tool has been of great interest to users. During the workshops, favorable comments on the system have been received, as well as observations for its enhancement and optimization. These observations have been evaluated to determine which are feasible for integrating the SCIGA.

A reoccurring question from users is: when will the information be updated? The answer is, since the system is designed for presenting detailed information on all the municipalities in the country, its updating will be done when a new Agricultural Census is performed. The information of a Survey cannot be incorporated since it does not present information of the entire universe.

On the other hand, despite the fact of SCIGA being on INEGI´s web-page for a year and two months, it needs more dissemination, therefore it is likely to intensify the workshops where users from different institutions would participate, who could at the same time be promoters of the system with their peers and fulfill the objective of reaching a larger number of users.

Updating the SCIGA by incorporating the user´s improvement proposals will represent an opportunity for further dissemination among agricultural, livestock or forestry producers, students from careers related to the agricultural sector, academy researchers or state governments and in general among the people that are interested in consulting the agricultural sector´s information in a quick and user-friendly way.

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SPP 7
Remote Sensing Technology

Organizer: Jeff Bailey, USDA/NASS

Chair: Denise Abreu, USDA/NASS

This session will focus on using remote sensing technologies and geospatial information to monitor agricultural crop production. Remote sensing usage continues to expand and is becoming an integral part of statistical organizations.

Possible topics for papers in this session include:

- Applications that create crop specific landcover classifications and statistics;
- Development of operational crop area and yield estimates;
- Development of the science and statistical applications to monitor and assess specific crop conditions and phenology;
- Development of applications to monitor and assess soil moisture, drought, flooding and other natural disasters in timely, operational and user-friendly systems environments;
- Applications using remote sensing for area frame development;
- Geospatial Information Systems to measure land area and locate operations.

Papers:

- Francisco Javier Gallego (Italy), “Alternatives to Medium Resolution Images for Crop Area Estimation: very high and coarse resolution images”
- Xinhua Yu (China), “Using Remote Sensing Cropland Classification Data to Update Area Sampling Frame”
- João Henrique Buschin, Otávio Celidonio, Daniel Ferreira et al. (Brazil), “Measurement of Avoided Deforestation in the Pasture Areas in Mato Grosso”
- Rick Mueller, Mark Harris (USA) “Reported Uses of CropScape and the National Cropland Data Layer Program”

Alternatives to Medium Resolution Images for Crop Area Estimation: very high and coarse resolution images

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Abstract

Classified satellite images with a pixel size between 20 m and 60 m are often used as covariates for crop area estimation combined with field data from an area frame survey (AFS). We explore the cost-efficiency of two alternatives. Two examples of application of coarse resolution images (MODIS images, 250 m resolution in Ukraine and SPOT-VEGETATION, 1 km resolution in Spain) and samples of very high resolution (VHR) images, with a pixel size around 1 m and covering an area of 10 km × 10 km to 20 km × 20 km. Coarse resolution images are comparable to medium resolution if the field size is very large. The combination of local expert data with coarse resolution images appears promising, although this approach is also applicable to medium resolution. Very high resolution images have few chances to be cost-efficient with the current prices.

Keywords: area estimation; satellite images; spatial resolution.

1. Introduction

Agricultural statistics has always appeared as a major application of Earth Observation (EO). In the 70's many scientists believed that satellite images would produce reliable agricultural statistics with very few field data (Mac Donald and Hall, 1980). The risk of bias of pixel counting became soon clear ant therefore the need to combine images with a consistent area frame survey. Calibration estimators are suitable when the units for the field survey are points (Card 1982, Hay, 1988, Czaplewski, 1992, Stehman, 2013), while regression estimators are better adapted when the survey elements are pieces of territory covering several agricultural plots (Wall et al, 1984, Germain and Julien 1988, Allen 1990, Haack and Rafter, 2010). Pure remote sensing approaches provide sufficiently accurate results only for crops that can be clearly distinguished on the images, such as paddy rice (Fang, 1998). Methods without a consistent ground survey are also useful when the access to the fields is problematic. For example, coarse area estimates could be made for Kosovo only based on image analysis at the end of war, when sending surveyors to the fields was dangerous (Geosys, 2000). Nearly-pure remote sensing estimates have been also applied in North Korea, where authorizations were difficult to obtain (Kerdiles et al., 2013). A general overview of the different ways to use remote sensing for agricultural statistics is provided by Carfagna and Gallego (2005). For potential users who wish to have a general idea of what is feasible in this field, the GEOSS community of practice has produced an easy-to-read general document (GEOSS, 2009).

Landsat TM images, with a spatial resolution of 30 m and a swath of 180 km, are probably the images that are most frequently applied to crop area estimation. Other sensors offer similar resolution with slightly different characteristics, but have been less often used for this purpose.

2. Comparing different sensors in Ukraine

This section presents the main results and conclusions of a pilot study carried out in 2010 on 3 oblasts in Ukraine, covering a total area of 78,500 km^2. (Kussul et al., 2012). The study compares the cost efficiency of several image types: MODIS (250 m resolution), Landsat TM (30 m resolution), AWiFS (56 m resolution) and RapidEye (6 m resolution). The study area included three oblasts (Kyivska, Khmelnytska, and Zhytomyrska) were selected in the study with total area of 78,500 km^2 and a cropland area of 2.45 Million ha according to official statistics.

Field surveys were conducted in July 2010, and included surveys along the roads and area frame sampling (AFS) surveys (Figure 1). Data collected along the roads were used to train satellite images classifiers while data collected during AFS surveys were used for testing purposes and for area estimation. The units of the AFS were cells of a 4 km x

4 km grid, that were stratified using the GLOBCOVER land cover map at the 300 m resolution (Arino et al., 2008). Three strata were defined: no cropland, some cropland up to 50% and more than 50% cropland.

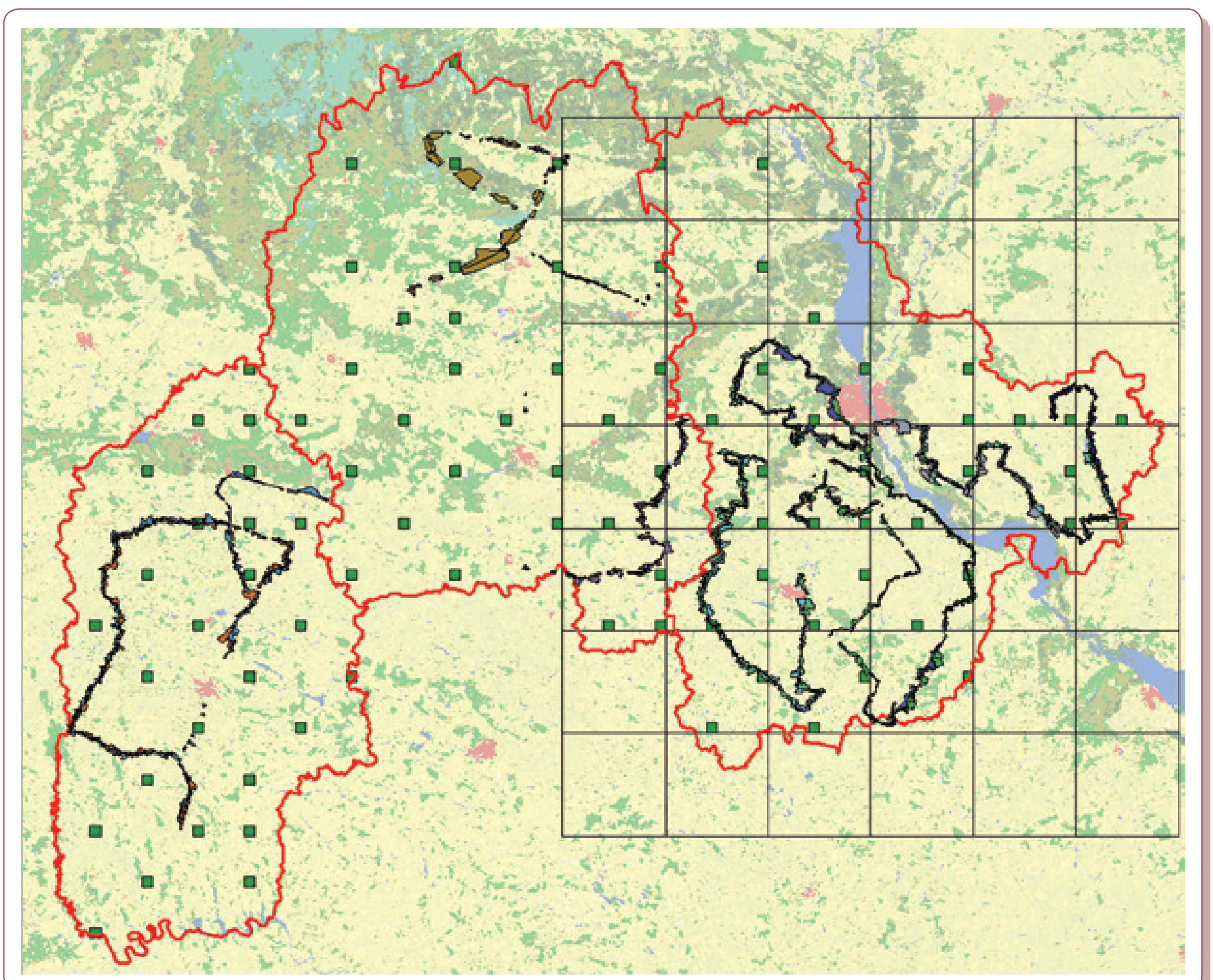
The acquisition of AWiFS images did not meet the expectations because of technical problems. Rapideye images were acquired in a rather small area with the specific purpose of testing the usefulness of the so-called red-edge spectral band for the discrimination of crops. The expected improvement thanks to the red-edge band was not confirmed. Here we focus on the comparison between Landsat TM and MODIS.

The MODIS dataset was obtained from the JRC Agri4Cast image server, and contained ortho-rectified MODIS Normalized Difference Vegetation Index (NDVI) images. The data are temporally aggregated to obtain a composite image every 10 days. Data from the end of 2009 were also used in order to better identify winter crops. Data with heavy clouds were excluded from the study. As a result, a time-series of 13 NDVI values for each pixel were used as an input to classifiers. MODIS was expected a priori to be the best suited sensor for the Ukrainian agricultural landscape because the coarse spatial resolution is not a major drawback in a landscape dominated by plots around 100 ha. In exchange MODIS should provide a better picture of the temporal evolution of the vegetation.

The Thematic Mapper (TM) instrument onboard Landsat-5 satellite was a very senior sensor, but still giving good performances. In total, 75 Landsat-5 scenes over the study area were downloaded from April to September. The number of images in each point of the area of interest ranged between 2 and 4.

Three classification algorithms were selected for this study: neural networks, Support vector

Figure 1: Distribution of the ground data. Boundaries of the oblasts, AFS segments (squares), along the road field data (curves).



machine (SVM) and decision tree. Neural networks have been successfully applied in remote sensing for decades (Foody and Arora, 1997, Lu and Weng, 2007, Mas and Flores, 2008, Bishop, 2006). The MLP classifier behaved generally better than the SVM and the classification tree, therefore the reported results correspond to the application of the MLP algorithm. The area estimates were computed combining the AFS field data with classified images (separately for each sensor) with a regression estimator.

$$\bar{y}_{reg} = \bar{y} + b\left(\bar{X} - \bar{x}\right)$$

where $\bar{y}$ is the AFS field survey estimate for a given crop, X refers to the covariate (proportion of pixels for the same crop in the classified image; $\bar{X}$ and $\bar{x}$ are the population and the sample means of X, and b is the slope of a linear regression between Y and X. Because the sample of segments was rather small, we used the variance estimator

$$V(\bar{y}_{reg}) = \frac{N-n}{N \times n}\left(1 + \frac{1}{n-3} + \frac{2G_x^2}{n^2}\right)\sigma_y^2\left(1-\rho^2\right)$$

where $G_x = \frac{k_{3x}}{\sigma_x^3}$ is the relative skewness, less biased than the more often used simplified approximation

$$v(\bar{y}_{reg}) \approx \frac{1}{n} s_y^2\left(1-\rho_{xy}^2\right)$$

that provides the relative efficiency

$$Eff = {v(\bar{y})}\big/{v(\bar{y}_{reg})}$$

The classification accuracy on test pixel sets is significantly better for Landsat TM than for MODIS, although the comparison results are not clear when we look at the efficiency of the regression estimator (Table 2).

3. Downscaling subjective estimations per commune

In this section we present a test case carried out in Andalucia, Spain (87,000 km^2). We applied an unsupervised classification to a stack of daily images from SPOT VEGETATION, with 1 km resolution. Every 10 days a composite image is built with the maximum value of the NDVI (Normalised Difference Vegetation Index). The images were classified into 45 classes using an ISODATA algorithm (Duda et al., 2001), a modified version of k-means clustering. Each class k has a time profile $NDVI_{kt}$ t=1....36. For each crop c there was a first selection of K_c time profiles that were roughly compatible with the phenological cycle of the crop.

The Spanish Ministry of Agriculture provided data for a sample of 1800 segments of 700 m x 700 m and crop area data per commune (780 communes) from local experts. Such expert estimates have a strong risk of bias, but they are useful to provide an idea of the geographical distribution of a crop. Field data were available for a stratified sample of 1800 segments of 700 m x 700 m visited for the ESYRCE survey (Ministerio de Agricultura, 2007). This sample provides the basic data for official crop area estimates, currently with a straightforward extrapolation. A potential improvement might come from a geographic covariate such as a classified image. We also used CORINE Land Cover (CLC), a land cover map produced with common rules across the European Union (JRC-EEA, 2005). This work is a follow-up of a method proposed by Khan et al. (2010).

For the traditional regression estimator to be efficient, we need a geographical covariate that is well correlated with the spatial distribution of the crop. If we

Table 1: Overall accuracy of image classification based on MODIS and Landsat TM.

Oblast	MODIS		Landsat-5	
	Training accuracy	Test accuracy	Training accuracy	Test accuracy
Kyivska (K)	74.67%	57.64%	71.3%	62.8%
Khmelnitska (KH)	65.07%	40.14%	68.63%	40.7%
Zhytomyrska (ZH)	75.91%	54.99%	82.37%	55.3%

Table 2: Relative efficiency of the regression estimator for main crops.

	MODIS			Landsat-5		
Crop\Oblast	K	ZH	KH	K	ZH	KH
Winter wheat	1.44	2.66	1.13	1.90	3.74	1.39
Spring barley	1.05	1.00	1.00	1.23	1.00	1.00
Maize	1.35	1.27	4.19	1.38	1.73	1.37
Soybeans	1.23	1.68	1.03	1.45	1.22	1.05

take wheat an example, an easy solution is considering the class "rain fed arable land" in CLC. This is probably a weak covariate for several reasons: too generic, spatially coarse and old, but may be cost-efficient because it is free and easy to use. A new covariate needs to provide better results to be useful. We build a covariate that combines subjective estimates by commune and classified images. For commune m A_{km} is the area classified in class k and Y_{km} the subjective estimate for crop c. The coefficients b_{ck} of a regression.

$$Y_{cm}=\Sigma_k \; b_{ck} A_{km} + \varepsilon_m$$

with restrictions $0 \leq b_{ck} \leq 1$ can be interpreted as an indication of the link between class k and crop c. We do not say that it is the estimated share of crop c in class k, but it will be useful if the correlation is good. Table 1 reports the adjusted r^2 for this regression. Some of the values are very high and can lead to a very optimistic assessment. The comparison with the r^2 between the crop area per commune and the relevant CLC class moderates the optimism. For some crops, such as wheat, barley and cotton, we still have a solid indication of usefulness, but this is not the case for sunflower, maize and rice. Failing to compare with a benchmark would have led to a fake positive message.

Attributing the coefficient b_{ck} to each pixel of class k we build a geographical covariate (Figure 2) that can be combined with the segments (49 ha each) of the ESYRCE survey. The values of r^2 at the segment level are much lower (Table 4) and give a more practical indication of the usefulness of the b_{ck} map through the classical approximation of the relative efficiency of the regression estimator $eff \approx 1/(1-r^2)$.

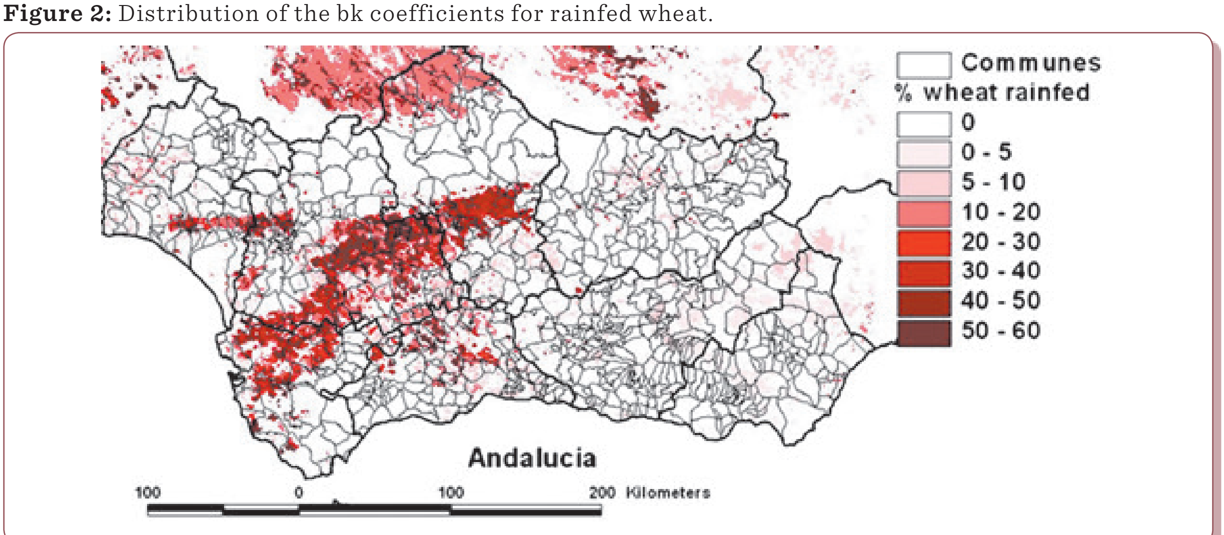
Table 3: Values of r^2 between crop area per commune and two covariates.

Crop	CLC	VGT-classification
Wheat	0.93	0.97
Barley	0.33	0.57
Cotton	0.65	0.91
Maize	0.50	0.47
Sunflower	0.72	0.72
Rice	0.99	0.97

Table 4: Values of r^2 between crop area per segment and two covariates.

Crop	CLC	VGT-classification
Wheat	0.26	0.45
Barley	0.06	0.10
Cotton	0.14	0.25
Maize	0.06	0.04
Sunflower	0.22	0.20
Rice	0.74	0.66

Figure 2: Distribution of the bk coefficients for rainfed wheat.



We can draw two main conclusions from these simple results. One conclusion is that an apparently high correlation (e.g. r^2=0.8) does not necessarily mean that the method used to obtain it is good and useful. A critical view requires at least comparing it with the r^2 that can be obtained with a basic inexpensive method that provides a benchmark. In the scientific literature we can find papers that conclude that classifications of coarse resolution images are valid for crop area estimation because they obtain correlations of the order of 0.8 (Verbeiren et al., 2008).

A second conclusion is the usefulness of combining two different data sources that are separately rather weak: subjective estimates by commune and classified coarse resolution images, in which individual fields cannot be identified. The relative efficiency is substantial only for dominant crops (wheat) and for crops that can be easily identified on images (rice). The procedure may become cost-efficient because the cost of coarse resolution images is low and the NDVI profiles are anyhow produced to monitor the status of vegetation and yield forecasting. Other coarse resolution images are being tested, in particular MODIS, with a resolution of 250 m, that were expected to give a better correlation than VGT (1 km resolution), but did not.

An additional point that requires further work is the efficiency of classifications earlier in the year. For the results given above we used images for the whole year. This means that the area estimates can be obtained only at the beginning of the following year. If we want to have area estimates by August in the current year we should use images only up to July. The efficiency in this case still needs to be assessed.

4. Sampling very high resolution images

Very High Resolution (VHR) images, with a pixel size that ranges between 0.5 m and 2 m, allow a better land cover identification, in particular when the plot size is small. Thus it is natural to think of using VHR images to monitor such areas. Full coverage of a region with VHR images is usually not affordable, and a sample of images can be considered. However the cost-efficiency of a sample of VHR images needs to be assessed. Figure 3 shows an sample of sites that were selected for VHR image analysis in the framework of the Geoland2 project (http://www.gmes-geoland.info/).

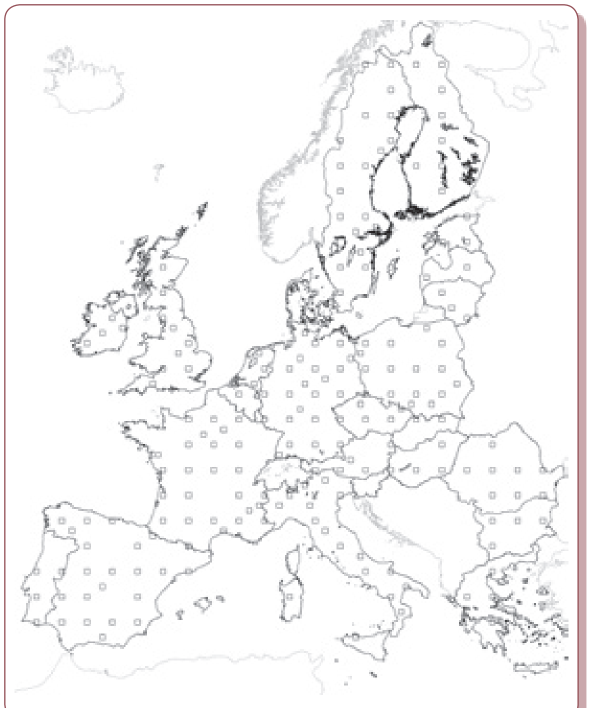
In this paper we focus on the potential variance of a sample of spatial units with a size compatible with VHR images (around 10 km x 10 km) compared with a sample of unclustered points that may be suitable for a field survey. We implicitly assume that the identification accuracy of crops on VHR images is comparable with the identification accuracy on the field. This assumption is very optimistic and corresponds to a stepwise evaluation: if a sampling plan based on units (clusters) of 10 km x 10 km has good chances to be cost-efficient, it is worth assessing the identification accuracy and its impact on the area estimation. Otherwise this exercise is unnecessary and we can disregard the potential use of VHR images.

The "equivalent number of points" is a useful indicator to compare a sampling plan of clusters.

$$Q = V(\bar{y})/V(\bar{y}_{\text{clus}})$$

meaning that a sample of n clusters gives the same sampling variance as a sample of nxQ points. For simple random sampling Q is nearly constant when n changes, unless the sampling rate n/N is high. The equivalent number of points can be computed from the intracluster correlation, narrowly linked with the correlogram when we talk about spatial units (Gallego, 2012).

Figure 3: A sample of sites in the European Union vor VHR analysis.



Under reasonable conditions (not very high sampling rate, large number *M* of elementary units in a cluster, i.e. large number of points in a VHR image), the value of each cluster in terms of equivalent number of unclustered points is approximately $Q \approx 1/\rho_M$ where ρ_M is the intracluster correlation. It is interesting to notice that the term *M* does not explicitly appear, although it has an indirect influence because ρ_M decreases when *M* increases. For example if *M* has a large value, e.g. $M=10^6$ and the ICC is $\rho_M = 0.1$, each cluster has a sampling value approximately equivalent to 10 unclustered points. The intracluster correlation can be estimated as a weighted average of values of the correlogram (Gallego et al., 1999). We obtained low values of the equivalent number of points of major crops or the overall area of arable land in the European Union (EU) with samples of 5 km x 5 km to 30 km x 30 km (Table 5), The correlograms for main crops in the European Union (EU) were calculated on the basis of LUCAS data (Land Use and Cover Area frame Survey).

For an economic assessment we need to know the cost of data collection for unclustered points. For the particular case of in-situ observations in the EU we find some useful information in the LUCAS-2006 management report (Eurostat, 2007). This report mentions an observation cost per point of around 14 € for a sample of unclustered points. Actually this figure does not include the general management cost. Also the cost per point has changed in different editions of the survey. Assuming a cost of 25 € per point for in-situ observation, the added value of a 10 km site for the estimation of major land cover classes ranges between 60 € and 400 €. This is not very encouraging if the observation mode is based on VHR images, since the market price of VHR images is generally higher. On this basis it seems that a cost-efficient use of samples of VHR images for land cover area estimation is limited to zones with difficult access, such as mountainous areas or regions where most private property has restricted access and the observation of points from the field boundaries is often impossible.

However it should be taken into account that the cost per point in LUCAS is low because the sample size is very large and the communication infrastructure is good, therefore the travelling time from one point to the next is short. Cost considerations will dramatically change if we consider a different geographic context or a less dense sample. For example ground observations in tropical rainforest or in Siberia are extremely expensive; in this case reaching a cost-efficiency threshold with samples of VHR images is much easier.

When we consider land cover change instead of land cover area, spatial correlation can be much lower and the equivalent number of points can be much higher. Unfortunately at the moment we do not have suitable fine-scale observations to assess the spatial correlation of land cover change. Rare land cover types may also have correlograms with specific behaviour. The "equivalent number of points" might be higher in more fragmented landscapes, such as agricultural landscapes in sub-Saharan Africa. This conjecture needs to be checked when suitable data are available.

The equivalent number of points seems to be slightly higher with stratified sampling, where the strata can be defined from a land cover map. However the improvement is not enough to modify the conclusions (Gallego and Stibig, 2013).

Table 5: Intra-cluster correlation and "equivalent number of points" for square sites of different sizes. The last three columns were computed using an exponential adjustment to the correlogram computed on the LUCAS sample.

Intracluster correlation (ICC)			
Site size (km)	Arable LUCAS	Wheat	Sunflower
5	0.425	0.201	0.144
10	0.341	0.126	0.066
20	0.300	0.113	0.060
30	0.266	0.093	0.047
Equivalent number of points			
5	2.4	5.0	7.0
10	2.9	7.9	15.1
20	3.3	8.9	16.7
30	3.8	10.8	21.3

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Using Remote Sensing Cropland Classification Data to Update Area Sampling Frame

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Abstract

The National Bureau of Statistics (NBS) of China has begun to use remote sensing technology to estimate crop acreage. With the limitation on data availability of current satellite imagery, however, it is more proper to use semi-current or near-historical imagery classification results to update an area sampling frame which is constructed by combining latest land-use census data and the latest agricultural census data. The new methodology has been used to produce cultivated land data (CLD) based land-use data and remote sensing classification data. Based on the CLD, a new area sampling method based on multivariate stratification using classification data was tried and two different methods to estimate using design-based inference and model-based inference was compared for illustrate the advantage of the new design. The further improvement of the new design was also discussed.

Keywords: cultivated land data; remote sensing; classification data; area frame sampling.

1. Introduction

Area frame sampling is one of the major sampling methods currently used in a large range of countries for agricultural statistics and other statistical survey programmes. The National Bureau of Statistics of China (NBS) began to bring in the area frame sampling method in its crops survey programme recently. There has been a series of pilot surveys implemented since 2010. In 2010, the pilot was conducted in six counties. In 2011, province level pilot surveys were conducted in three provinces. The province level pilot survey expanded to five provinces.

Following the rapid development of China economy and society, the rural economic and agricultural structure also changes dramatically. These changes bring in large changes of rural statistical works in aspects of work environment, work conditions, and survey objectives. In this new situation, the agricultural statistical work faces with more difficulties and challenges. The statistical data quality is also affected by these rapid changes.

The conventional crop area statistics, which was mainly based on completely reporting system, are facing the difficulties of weakening statistical reporting infrastructure and data susceptible to interferes. After the reform of township administrative institution, the statistical workforce at base level weakened. There are no more specialized statistical staff or institutions at base level in many places. The administrative records are not with good integrity and coverage. Some complete statistical reporting from administrative village doesn't have sound quality. Besides, since the data are reported level by level, it is susceptible to interferes. For example, farmer based survey is susceptible to bias because of agricultural taxation and subsidy policy. When there is taxation, area and production are reported less; when there is subsidy, area and production are reported more.

Sampling survey are facing the difficulties the sample attrition and representation level. In the recent years, the agricultural structures are changing rapidly. The sample counties of crop sample survey, which were selected in 1983, becomes less representative for some crop kind, such as cotton and oilseed. The bias of some estimates is originated from this cause.

The crop sampling survey using mainly farmers as respondents becomes more and more susceptible to bias because of fast mobilization of rural workforce recent years. Many rural families immigrate outside. Their cultivated land is not easy to trace if survey is based operators' interview. The survey base data were highly affected by these changes. Moreover, the population of frame becomes uncertain, which entailing bias to estimates too.

Farmer based sample survey is difficult to designed to meet sample size constraints and multi-purpose survey objective because of the small parcel operation and decision behaviour diversification of farmers. The outdated survey vehicles and tools, such as tape rulers and measuring dividers, also hampered and affected the survey conducts and results greatly. It really needs big improvements in this aspect.

To cope with all these difficulties, though no all of them can be resolved immediately, some reform can be taken with proper direction. The application of area frame sampling and remote sensing methods should be right direction.

With the assistant of remote sensing satellites, based on the 2nd National Land Use Survey and 2nd National Agricultural Census results, NBS has began to develop a system of Crop Area and Production Estimation using Remote Sensing and Area Frame Sampling Survey (CAPERAS) to produce the planted acreage and production of crops at provincial level. The CAPERAS has been taken the considerations of the characteristics and difficulties encountered to Chinese crop production such as plant scattered, complex planting structure, division by the south and the north, multiply planted crops in a year, frequently clouding and raining. Taking the pilot survey design in 5 provinces as an example, this paper illustrates the frame updating procedures of the CAPERAS. The result from the output of sampling design has demonstrated that it could meet the requirements of sampling design for CAPERAS by the best use of remote sensing technology. The design results from pilot CAPERAS could completely satisfy the precision requirement of national agricultural statistics in China.

In 2012, the National Bureau of Statistics indicated the need of obtaining estimates at county level for large counties of food production. To meet this request, the decision was made to start with new materials and reconstruct the entire area frame. This would allow the correction of problems that had been identified when using the original area sampling frame. In 2011 and 2012, a complete new frame needs to be constructed using all new materials and the sample designed and selected to provide estimates for counties.

2. Methods and Results

Although the methodological research of remote sensing monitoring on crops was implemented, its operational application at large scale for monitoring crop planting area and estimation directly based on remote sensing data source still faces some difficult problems:

Remote sensing data cannot cover area of interest completely during crop growing season. The cost to acquire suitable data is still high and unaffordable for agricultural agency. Even if data are available, it is also not easy to process in the sure time. The methods through complete coverage with current RS data are not applicable for remote sensing crop area and production estimation.

Because the weather factor's influence, it is difficult to acquire high resolution remote sensing data in proper time period.

In the current land tenure system, the right of land use is decentralized, the land for agricultural production is fragmentized. The planting is scattered. Inter cropping and reply cropping are prevalent.

Therefore, if we want to conduct crop area monitoring operationally at national wide, the sampling methods combined with remote sensing must be adopted. It will not only resolve the difficulty of whole coverage remote sensing data, and saving money, but also can carry on quality controls and error analysis. Sampling techniques have been used in large agricultural survey projects worldwide. The MARS project of the European Union adopted a stratified area sampling method. The AGRISTARS of the United States also used area sampling frames.

A. Objective

With the support of middle or high resolution remote sensing data, the 2nd national land use survey data and the 2nd national Agricultural Census data, targeting on major crops (wheat, corn, rice) and other related land cover categories, the methods on area sampling frame construction, the methods of area sampling combined with remote sensing classification and the methods for estimation are developed. After assurance of statistical analytical accuracy, the field sample are arranged, which includes the sample size, the shape of sampling unit, survey content, spatial dispersion and the formula for universe and sampling error estimation. The spatial sampling methods are also developed to support crop planting area measurement and cross-validated with current sampling survey technology.

The area frame sampling survey method for crop planting area will mainly utilize the feature of middle spatial remote sensing data which can be acquired for large area, periodically and precisely, to resolve the specific problems in conventional sampling surveys. The acquiring capability of middle spatial resolution at large area and in almost real-time can be used to resolve the low data currency problems with base data for crop planting area sampling survey. The advantage of high spatial resolution remote sensing data can be used to relieve the workload of fieldwork in conventional survey.

B. Methods

The area frame sampling survey method for crop planting area based on high resolution remote sensing data includes the following steps:

Step 1. The cultivated land in land use datasets is in vector polygons format and geo-referenced. The village level administrative boundaries are also included in the same datasets. But with the low data currency of land use data, remote sensing classification was used to update cultivated land in land use datasets. The updated cultivated land data are used to construct the area sampling frame.

Step 2. Using the current, multi-phase middle spatial resolution data, combined with field survey data, the planting area for major crops are extracted with automated classifications.

Step 3. Stratified PPS sampling methods was adopted to draw enough administrative villages as sample. Because of the clear boundaries and convenience of field survey, the administrative village is chose as sampling units.

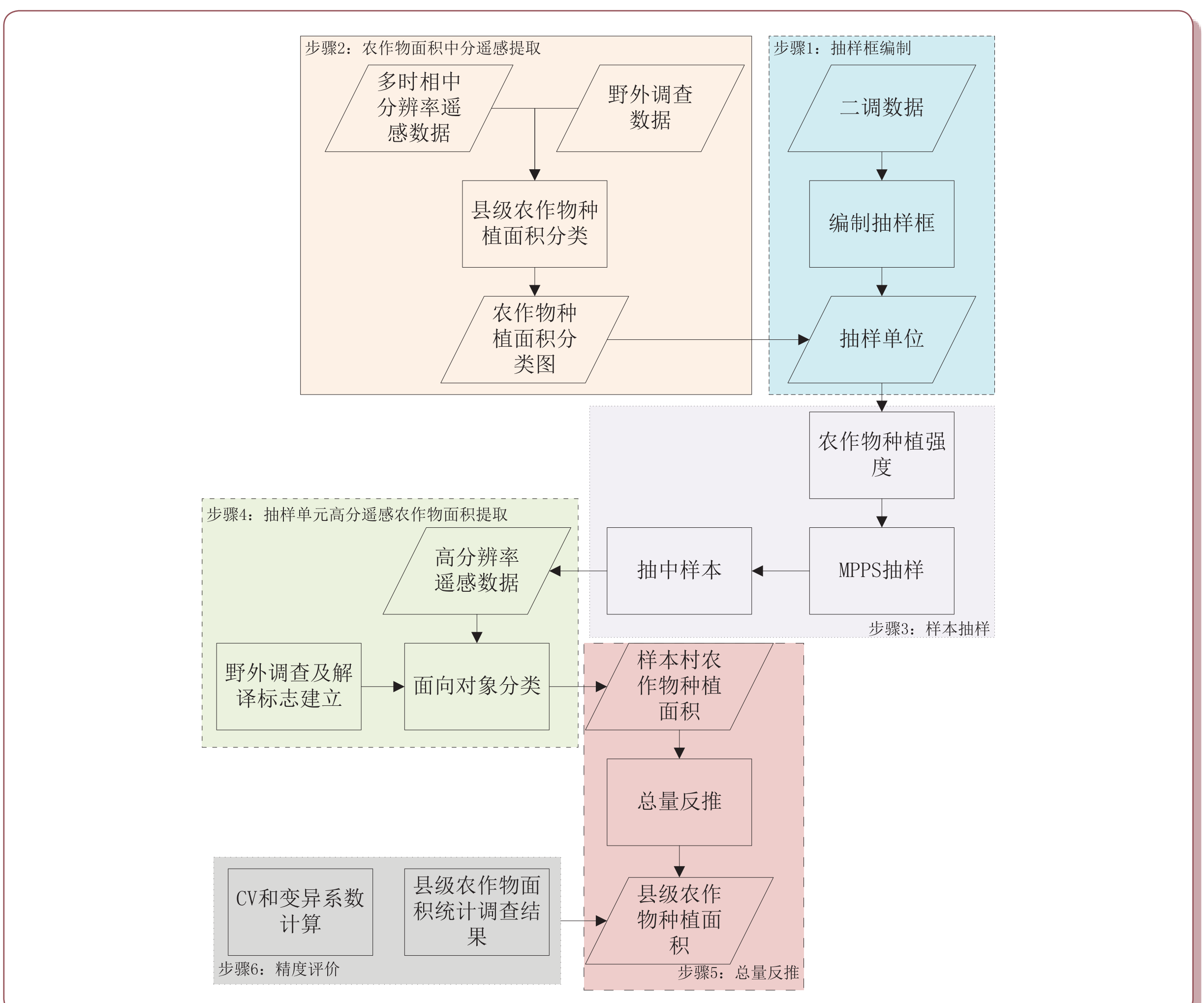
Step 4. ZY1-02C high spatial resolution data (5 meter) were used for classification, based on interpreting signatures from the ground truth. An object-based high spatial resolution imagery extraction method was used for crop planting area identification within sampling villages.

Step 5. The estimates of county level crop planting area are computed with PPS direct expansion estimator and regression estimator separately.

Step 6. The sampling variance and relative error (CV) were computed and analyzed at same time. The effectiveness of the two estimators was compared. The estimates from area frame sampling were also compared with the conventional survey estimates.

The schematic flow chart of the pilot area frame sampling method is as following:

Figure 1: The overall technical flow chart.



C. Pilot Application

Taking the year 2012 crops planting area estimation of Beizheng in Liaoning Province as an example, three major crops which are wheat, corn and rice are measured by using area frame sampling survey based on remote sensing data and land use data. The major aspects of the pilot application were described as following:

1. Crop planting area identification using moderate spatial resolution HJ1A/1B data

Since the variations in colours and tones of different crops in the moderate resolution images from the same period are not obvious. The major task of crops area extraction from moderate spatial resolution remote sensing is identification of crop type. Major steps include: the choice of remote sensing data time, the processing of data, ground truth interpretation criteria, signature extraction and classification.

The choice of remote sensing data time phase: Because of the differences of crop phenologies, the extraction of crop planting area at county level is mainly depended on the crop phenologies. By selecting the moderate spatial resolution data at different key time period for crop identification during crop growing season and using the characteristic differences of crop types in phenologies, the classification was carried on. According the crop phenologies of Beizheng in Liaoning province, the differences of wheat, corn and rice are evident in April, June and August. In April, rice and wheat were sown, but corn not yet. In June, rice is in irrigation. In August, wheat is harvested, but rice and corn are in maturation. Therefore, those three months are chose for crop area extraction.

The processing of remote sensing data: The pre-processing of remote sensing data includes: geometric correction, radiometric correction, and the choice of key vegetation index. Geometric correcting HJ data with SPOT5 (2.5 meters) data as base map, the correcting error will be less than one HJ pixel. Envi 5.0 flaash will be used radiometric correction. Because the time serial NDVIs can reflect the growing progress of crops. So three NDVI were computed in three periods and crop classifications are based on time series NDVI.

The setup of ground interpretation criteria: The setup of ground interpretation criteria is through field survey. Different signatures at remote sensing images for different crop types were created. The cultivated land polygons were overlaid on NVDI data, obvious paddy and field can be identified and obvious differences when field crops turn green.

Signature extraction and classification: The cultivated land polygons were used to creat AOI for crop identification, Spectral Angle classification method is used for extraction of crop planting area of Beizheng.

2. Multivariate stratified PPS Sampling, using cultivated land as measure of size

Multivariate stratified PPS Sampling method was used when sampling villages. 24 sampling villages were selected from Beizheng pilot survey. There are 226 villages in the population.

3. The extraction of crop planting area within sampling villages

Object-based extraction method was adopted in this step.

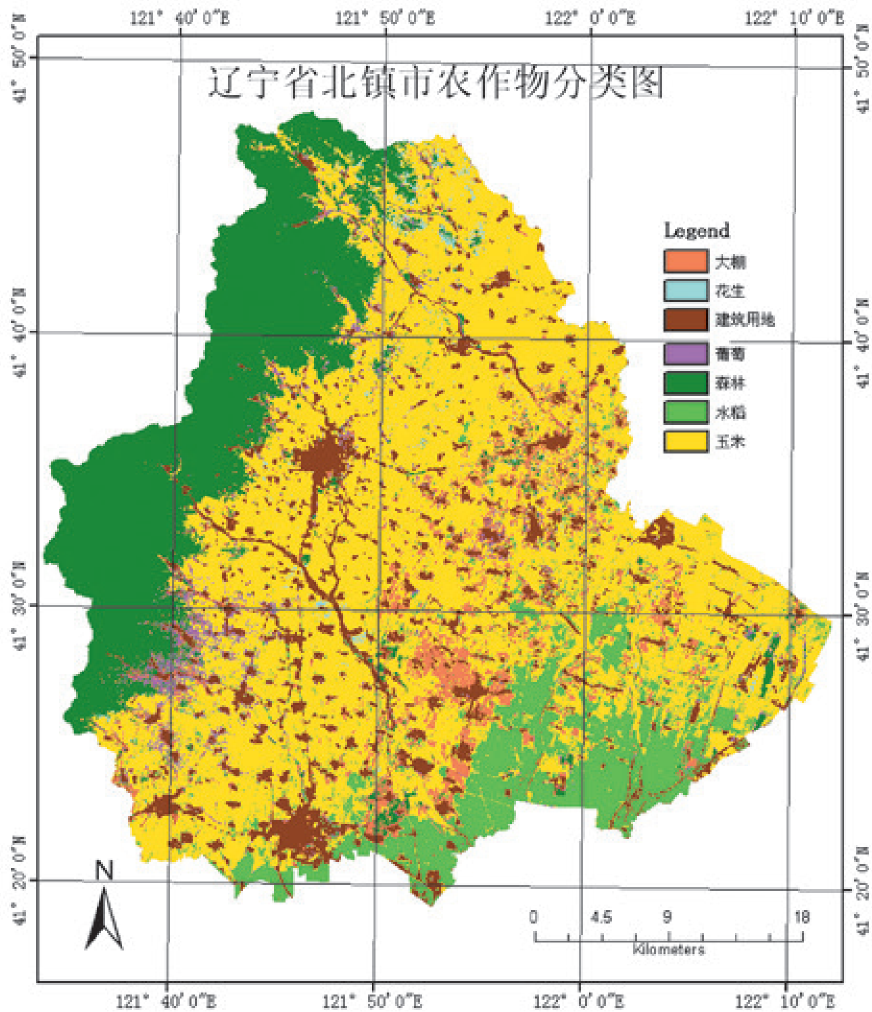
4. The population estimation and accuracy evaluation

Using direct expansion estimators, the CV of rice is 6.9%, the CV of Corn 5.4%. The wheat is a minor

Figure 2: Beizheng crop phenologies.

月份	4月			5月			6月			7月			8月			9月			10月		
旬	上	中	下	上	中	下	上	中	下	上	中	下	上	中	下	上	中	下	上	中	下
一季稻		301	302	303	304	305	306	306	307	308	308	309	310	310	310	311	311	311	311		
春小麦	101	101	103	107	108	109	110	111	111												
春玉米			201	201	202	202	202	203	203	204	205	205	206	206	206	207	207	207	207		
大豆					501	502	503	503	504	504	504	505	505	505	506	506	506	506			
甘薯					701	703	703	703	704	704	704	704	704	705	705	705	705	706	706		
马铃薯	701	701	702	702	703	704	704	704	705	705	706	706									
花生			701	701	702	702	703	703	703	703	703	703	703	704	704	705	705	706	706		
高粱				701	702	702	703	703	703	704	704	705	705	705	706	706					
其他作物																					
白菜											801	801	802	802	803	803	804	804	805	806	806

Figure 3: Beizheng crop classification thematic map.



crop in Beizheng, its CV was reasonably large and not reported here.

Using regression estimators, the CV of rice is 5.3%, the CV of Corn 3.7%.

Comparing with the conventional statistics, the ratio of the pilot estimates are 92.48% and 92.86%.

3. Outlook

With the development of remote sensing methodology in China agricultural agencies and the availability of usable multi-source remote sensing data especially high resolution satellite imagery, it is becoming more liable to the operational application of remote sensing. It is a good manner to improve the area frame sampling with remote sensing, whatever on frame construction, sampling and estimation. But many aspects in area sampling should be research more deeply in china, such as small administrative unit as sampling unit, clustering and ordering of sampling units, small area estimation using remote sensing data as auxiliary variables and model-based estimation.

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Measurement of Avoided Deforestation in the Pasture Areas in Mato Grosso

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Abstract

The advancement of technology provides productivity gains to all agricultural activities.

For beef cattle this can be verified by reducing the need for new pasture areas and / or better use of existing areas. A pointer to the facts cited above is "avoided deforestation", therefore, the area used to be avoided by the productive system due to the increase of production indicators. This way, was observed the influence of technology used in the development of livestock in Mato Grosso and the impact that this advancing technological level may have caused the mitigation of deforestation in areas of savanna, pantanal and forest. Based on database of beef cattle herd and slaughter from the Institute of Agricultural Protection from Mato Grosso State (Indea) and the Mato Grosso´s Agibusiness Institute (IMEA) and pasture areas obtained with the Geographic Information System (GIS) performed through remote sensing was possible to verify the avoided deforestation area in the state. Based on the technological level of 2012 for slaughter and herd, was calculated the avoided deforestation for the previous years. The results taking into account the level of technology used in the herd in 2012 the avoided deforestation was 14.7 million hectares compared with 1996. Doing the same analysis with the level of technology used in the slaughter for the year base 2012, the avoided deforestation was 11.7 million hectares in 2004. The advancement of technology through improved pasture and herd genetics have a positive effect on mitigation of deforestation in Mato Grosso. Furthermore, strategies for finishing cattle intensively contribute to the increase in the number of slaughtered animals and reduce the need for area in the state. Important to remember, the sustainability of any biome is supported on the tripod environmental, social and economical and should be taken into account in decision-making when the choice of the production system.

Keywords: deforestation; slaughter; cattle.

1. Introduction

Meat production in Mato Grosso has undergone significant changes in recent years. Technological advances stepped into rural properties and cost/benefit ratio is positive for farmers, leaving the beef production chain more competitive. The technological level used in production nowadays, as the use of confinement systems, agricultural practices for soil correction and improvement of pastures, besides the increase in genetic material, have considerably improved the performance of beef cattle.

This advancement in technology has brought a reduction in the need area available to beef cattle in recent years, expanding the number of so-called "avoided deforestation" - the area that is prevented from being used by the production system due to the increase of production indicators and productivity.

In designing the present study, it is understood by deforestation and/or wood clearing the definition proposed by Alves (2001), in which the first term applies to wood clearing activity by man for the purpose of use or consumption of the noblest woods subsequently woods industrial (construction) and finally the implementation of some activity, usually growing pastures. Already deforestation, according to the author, is a generic term that can describe the activity of felling of forests and also the activity of the overthrow of any other form of vegetation, aiming to any other use of the area. Therefore, the cattle production, sometimes tortured, is not to blame for deforestation, is rather the way it was found by explorers Brazilians to occupy and extract other natural resources, valuing these lands over time and preparing for future activities, such as agriculture or urban use.

Does not enough discussion on the beneficial effects and undeniable technologies bring the

authors see the need to discuss the issue logging or deforestation of Mato Grosso at the biomes found in the state, given that there are three distinct biomes (Amazon , Savana and Pantanal) spread over an area of 90,336,619 hectares (IBGE, 2010).

Thus, the objects of analysis, biomes are described in the following ways. The Amazon forest is spread over nine states (Acre, Amapá, Amazonas, Maranhão, Mato Grosso, Pará, Rondônia, Roraima and Tocantins), has an area of 4,196,943 km^2 or 40% of the Brazilian territory (IBF, 2014), there a wealth of species and habitat diversity. According to Ab 'Saber (2005), this biome are present large tracts of rainforests diverse, highlighting the dense rainforests and open forests and river beyond the enclaves of Savana.

In Mato Grosso still has the Savana biome, characterized by extensive savanna areas with grasses, shrubs, scattered trees, compacted (savanna woodland) and covered by a thick bark, and leaves which are usually broad and rigid. The biome is the second largest in the country and covers an area of 2,036,448 million hectares, accounting for over 23% of the national territory (IBF, 2014). The Savana is present in Distrito Federal, Bahia, Goiás, Maranhão, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraná, Piauí, Rondônia, São Paulo and Tocantins.

The last of the three biomes found in the State, the Pantanal is considered the largest alluvial plain of the planet, bordered to the north by the southern Amazon forest formations on the east by the savannas of central Brazilian plateau, to the west by wetlands-Bolivian border Paraguay and on the south by the steppe grasslands on the border with Paraguay (Silva et al., 1998). Present in two Brazilian states, Mato Grosso and Mato Grosso do Sul, its area is approximately 150,355 km^2 (IBF, 2014). With respect to weather, the Pantanal biome is warm, dry winters and rains concentrated in the summer (80%), causing the flooding of the Great Plains found therein.

Since the diversity that has Mato Grosso and knowing that there are different technological levels between them, it is expected that the dynamics of deforestation and wood clearing is also different. It is worth noting that the dynamics of deforestation and wood clearing causes, no exceptions, a change in land cover. Furthermore, this change in land cover is caused by human activities that aim to meet their needs, for example, conversion of primary forest in agricultural areas (WALKER, 2004).

The numbers presented by Prodes-INPE show a reduction of more than 90% of the deforestation in the state since 2004. Even so, indicators of herd and slaughter followed growing, indicating an increase in productivity of beef cattle. This indicates that the impossibility of expanding agricultural frontiers farmers found technology solutions and management that allowed an increase in the intensity of use of pastures established.

One of the best indicators to evaluate that "avoided deforestation" in beef cattle is to relate the variation of pasture area with slaughter effective and also with the evolution of herd. Thus, this study aims to observe the general influence of technology used in the development of livestock in each biome of Mato Grosso and the impact that this advancing technological level may have caused the mitigation of deforestation in areas of savanna, pantanal and forest.

2. Methodology

To obtain grazing areas, was used Geographic Information System (GIS) to cross the shape file of the pasture areas of Mato Grosso between the period 1996 to 2012 (raised by synoptic held in 2008 and 2012 through the remote sensing) and each of the biomes of the state, which are: Pantanal, Savana and Amazon demonstrated results are in Table 1 below.

In order to obtain data from the herd cattle and slaughter stratified by county that make up the state, a consultation was held in the database of the Brazilian Institute of Geography and Statistics (IBGE) and the Institute of Agricultural Protection (INDEA). The data from the town herd available in 1996, while the slaughter local data are available since 2004. To obtain the values by biome, with the help of the GIS tool, the herd and slaughter each county was apportioned according to the proportion of pasture area in each biome. The aggregated data for each biome are shown in Table 2.

Based on the analysis of the data cited above and the result of the adoption of the technologies that have been developed over the last few years, it was possible to measure the avoided deforestation, both as to herd cattle and the slaughter. The year used as the basis for the calculations was 2012, compared with previous years and the results were recorded.

For determining the area of avoided deforestation, taking into account the slaughter (DEA) established a relationship between the total area of grassland in the period analyzed (APTP) with the slaughter in the

same period (Abp), whose result was multiplied by the slaughter in the current period (Abh) and subtracted from the pasture area in the current period (Apth). This resulted in the calculation formula described below:

$$DEA = \left(\frac{A_{ptp}}{A_{bp}} X A_{bh}\right) - A_{pth}$$

DEA: Avoided deforestation in the slaughter;
A_{ptp}*: Pasture area in the period analyzed;*
A_{bp}*: Slaghter in the period analyzed*
A_{bh}*: slaughter in the current period;*
A_{pth}*: Pasture area in the current period*

To calculate the avoided deforestation, taking into account the level of technology used in the herd (DER), was the relationship between the pasture area in the the period analyzed (Aptp) with the herd in the same period (RP), multiplying this result by the herd current period (Rh).

$$DER = \left(\frac{A_{ptp}}{R_p} X R_h\right) - A_{pth}$$

DER: Avoided deforestation in the herd;
A_{ptp}*: Pasture area in the period analysed;*
R_p*: Herd in the period analysed;*
R_h*: Rebanho no período atual;*
A_{pth}*: Área de pastagem no período atual*

3. Analysis of the data

The results with the evolution of pasture area by biome can be seen in the graph below.

In the graph it is evident that the total area of pasture in Mato Grosso decreased from 2008. Analyzing each biome, in the Amazon, the area increased by 2008, from 9.2 million hectares to 13.1, and in 2012 decreased 0.6 million hectares, equivalent to 5%. In the Savana, the values of pasture area had little changed between 1996 and 2008, a decrease of 0.3 million hectares or 3%. The pantanal was the only biome that showed steady increase in areas, reaching 1.96 million hectares in 2012.

In Table 1 it is possible to observe the estimative of the herd and slaughter of cattle per biome.

The numbers of livestock and slaughter consulted the database from IMEA and Indea presented in Table 1 show that all biomes of Mato Grosso had a considerable jump in both the number and in the number of the cattle slaughtered. In 2012, the Mato Grosso's herd totaled 28.6 million cattle whose positive variation was 84% compared to 1996, the first year used in the analysis. Meanwhile, the slaughter was 5.5 million heads, was increased by 46% compared to the first data released in 2004.

While there is an increase herd and slaughter over the years, it can be observed a decrease in the pasture areas in the same period, thus increasing the stocking rate of pastures, with the exception of wetland biome, which has its grazing area growth increased as the herd. In Figure 2 it is possible to verify the increase in productivity per hectare depending on the herd (1) and slaughter (2).

Figure 1: Pasture area by biome in Mato Grosso State.

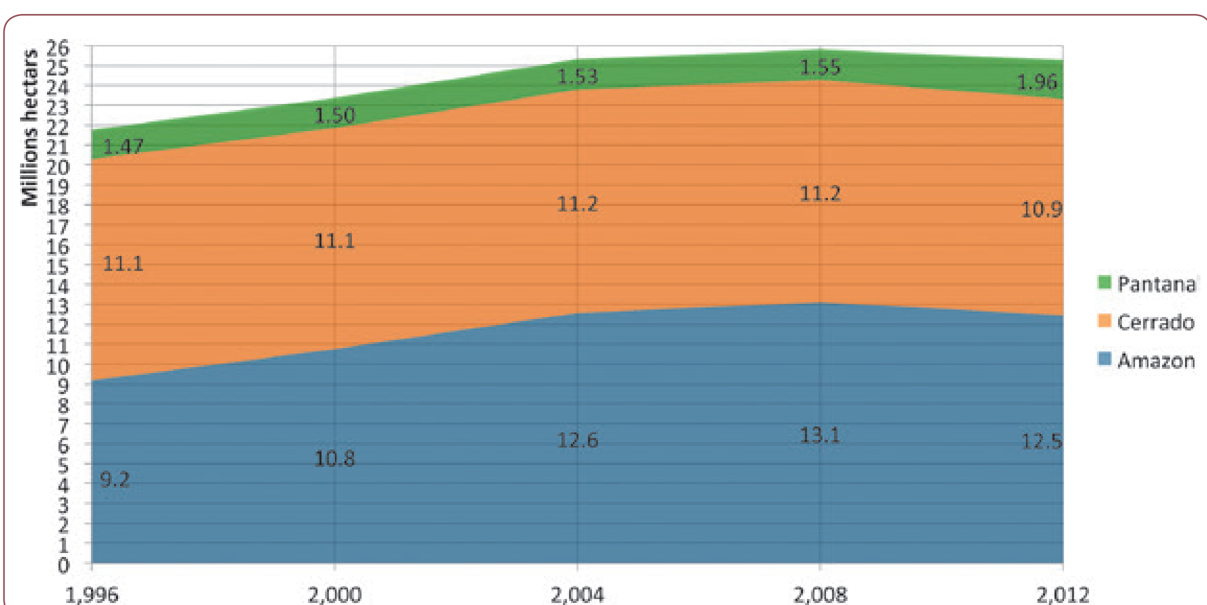
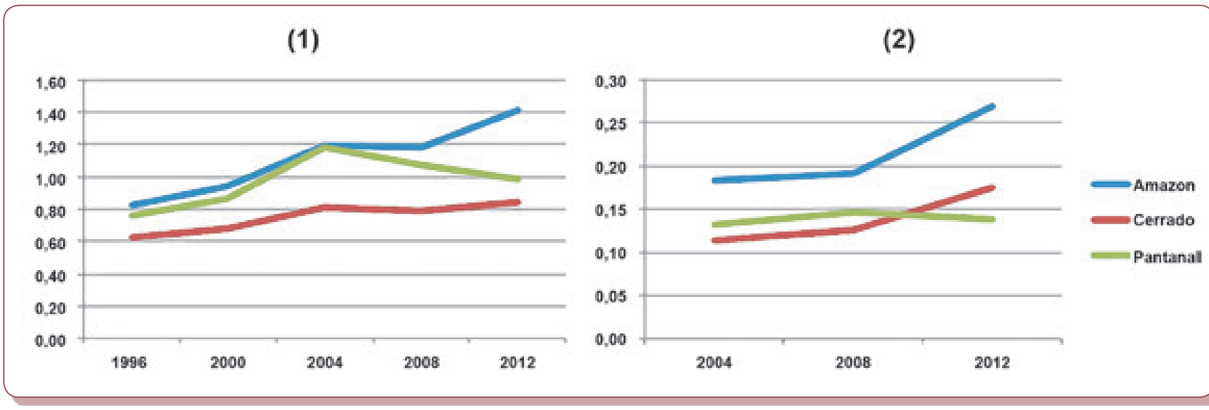


Table 1: Data of the herd and slaughter in different biomes of the Mato Grosso State.

Year	Amazon		Savana		Pantanal		Total	
	Livestock	Slaughter	Livestock	Slaughter	Livestock	Slaughter	Livestock	Slaughter
1996	7.554.832	-	6.901.385	-	1.116.877	-	15.573.094	-
2000	10.137.923	-	7.495.569	-	1.291.040	-	18.924.532	-
2004	14.995.493	2.293.668	9.104.551	1.276.283	1.818.954	200.791	25.918.998	3.770.743
2008	15.538.248	2.496.260	8.812.768	1.399.361	1.667.200	226.857	26.018.216	4.122.478
2012	17.550.764	3.342.262	9.169.459	1.899.432	1.931.032	271.003	28.651.256	5.512.697

Source: Imea; INDEA.

Figure 2: Rate of stocking the herd (1) (heads / ha) and slaughter (2) (slaughtered animals/ha) in different biomes in Mato Grosso.



For the results of avoided deforestation in the different biomes of the state, were found the values presented in Table 2 for the technological increments in cattle and slaughter.

Table 2: Avoided deforestation (ha) with the herd and slaughter in different biomes in Mato Grosso.

Year	Amazon		Savana		Pantanal		Total	
	DER	DEA	DER	DEA	DER	DEA	DER	DEA
1996	8.854.651	-	3.929.528	-	585.044	-	14.785.555	-
2000	6.154.477	-	2.745.276	-	287.087	-	10.109.899	-
2004	2.250.776	5.854.881	450.578	5.851.049	-330.571	111.285	2.724.431	11.754.684
2008	2.344.529	5.088.764	753.574	4.288.769	-166.064	-109.789	3.150.031	9.241.980
2012	-	-	-	-	-	-	-	-

Source: Imea; INDEA.

The analysis of the data over the last few years shows that to have the same herd and slaughter cattle, 2012, the area for pasture would be considerably higher using the technology of 1996, 2000, 2004 and 2008. One of the factors that directly contribute to this improvement in productivity levels by pasture area was confirmed by (Restle, 2002), which according to the author, the use of cultivated pastures in summer, properly managed, allows high weight gains per animal and area, thus becoming an excellent alternative to intensify the production of beef cattle. In this sense, Canto et al (2010) points out that the recognition of the role and potential of pasture is very important for the development of beef cattle in Brazil.

To slaughter 5.5 million heads (the value obtained in 2012) the technology of 2004 and 2008 would be required areas by 47% and 37% largest than the

25.2 million hectares used in 2012, namely 37, 0 and 34.5 million hectares, respectively.

The biome that yielded better results compared to avoided deforestation in the Amazon was the flock. Taking into consideration the technological level of slaughter in 2012, this could prevent deforestation in the order of up to 8.8 and 2.3 million hectares if they used the technologies of the years 1996 and 2008, respectively.

The results for the Pantanal of Mato Grosso was lower compared to the other two biomes, when considering the levels of technology applied both in the herd as the slaughter. To have an idea for a herd of 2012 with the technological level of 1996 and 2000 would require 585,000 and 287,000 hectares more, respectively.

Compared with the technology of 2004 and 2008 with increasing herd was opposite movement, that is, would require 330,000 and 166,000 hectares less than pasture. This jump frustrated productivity may have several explanations, but despite the productivity decrease, the absolute number of the herd and slaughter increased, was not greater than the increase in pasture area. This increase in area due to the herd was confirmed by Arruda et al (1985) found a positive correlation between low annual costs of this biome with phases creates rebuilds. This fact is evidenced by the tendency to allocate these activities of beef cattle in areas of minimum operating cost, in other words, on large estates, distant regions of slaughter and consumption (Arruda et al., 1985). As assessed by Abreu et al (2006a), the result of the balance of revenues and annual expenditures was lower in the Pantanal when compared to other regions.

One of the factors that directly contribute to this improvement in productivity levels by pasture area was already confirmed by Restle et al in 2002, according to the author, the use of cultivated pastures in summer, properly managed, allows high weight gains per animal and area, thus becoming an excellent alternative to intensify the production of beef cattle. Such a scenario could be verified in the Savana of Mato Grosso, where there was the highest level of technology used over the years, which probably contributed to lower deforestation.

4. Conclusions

The advancement of technology through improved pasture and herd genetics exert extremely positive effect on mitigation of deforestation in Mato Grosso. Furthermore, strategies for finishing cattle intensively contribute to the increase in the number of animals slaughtered and reduce the need for the area in the state.

The work makes clear the need to analyze in more detail the use of production technologies in the wetland, since apparently the technology leap observed through the production indicators in 2004 did not materialize as in other biomes. Even if significant advances in productivity, increased absolute production since the only economic activity that enables the sustainable use of this ecosystem is beef cattle.

It is important to remember, the sustainability of any biome is supported on the tripod environmental, social and economical and should be taken into account in decision-making when the choice of the production system.

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Reported Uses of CropScape and the National Cropland Data Layer Program

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Abstract

This paper will highlight the unique cropland area monitoring program which was developed within the United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS). The report will also focus on the remote sensing based land cover products which are delivered via an interactive web portal known as CropScape. CropScape provides open accessibility, visualization, and geospatial analytics to the user community. CropScape also supports the ethos of data democracy, providing free and open access to digital geospatial data layers. CropScape utilizes open web standards, thereby supporting transparent and collaborative government initiatives. This paper discusses documented uses and applications of NASS' Cropland Data Layer (CDL) products, and how CropScape, a web-based program, delivered across the internet to connect USDA researchers with a previously unreachable audience. CropScape users can now interact, visualize, and query CDL products to determine planted agricultural cropland area at the field level for any given year across the landscape of our nation.

Keywords: Cropland Data Layer; CropScape; land cover; geospatial.

1. Background

Since 1997, NASS has produced an annual crop-specific land cover product called the Cropland Data Layer (CDL). The CDL depicts more than 100 unique crop categories across the United States, and is delivered at 30 meters, or .09 hectare pixel resolution. Today, a national CDL product is available for the years 2008 through 2012, with the entire historical CDL dataset disseminated via CropScape at http://nassgeodata.gmu.edu/CropScape. The CDL is a national land cover product delivered just a few months after the growing season concludes. Combined, the CDL and CropScape, are unique land cover products and dissemination methods that are not duplicated anywhere in the world on a national scale and are performed annually.

The CDL is derived using a supervised land cover classification approach. It combines the satellite imagery collected during the growing season from such sensors as Landsat, Resourcesat, and the Disaster Monitoring Constellation. It also combines agricultural-specific ground truth data from USDA's Farm Service Agency (FSA) program known as the Common Land Unit (CLU). And, it combines ancillary, non-agricultural ground truth data through the United States Geological Survey's (USGS) National Land Cover Dataset (NLCD). The process integration of these satellite resources with highly accurate and abundant ground truth provides for this one-of-a-kind, annual national land cover data product.

In January 2011, NASS, in cooperation with George Mason University's Center for Spatial Information Science and Systems (CSISS), released CropScape, a new data visualization portal, thus enabling open access to NASS's CDL geospatial data. CropScape was designed to provide users with free and open access to interactively visualize, query, and disseminate the CDL by using a standard browser interface to extract cropland area statistics, derive charts and graphs, and perform change analysis between years. Additionally, CropScape delivers online geoprocessing services such as dynamic, mashable, on-demand data delivery which effectively links directly to other geospatial applications such as Google Earth.

2. Methods

The CDL program relies on synergistic partnerships with the USDA's FSA who provides updated reported field level data on an annual basis from the CLU data set. This effectuates a robust ground truthing set of the agricultural domain. USDA's Foreign Agricultural Service (FAS) provides subscription-based access to their Satellite Image Archive, thus providing independent collections of satellite-based data (i.e., Resourcesat or Disaster Monitoring Constellation). The USGS, which produces the NLCD (Xian 2009),

was utilized to derive the CDL's non-agricultural domain, along with the Percent Tree Canopy, Percent Imperviousness and National Elevation Dataset products. The USGS's Earth Resources Observation Systems (EROS) Data Center has been providing free access to Landsat imagery since 2008, and is also used as an image input. The CDL program and process to derive the CDL were described in detail (Boryan et al. 2011 and Johnson and Mueller 2010), utilizing a supervised decision tree classification approach with the aforementioned data streams.

The CDL was initially disseminated via CD-ROM and DVD media in the early 2000's, and subsequently select states became available for download via File Transfer Protocol (FTP) from the NASS website (NASS 2013). In the mid-2000's, USDA's National Resources Conservation Service (NRCS) began serving the entire inventory of CDL products through their Geospatial Data Gateway (NRCS 2013). It became apparent that better dissemination methods were needed to meet the growing end-users' need to interact and query this content-rich dataset.

Hence, a new interactive web-based CDL visualization method was developed to provide access like never before to users via web mapping services, while also offering open, geospatial protocols for data sharing. CropScape's primary function (Han 2012) was to offer an interactive, visual, and analytical experience that would enable users to download crop area statistics, examine quantitative changes on maps between crop years, perform a visual swipe function between years, and print map products. This could all be accomplished on a national level, within a state, an agricultural statistics district, or even within a county. One could also draw their own ad-hoc areas. Since CropScape was launched in January 2011, more than 81,000 users have interacted with the site, leveraging its comprehensive capabilities with continued demand for enhanced functionality or system improvement. CropScape facilitates a dynamic user experience in an open framework for decision support, while also upholding numerous agricultural-specific research projects. The remainder of this paper focuses on published uses of CDL datasets from peer-reviewed journals and documented websites that have ingested CDL data via CropScape mash-ups.

3. Uses of CDL

The CDL product has matured since its creation in 1997, with methods (Boryan et al. 2011), ground truth data, and accuracies of cropland identification making vast improvements, while the CropScape portal expanded product usage from mostly power Geographic Information Systems (GIS) users to those who had little or no GIS-related experience, but had extensive agricultural industry knowledge. CropScape has empowered the masses to perform area change and rotational crop analysis with a queryable, interactive interface. CDL end-users are now documenting their uses in peer-reviewed literature, with uses of the CDL product ranging from research on agricultural sustainability studies, to environmental issues, land conversion assessments, crop rotations, decision support, disasters, farmer surveys, carbon, bioenergy, ecology, and biodiversity. However, there is a segment of our user community who is using it for agribusiness decision support, as well as for insurance and financial purposes. These users cannot be quantified and will not publish their uses of the CDL dataset, as their uses are considered confidential or trade secrets. Additionally, other web portals are developing protocols that either host the CDL data or deliver it as part of web mapping services.

The research communities documented uses of CDL range from local food studies in Greenbrier Valley, West Virginia, where they are identifying agricultural production areas (Hartz et al. 2011), to Montana's Tongue River Basin, where scientists are studying water resources and availability to provide a detailed picture of land use versus agricultural statistics (Fitzgerald and Zimmerman 2013). And, users at the University of Idaho Extension (Painter et al. 2013) are leveraging CropScape to design an oilseed survey that will help producers and processors who were interested in trying oilseed production. In another study, the CDL was utilized to identify wheat area, mask wheat fields, and then derive an empirical regression yield model for Kansas, which was then scaled to a wheat-producing region in the Ukraine (Becker-Reshef et al. 2010). Finally, the CDL was utilized to characterize crop distributions and changes in crop rotations across the Great Lakes Basin (Lunetta et al. 2010).

The following studies focused on land conversions and transitions, where wetlands were transitioning to row crops (Johnston 2013), and where western corn belt grassland was being converted to corn/soybean production (Wright and Wimberly 2013). Users access the CDL to screen results with an agricultural

mask and examine the agricultural rotational patterns and fallow land for wetland change monitoring in the Northern California marshlands (Potter 2013). Users in Illinois and Indiana accessed the CDL to study county level rates of conversion from farmland to evaluate developed farmland preservation policies (Thompson and Prokopy 2009). And, researchers examining the Northern Great Plains grassland conversions noted the need for additional statistical research of such large datasets, and cited CDL accuracy assessments as a critical means for deriving parameter estimates in empirical land-use models (Rashford et al. 2013).

The following studies focused on crop rotations, crop area expansion, tilled and cultivation studies, and statistical sampling. A study (Plourde et al. 2013) focused on crop rotational patterns, with trends moving towards monoculture cropping practices, and examined rotation sequences, which reflected the increasing intensification of corn production. The CDL served as a regression tree training model for agricultural production trends and crop rotation practices in the Great Platte River Basin (Howard et al. 2012). Research on Iowa crop rotation patterns indicated corn expansion into land not under recent cultivation, which impacted the amount of soil carbon sequestration (Stern et al. 2012). Four years of CDL data were assimilated to create a consistent national level annual tilled cropland dataset, and another approach derived a cultivated rule-based dataset modeling (Boryan et al. 2012). And, yet another study used the CDL to characterize statistical sampling units into strata, to classify land into different types at the field level, and then as a proxy to estimate variances for crops of interest (Zimmer 2012).

The following chemical/environmental studies have used the CDL for project input: sampling site selection for pesticide contaminants in High Plains wetlands (Belden et al. 2012); estimating total pesticide usage and intensity in the Chincoteague Bay subbasin; characterizing agricultural, environmental, and other scientific parameters (Kutz et al. 2010); estimating the watershed scale environmental impacts of corn stover removal using the Soil Water Assessment Tool (SWAT) for determining that stover removal was sensitive to watershed characteristics and management inputs, including slope and fertilization applications (Cibin et al. 2012), and estimating field level nitrogen losses in another study that merged SWAT predictions with CDL data, thereby tying the changes in corn and soybean prices based on the US ethanol mandate to the expansion of the hypoxic zone in the Gulf of Mexico (Hendricks et al. 2013).

The CDL has also demonstrated uses in the carbon, bioenergy, ecology, and disaster domains. It has been utilized to derive net annual soil carbon changes, calculate the fossil fuel emissions from crop production, compute the cropland net primary production, which is used for estimating and spatial distributions, and to provide improved estimates of crop carbon dynamics in a spatially explicit manner (West et al. 2009). Another study used the CDL to evaluate the potential of marginal lands for biomass production and mitigation efforts on greenhouse gas emissions (Gelfand et al. 2012), and a bioenergy production study (Muth et al. 2013) of comprehensive spatial assessments of residue removal across the United States. A unique application was used in a North Dakota sunflower field study, which focused on (Schaaf et al. 2009) the foraging use of fall migrating non-blackbirds. Finally, scientists utilized CropScape to analyze the crop damage and loss following the devastating tornadoes that devoured sections of Alabama in April 2011. Using CropScape with tornado swath, along with National Aeronautics Space Administration resources, scientists were able to accurately describe crop damage and loss (Herdy 2012).

CropScape provides for a dynamic user experience with wide-ranging capabilities in an open, geospatial context, and facilitates the delivery and analysis of geospatial cropland information to the user community. Currently no other entity provides an annual national crop specific land cover product in an interactive, accessible manner, via a visually immersive experience. CropScape's Open Geospatial Consortium compliant architecture and web mapping services have created opportunities from within the geospatial community to develop data sharing through the wire, encapsulating one website's geospatial data within another, using a technique called mash-up (Han et al. 2012).

Many sites utilize web-based tools for the United States cropland, bioenergy, and soils data exploration, including the demonstration of linking CDL spatial functionality to detailed crop rotation management for agroecosystem modeling (Kipka et. al 2013) using web service requests. The Billion Ton Study (US Dept. of Energy 2011) hosts a mashable site called the Knowledge Discovery Framework at

https://bioenergykdf.net/ where varying scales of data i.e., national, regional, and local can be queried, analyzed, uploaded, and visualized for decision-support with regard to economic and environmental impacts of development options for biomass feedstock production and biorefinery infrastructure. Another site where the CDL can be queried against bioenergy datasets for acreage planted information (Yang et al. 2011) was developed in another application called integrated Agricultural Information and Management System (iAIMS), and it delivers dynamic and interactive climate, soil, CDLs, and road infrastructure databases at https://beaumont.tamu.edu/CroplandData/.

4. Discussion

In preparation for this paper, Google Analytics were run against CropScape's user base, and the following information was tabulated. Figure 1a depicts CropScape's global user base, with the majority of users coming from the United States. However, the reach of CropScape was global with users reporting from every continent except Antarctica. Table 1 shows the number of top ten country unique visitors in descending order using CropScape with the United States, Canada, China, Germany, United Kingdom, Argentina, France, Brazil, Spain, and Mexico. Figure 1b shows the United States locations of CropScape users; California, Illinois, Minnesota, Virginia, and Iowa were the top five reported state users, in descending order. Note that both the CSISS and NASS Spatial Analysis Research Section were located in the state of Virginia, which could account for higher than expected numbers. The total number of unique reported visitors was 81,650 as of June 2013. Figure 2 shows the reported number of CropScape visitors since CropScape became operational in January 2011. Note the sharp user access increase during both January 2012 and 2013, when the newest CDL products were released. However, there was an intense user spike for unforeseen reasons during the end of June 2011, when users visited CropScape coincident with the release of the NASS June Acreage Report. It is believed that the public thought that the CDL was going to be updated and released coincident with the June Acreage Report. However, it is impossible to release a completed, final CDL product at this time, as it is necessary to wait until the growing season has completed, all crops have emerged, matured, and senesced. Once that is complete, the metadata is finalized, and all products are checked for quality assurance and quality control.

Figure 3a shows the CropScape website and interface at http://nassgeodata.gmu.edu/CropScape. CropScape provides additional ancillary data layers for purposes of navigation and dissemination, including a crop mask to shade-out all non-agricultural areas, and political, water, and road boundary layers to facilitate orientation purposes. Figure 3b shows an enlarged depiction of Craighead County, Arkansas in 2012, with the crop legend appearing on the left side of the graphic. Note there was much discussion and many decisions to be made to properly represent each crop category cartographically. When making these decisions, we considered each crop category color and its geographic distance to similar crop colors. Mapping the more than 100 crop categories was extremely challenging (Ebinger 2012).

Figure 1a: The darker blue color indicates higher incidence of reported CropScape users globally.

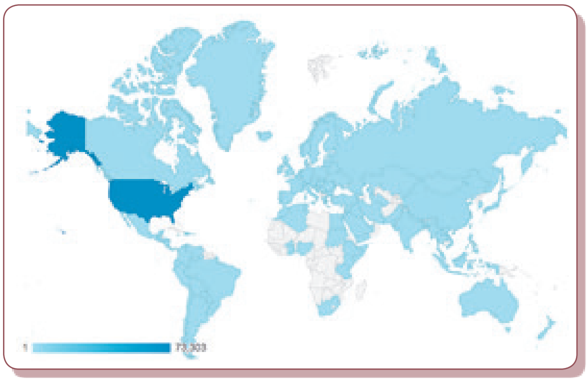


Figure 1b: The darker blue color indicates higher incidence of reported CropScape users in the US.

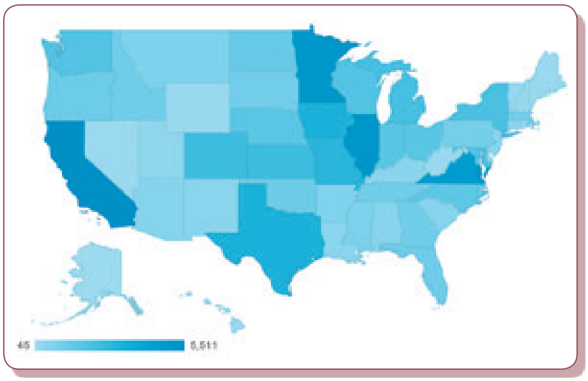


Table 1: List of the top ten unique national country visitors to CropScape, note n = 81,650.

Country	Unique Visitors
US	73,303
Canada	1,100
China	913
Germany	502
United Kingdom	441
Argentina	393
France	388
Brasil	362
Spain	300
Mexico	291

Figure 2: Lists the unique number of unique visits since January 2011 when CropScape became operational.

Figure 3a: CropScape website interface, note the CDL years of data available.

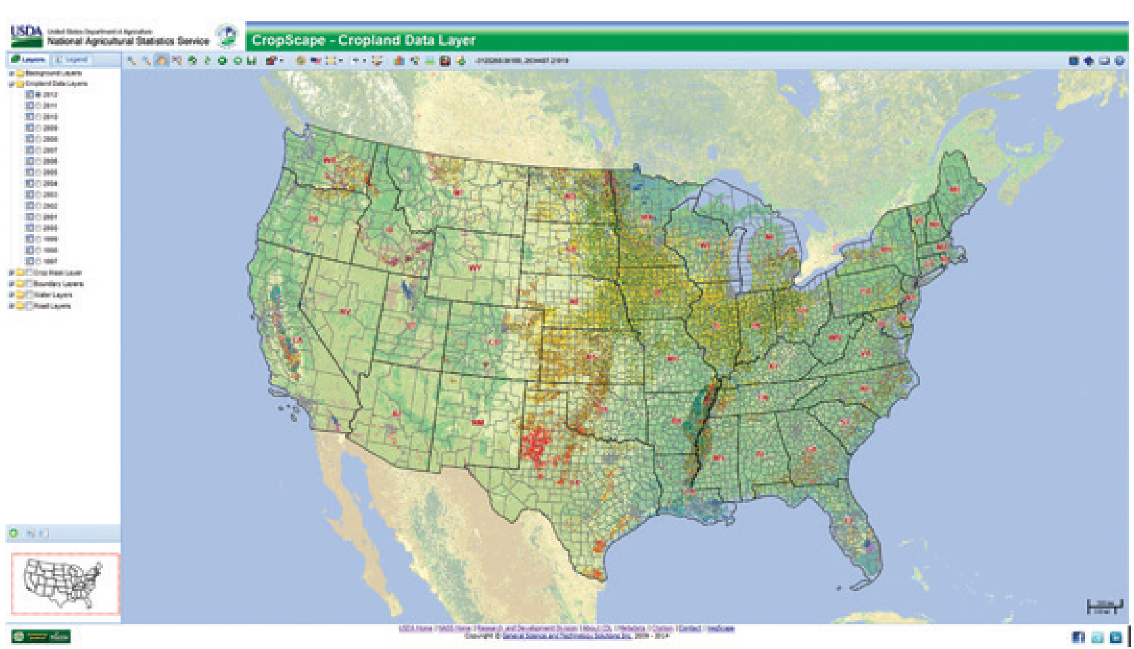
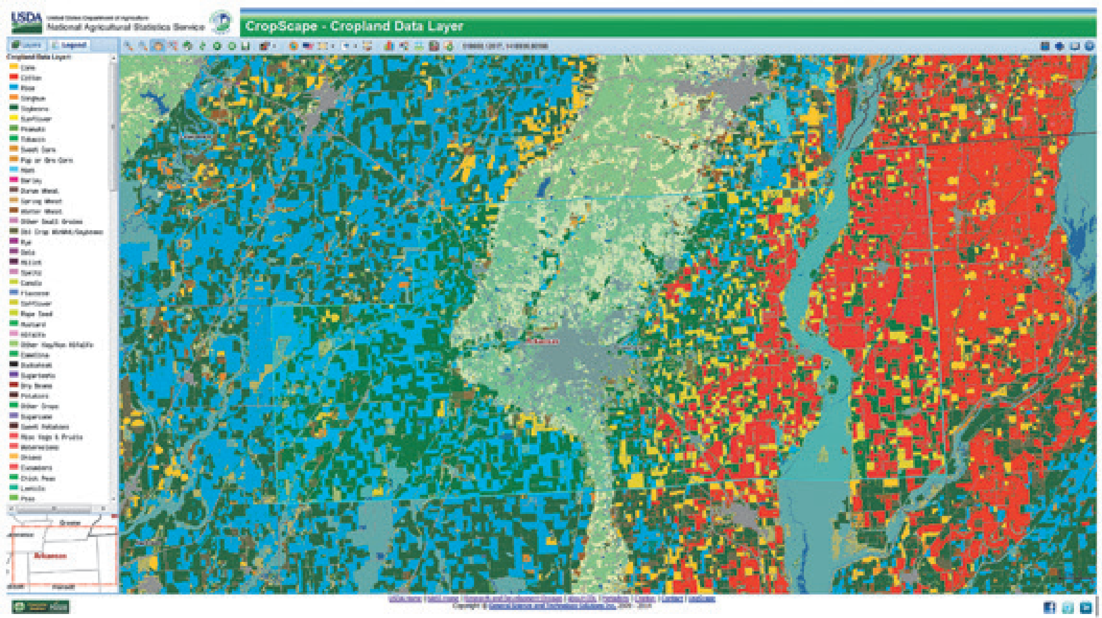


Figure 3b: A zoom enlargement of Craighead County, Arkansas 2012. The crop legend appears on the left side of the graphic.



5. Conclusion

The combinations of the CDL product disseminated with CropScape provide a unique one-of-a- kind, interactive, visual, and analytical experience. The ethos of data democracy were upheld, providing free and open access to digital geospatial data layers in an open standard web format, supporting a transparent and collaborative government initiative. Users can query, compute statistics, perform change analysis, map, and visualize the entire inventory of CDL data derived at 30m or .09 hectares resolution and show field level accuracy. The CDL is now a national level product, reproduced annually and publically disseminated just a few months upon completion of the growing season. The reported uses of CDL and CropScape in published peer-reviewed journals and literature were discussed.

The uses of CDL data have grown, where users leverage it for agricultural decision support and scientific research. And finally, perhaps the most successful use of CropScape and the CDL were related websites that have developed protocols whereby they either host CDL data or deliver it as part of web mapping services. That is the ultimate mash-up of technology and product success.

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Analytical and Policy Needs (APN)

Plenary Sessions

Plenary Session 3
Environmental Issues

Organizers: Johan Selenius, EUROSTAT and Eszter Horvath, UNSD
Chair: Eszter Horvath, UNSD

Agriculture and forests occupy close to 70 percent of Earth surface, fishery activities can be found on virtually any marine and terrestrial water body and farming uses 70 percent of water withdrawals. Because the food and agriculture sector heavily depend on natural resources (land, water, biodiversity and carbon and nitrogen cycles) in the production process, healthy ecosystems are a precondition for food security and livelihoods. Agricultural activities can cause both environmental harm and provide environmental benefits. If agriculture, forestry and fisheries are managed in a sustainable fashion, the sector can deliver ecosystem goods and services more than any other economic activity - while providing food and livelihoods - and thus, provide a tangible transition towards a green economy. However, a growing population demands a higher output from agriculture, a target that can hardly be met without great efficiency gains in the sector.

Agricultural policies for green economy in the context of sustainable development and poverty eradication should be guided by and in accordance with all the Rio Principles, Agenda 21 and the Johannesburg Plan of Implementation and contribute towards achieving relevant internationally agreed development goals, including the Millennium Development Goals.

Policy makers need to be able to analyse the situation to allow them to make the right decisions. This requires basic statistics and accounts that provide indications on how trends in agriculture impact on the environment. Often such analyses are summarized in agri-environmental indicators that bring together a set of coherent and consistent statistics and accounts complemented by estimates, models and other tools to give an overall picture of the situation.

The aim of the of Plenary Session 3 is to give an overview of (i) the latest developments in integrating environmental concerns in agricultural policies, and (ii) the work so far on international statistical standards, recommendations and frameworks that help identify the necessary agricultural and environment statistics and link environmental conditions and health of ecosystems to economic and other human activity.

Greening agriculture in the context of sustainable development and poverty eradication - (somebody from a Ministry of Agriculture or FAO)	The speaker should address changing agricultural policies related to on the one hand the growing need for food and sustained economic growth of the agricultural sector in conjunction with rural development; and on the other hand enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the functioning of the ecosystems, improving management of natural resources and enhancing sustainable production and consumption.
Frameworks for agro-environmental statistics in support of sustainable development	The speaker should address the integrated use of statistics, accounts and indicators and related frameworks for the analysis of agriculture-environment relationships. Moreover, these statistical issues should be addressed in the context of strengthening the the institutional environment and political motivation.

Speakers:

- Ademar Romeiro (Unicamp) "Agro-Environmental Indicators and the Challenge to Gauge Non-linear Paths of Ecosystems Degradation: a conceptual approach"
- Dale Andrew (OECD), Robert Mayo (FAO), Johan Selenius (Eurostat), "Frameworks for Agro-environmental Statistics in Support of Sustainable Development"[1]

Summary:

Greening agriculture in the context of sustainable development and poverty eradication" Ademar Romeiro (Unicamp). This presentation argued that the focus of agro-environmental indicators is too often on 'Pressure indicators' such as nutrients surplus (N balance and risk of P pollution) related to mineral fertilizers consumption indicator; pesticide risk indicator related to consumption of pesticides indicator; soil erosion related to soil cover indicator; ammonia and other greenhouse gases emissions; water abstraction; and intensification/extension. He would like to see here more emphasis on 'State indicators' to cover all the degradation problems of the agro-ecosystem resulting from environmental pressures resulting from the predominant agricultural practices'. He concludes that this situation is due to the difficulty in producing 'State indicators'. He proposed that in Brazil it would be feasible to build a simpler State indicator to take into account a changing agricultural landscape scenario towards a more or less resilient agro-ecosystem.

Frameworks for agro-environmental statistics in support of sustainable development", Dale Andrew (OECD), Robert Mayo (FAO), Johan Selenius (Eurostat). This joint presentation focused on the following themes: farming and the environment; Agri-environmental indicators (AEI): trends and recent developments: Limitations of AEI and improvements to come. Food and agriculture sector is heavily dependent on natural resources (land, water, biodiversity and carbon and nitrogen cycles) in the production process and healthy ecosystems are a precondition for food security and livelihoods. The notion that agricultural activities can cause both environmental harm and provide environmental benefits was highlighted. Recent developments in understanding some of the interactions between agriculture and the environment, such as the calculation of GHG's from Agriculture, was presented. The need to make sure that agro-environmental indicators are relevant to the policy issues that need monitoring or analysis was also stressed. The current problems of agro-environmental indicators such as: data developed to answer one particular problem or question; it being difficult to figure out if all the information is included and it is not easy to see the whole picture was discussed. The current work on FDES and SEEA/SEEA-AGRI as tools to help over-come some of the problems faced by agro-environmental indicators was highlighted.

Endnote

1 There is no paper related to this presentation.

Agro-Environmental Indicators and the Challenge to Gauge Non-linear Paths of Ecosystems Degradation: a conceptual approach

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A Necessary Pre-Analytical Vision

Resilience is one of the main ecosystems properties. A property that enables them to resist to negative impacts without losing their systemic integrity. Thanks to this property the impacts resulting from human interventions can partially be absorbed by the ecosystems which results in non-linear paths of degradation. So, this property translates into a service, the absorption capacity service. The conjoint absorption capacities of all ecosystems on earth are the most important ecosystem service offered by nature to human beings. Pollution occurs when the absorption capacity of the ecosystems is overloaded.

In this sense, understanding ecosystem dynamics is crucial for devising a set of environmental parameters and indicators. However this understanding effort can be time consuming and/or biased by wrong insights. In the case in point, the agro-ecosystems, after Liebig's discovery in many main-stream agronomical circles the soil came to be viewed as a simple nutrients reservoir, which could be substituted by chemical fertilizers. Based on such an "ecological model" of the soil, an environmental parameter like *soil losses tolerance* would have its meaning almost lost too, largely replaced by the fertilization cost.

As the soil science progressed, however, a more realistic view of the soil as a complex ecosystem has evolved. Based on this new vision soil erosion not only depletes its nutrients content but also threats other ecosystem services such as capacity of water storage, adequate mineral/organic structure favoring plant development, capacity of nutrients mobilization, prevention of fertilizers leaching/runoff, among others less known. So, an indicator such as the rate of soil erosion referred to the parameter soil losses tolerance would acquire new meanings. By the same token the parametric values for indicators like nitrogen or phosphorus surplus would have to be revised.

Other ecosystem services can be expected to be in offer by the adoption of complementary practices to the agro-ecological management of the soil, such as crop associations or crop rotations (which are temporal crop associations) which provide diseases/pest control services, and recovery/protection of natural vegetation areas as part of the agro-ecosystem which provide pollination, pest control and other services.

The key point is the vision of the agricultural production itself as an ecosystem service – the provision service, to be provided by a resilient agro-ecosystem. The farmer is a crucial part of this agro-ecosystem as he can manage it as to have a sustainable agricultural production in the very long run. The guiding rule for sustainable agro-ecosystems is the search for enhancing their biodiversity while keeping a high level of labor productivity. So, the share of the area under more or less sustainable agro-ecosystems in the utilized agricultural area – UAA would be a good agro-environmental indicator. In Europe different indicators based on good agricultural practices have been proposed but mostly not yet stemming from clearly defined agro-ecological models.

Agro-Environmental Indicators: a comparative analysis[1]

Biodiversity Indicator

High Nature Value (HNV) farmland is a new indicator still being developed in Europe, which is based upon clearly defined agro-ecological models. It is viewed as a key indicator for the assessment of the impact of policy interventions with respect to the preservation and enhancement of biodiversity, habitats and ecosystems dependent on agriculture and of traditional rural landscapes. Its concept refers to the causality between certain types of farming activity and corresponding environmental outcomes, including high levels of biodiversity, the presence of environmentally valuable habitats and species. The main indicator is the share of estimated HNV farmland in utilized agricultural area, which is relatively easy to have if its quality is not taken into account. The most important HNV is the low intensity cattle breeding on unimproved

vegetation. Considering that the pristine landscape has long ago disappeared, the share of the estimated HNV farmland is a goodbiodiversity indicator for the region.

In Brazil the scenario is altogether different. Although there exist some situations where traditional extensive cattle breeding on unimproved vegetation, as in Pantanal region, fits the HNV concept, for most of the country it contributes to land erosion and deforestation, so to biodiversity losses. Protecting and/or recovering biodiversity in the country means primarily protecting and/or recovering the *original* vegetation cover. In this respect there are clearly two broadly distinct situations: on one side the regions with vast areas still covered by the original vegetation, as the Amazon, where the agro-environmental policies should be aimed primarily at stopping the expansion of the agricultural frontier; on the other side, the regions where the original land cover has almost disappeared and should be recovered into a minimum of biodiversity resilience threshold as is mandated by the Forest Code.

Actually in this last case one find in many regions a situation where the forest recovering should be stimulated beyond the low limits established by the Forest Code. They are regions where the soils have been severely degraded by previous inadequate agricultural activities, the extensive cattle breeding being what was left as the only economic sound land using. In these regions, however, cattle breeding not only prevent forest recovery but also continue to degrade the soil as the grass cover in the existing conditions offer little protection against heavy tropical rains. Only natural forest offers enough protection beyond a certain slope degree. For intermediate ramp inclination levels forestry could offer a good soil protection. Cattle breeding could be sustainable, however, if based on improved grass cover in the more favorable areas of the region. So, it is possible to apply a HNV concept of a kind in these regions based on an agro-ecological model composed by tree different land covers: a natural and recovering forest in the more vulnerable areas, protected by a buffering forestry, followed by a more intensive but sustainable cattle breeding in the more favorable ones. This model could be labeled as “Forest and Milk”.

Pressure Indicators: Nutrients Excess

Inputs of nutrients to agricultural land across Europe are generally in excess of what is required by crops and grassland, resulting in nutrient surpluses, the nitrogen being the most problematic. The magnitude of these surpluses reflects their potential for detrimental impacts on the environment since they are available for gaseous loss to the atmosphere as ammonia, build-up in soil pools over time, or transport to the nearest receiving water body.

Excessive emissions of nutrients to freshwater cause eutrophication, characterized by the proliferation of algal blooms that are toxic, aesthetically unappealing and reduce the clarity of water, giving it the appearance of “green soup”, often accompanied by unpleasant smells. This proliferation is also associated with the loss of “desirable” plant and animal species. The process of dissolved oxygen concentrations fall can be compounded when the aquatic plant life dies, generating huge amounts of organic matter and further diminishing oxygen levels. Impacts of eutrophication on freshwater ecosystems are documented throughout Europe. However, excessive levels of nitrogen have greatest significance with respect to the eutrophication of estuarine and coastal waters, which remains widespread throughout Europe.

Toxic cyanobacteria associated with algal blooms pose a threat to public health. Direct skin contact with water containing these cyanotoxins, for example through freshwater and marine recreation, can cause allergic reactions similar to hay fever and asthma. Skin, eye and ear irritations can also occur, and ingestion of the toxins may result in gastrointestinal illness and liver damage. Cyanotoxins can also affect the nervous system. A recent assessment of European waters indicates that mass populations of bloom-, scum-, mat- and biofilm-forming cyanobacteria with cyanotoxin potential are relatively widespread and occur in water resources used for drinking water supply, aquaculture, recreation and tourism and moreover, health incidents involving cyanotoxins have been reported in some European countries. While excessive nutrient levels are strongly linked to cyanobacteria blooms, understanding of the impact of human activities on their occurrence remains incomplete. Municipal drinking water supply systems supply treated water under quality controlled conditions ensuring that nitrate concentrations do not exceed the threshold. However, in some rural areas of Europe, drinking water is taken from wells and consumed without purification. Excessive levels of nitrate in groundwater in the vicinity of such wells could, therefore, pose a threat to public health.

As for ammonia emissions (a harmful greenhouse gas), in 2010 the EU-27 agricultural sector was

responsible for 94 % of total emissions across the region. The ammonia emissions mainly occur as a result of volatilization from livestock excreta. A smaller fraction of NH_3 emissions result from the volatilization of NH_3 from nitrogenous fertilizers and from fertilized crops. So the production of NH_3 is closely related to livestock production levels. However, the amount of emissions by livestock is a function of many variables, such as the properties of the animal manure, the animal type, the manure management system, the soil properties, and the method of application of manure into agricultural land. The magnitude of NH_3 emissions that occur as a result of the application of mineral nitrogenous fertilizers will similarly depend on many factors such as the type of fertilizer used, meteorological conditions and the time of fertilizer application in relation to the stage of crop canopy, the soil type and pH. Ammonia emissions emitted from the foliage of growing fertilized plants are generally related to the level of nitrogen fertilizer applied. However, NH_3 emissions from decomposing plants are uncertain, and are difficult to calculate due to the variable emissions that occur from this source.

Since 1990, however, following the general trend of nutrients surpluses reduction, these emissions have decreased by 30 %. Besides the reduction in livestock numbers, the decrease in emissions was mainly due to a change in agricultural practices aiming at a better management of organic manures and at a decreasing in the use of nitrogenous fertilizers. Regarding the former, specifically, manure spreading by broadcasting on the soil surface has been phased out, and has instead been replaced by application of slurries by injection or band spreading and rapid incorporation of manure into the soil. However, the side effect of this measure can be to increase the amount of mineral nitrogen retained in the soil that, under anaerobic conditions, could be emitted as N_2O. Incorporation of manure can also lead to increased nitrate leaching and subsequent pollution of water resources.

In Brazil most of meat production comes from extensive cattle breeding. In some regions, however, where poultry and pig production concentrates there are similar problems but the environmental concern is direct rather toward water pollution. The case of Ariranha Valley in the State of Santa Catarina is representative. There the river has been polluted by nitrates run off due to incorrect manure spreading on the soil: too much manure per hectare. The reason for that is the cost of manure spreading. The producers are being pressed by the authorities to find a solution for their "ecological footprint". That could be achieved either by enlarging the manure spreading area or by reducing the manure content in nitrogen. The last one has proved to be the less expensive; different techniques of composting have been tried to this aim[2].

As for the nitrogenous fertilizers, a technological breakthrough on atmospheric nitrogen fixation more than two decades ago has enormously reduced its use in the main crops. Technologies of atmospheric nitrogen fixation and zero tillage practices, developed and/or improved in the country, are agricultural practices that manage the agro-ecosystem as to benefit from ecosystem services: nonvolatile N, leaching retention and erosion resistance, among others services that are provided by soils agro-ecologically managed. So, just the share of the crops based on these agro-ecologically integrated technologies in the total of UAA (utilized agricultural area) would be an adequate agro-environmental indicator for nitrogen associate environmental problems.

After the Nitrogen, the risk of Phosphorus (P) leaching/run-off follows as a matter of concern. However, the phosphorus cycle is very different from the Nitrogen cycle. Depending on the soil P capacity, excessive P can be stored in the soil. Not all of P in fertilizers and manure are directly available to the plant, a part is converted from active P (active P pool is the main source of available P for crops) to fixed P (The fixed P pool of phosphate will contain inorganic phosphate compounds that are very insoluble and organic compounds that are resistant to mineralization by microorganisms in the soil. Phosphate in this pool may remain in soils for years without being made available to plants and may have very little impact on the fertility of a soil). Depleting the active pool through crop uptake may cause some of the fixed P to slowly become active. The storage capacity of the soil is however depending on soil characteristics like soil texture. However, an important aspect of the ability of a soil to hold phosphate is that a soil cannot hold increasing amounts of phosphate in the solid phase without also increasing soil solution phosphate.

In turn, increased amounts of phosphate in solution will potentially cause more phosphate to be lost to water running over the soil surface or leaching through the soil. Loading soils with very high levels of phosphate will generally not hurt crops but may result in increased phosphate movement to nearby bodies of water. It has been estimated that 25 % or less of P applied annually is actually taken up by the growing crop, the remaining 75 % becomes bond

in the soil profile or is lost to the water. The crop uptake of P is in sharp contrast to the crop use of N and K fertilizers, where the recovery in the season of application can be as high as 80 %. Yield and therefore the uptake of P by crops is not only determined by inputs but also by uncontrollable factors like climate.

So, the estimated P surplus represents the potential risks to water and soil. However, the actual P loss from agricultural land to surface waters is a complex function of climate, topography, soil type, soil P status, P fertilization, and land management. These factors vary greatly in space and over the year, and the hydrological pathways for P losses also vary greatly in space and time. The effects of these individual factors on P loss from agricultural land to surface waters are rather well understood, but in combination the understanding is less well developed. As a consequence, current simulation models do not simulate the actual P loss from agricultural land to surface waters very accurately yet. Further, the ecological effect of P from agricultural land in surface waters depends on the 'bio-availability' of the P. A significant fraction of the P from agricultural land that is lost to surface waters is particulate P and the availability of this P to growing organisms in surface waters is much less than dissolved reactive P, at least in the short term. Hence, "the pollution effect" of P lost from agricultural land to surface waters does not depend on the total P loss but on the fraction 'reactive P'.

To sum up, the accumulated amount of P represents a larger actual risk for the environment than the amount of P which is applied yearly, or the surplus on today's balance. However, the future risk is strongly influenced by the P balance of today and the near future, in combination with the capacity of a soil to bind P. This contrasts with nitrogen, for which the cumulative N balance of the past is much less relevant since N hardly accumulates in soils. This is why the main indicator – the estimated P surplus, on its own is not sufficient to indicate areas at risk of phosphorus pollution. For these reasons the results of this indicator should be interpreted in relation to a sub-indicator still to be developed - an alternative could be to resort to modeling.

Currently only limited data are available, for instance, on mapping the capacity of the soil to retain phosphorus by sorption and by resistance to erosion. 'Sorption of P' in the soil is defined in the study as a process whereby readily soluble phosphate is changed to less soluble forms by reacting with inorganic or organic compound of the soil so that P becomes immobilized. So the level of P-Sorption combined with the erosion risk of a soil translates into an indicator - 'P-sensitivity', of potential phosphorus pollution. Its level will depend on the soil type/slop and conditions and the agricultural practices which, in turn, influence soil conditions.

In Brazil the diffusion of zero tillage practices in the main crops, the most phosphorus demanding crops, have contributed for reducing the risk of P pollution. Also the fertilizers cost contributed to a change in fertilization practices which, in the Cerrado region, consisted in loading the soils with very high levels of phosphorus as to saturate the high cations exchange capacity typical of the soils there, which strongly bind P. Advanced scientific research in the role of mycorrhiza in plant nutrition has raised hope in the development of engineered mycorrhiza able to make important amounts of immobilized phosphorus available for the plants. Independently, however, of having engineered mycorrhiza a living soil careful managed usually has a high level of enzymatic activity as so to provide the ecosystem service of nutrient mobilization, including a macro nutrient such as P, which is usually found strongly immobilized in the soil.

Pressure Indicators: Pesticides Pollution

The intense use of pesticides in agricultural production is emblematic of what is considered environmentally wrong with modern agricultural practices. It can have negative environmental impacts on water quality, terrestrial and aquatic biodiversity (persistence and toxic effects on non-target species, etc.). Pesticide residues in food can also pose a risk for human health. In EU the pesticides use has more or less stabilized and many residues in excess of the established maximum residue limits (MRLs) observed during the annual monitoring activities are ascribed to pesticides used during production of food imported from outside the EU. The risks of pesticide use to the environment vary considerably from one pesticide to another, depending on the intrinsic characteristics of their active ingredients (toxicity, persistence, etc.) and use patterns (applied volumes, application period and method, crop and soil type, etc.). However, most of statistics on these factors are not available yet, some of them probably will not be available for long.

Statistically what is readily available is the amount of total active ingredient. As pesticide indicator it does provide a broad indication of loading, but it overlooks factors governing pesticide fate – decaying into another substances (some often more harmful), which are often key parameters for determining long-term

environmental impact. In Brazil, the second largest pesticide market in the world, an experiment[3] designed to follow the decaying pattern of the active ingredients of two pesticides much in use in sugar cane crops in the State. It has shown decaying patterns which explain why the expected residues were not found by the State agency in charge of pollution control.

Contamination of the environment from pesticides may result from spray drift, volatilization, surface run-off, and subsurface loss via leaching/drain flow. Pesticide fate (and hence environmental risk) is primarily governed by vapor pressure, sorption characteristics, solubility in water, and environmental persistence. Vapor pressure governs the tendency for pesticides to volatilize and be lost to the atmosphere in gaseous form, while sorption properties govern bonding to organic and inorganic soil surfaces. Sorption properties limit the mobility of pesticides in the environment, and are influenced by factors including soil organic matter, clay content, and soil pH. Pesticides with greater water solubility often have lower sorption behavior, which makes them more mobile in the environment and hence more prone to leaching to water bodies.

The persistence of pesticides in the environment differs greatly and is dependent on factors such as their susceptibility to attack by micro-organisms and enzymes, soil temperature and water content. So, there is no absolute relationship between the loading of active ingredients and the potential threat to the environment and human and animal health. Indicators of the intensity of pesticide use, however, are a necessary step towards risk evaluation, despite the fact that total active ingredient values also do not discriminate between pesticides with transitory effects and those with characteristically longer residence times in the environment which may pose a greater risk to environmental and ecological quality objectives.

In Brazil integrated pest control methods are in use in some of the main crops of the country, where some agro-ecological practices are adopted as to minimize the use of pesticides. It is worth notice the development of a very effective method for controlling a worm that is very damaging for soya beans crops. The method is based upon the spreading of what is popularly called a "worm juice", made of naturally virus infected worms. Also an agro-ecological technique such as crop rotations is considered as very effective in controlling nematodes infestations. However, the amount of total active ingredient in use per hectare/year is still very high for most of the main crops.

Soil Erosion

Approximately 15 % of the EU territory is estimated to be affected by a significant soil erosion rate (moderate – high level or more than 5 tons per ha per year), especially in southern countries. It has cost an enormous amount of money to the countries. On-site effects of water soil are particularly important on agricultural areas resulting in a reduction of cultivable soil depth and a decline in soil fertility. The loss of soil productivity following erosion may be significant. Topsoil, which is the most fertile layer of the soil, is the most exposed to erosion; also the mechanisms of soil erosion preferentially remove soil organic matter, clay, and fine silt material. Soil erosion also reduces the volume of soil available for plants roots and degrades soil physical properties (such as water holding capacity). Off- site effects of soil water erosion arise from sedimentation, which causes infrastructure burial, changes in watercourses shape and obstruction of drainage networks enhancing the risk of flooding and shortening the life of reservoirs. Many irrigation or hydroelectricity projects have been damaged by soil water erosion.

There has been much discussion in the literature about thresholds above which soil erosion should be regarded as a serious problem. This has given rise to the concept of "tolerable" rates of soil erosion that should be based on reliable estimates of natural rates of soil formation. In general, losses above 1 tons per hectare per year are generally considered as irreversible. But erosion not only threats to deplete a non-renewable natural resource, but also damage soil functions which are responsible for many ecosystem services as described above.

However, it is impractical and technically difficult to measure soil loss across whole landscapes and thus research is urgently needed to improve methods of estimating soil erosion using modeling, upon which mitigation can be implemented. A wide variety of models are available for soil water erosion estimation. The selection of a model depends mainly on the purpose for which it is intended and the available dataset. Some models are designed to predict soil erosion from single storms while others predict long-term effects. Models such as the Universal Soil Loss Equation and derived versions are developed to predict only sheet and rill soil erosion and do not take into account other processes like gully erosion.

Two soil erosion indicators have been produced on the basis of empirical computer model. The main indicator represents estimated soil erosion levels for

territorial units; the second indicator is a cell-based map that estimates the rate of soil erosion by water in Europe in tons per hectare per year for cells of 1 km x 1 km for the EU.

These indicators are derived from an enhanced version of the Revised Universal Soil Loss Equation (RUSLE) model. The model was developed primarily to guide conservation planning, inventory erosion rates and estimate sediment delivery on the basis of accepted scientific knowledge and technical judgment. Due to the scale of the input data it offers an overview of the soil erosion susceptibility in the landscape rather than a real estimation for a specific location. In this assessment, the basic RUSLE model has been adapted through the addition of a new factor that improves the estimation of the effect of stoniness on soil erosion.

The revised version of the RUSLE is an empirical model that calculates soil loss due to sheet and rill erosion. The model considers seven main factors controlling soil erosion: the erosivity of the eroding agents (water), the erodibility of the soil, the slope steepness and the slope length of the land, the land cover, the stoniness and the human practices designed to control erosion.

The model estimates erosion by means of an empirical equation: Er = R K L S C St P Where:

Er = (annual) soil loss (tons per hectare per year)
R = rainfall erosivity factor
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = cover management factor
St = stoniness correction factor
P = human practices aimed at erosion control

Among the limitations of this model are the lack of high-resolution pan-Europe environmental datasets, the non-linearity present within the climatic-based ensemble model and the underlying principles of the RUSLE model that considers only some categories of soil erosion. There are also great difficulties in gathering enough information to drive an adequate validation of the model results, but this aspect applies to the output from any large area erosion-prediction model. The validation of erosion estimates at continental scale is not technically and financially feasible. One validation option is through the upscaling of local monitoring studies of large-scale modeling assessments. However, the RUSLE model has been used due to its flexibility in relation to input data requirements and despite its limitations it is a scientifically valid method that renders operationally feasible a systematic follow up of an important land degradation factor.

In tropical countries soil erosion represents a much worse environmental problem as the heavy tropical rains translates into a very high value for the parameter R (rainfall erosivity factor) of the equation. In many tropical regions the top soil, the fertile one on which agricultural production depends, has vanished. In most there is a risk of suffering the same fate. In Brazil historically severe soil erosion has depleted large agricultural areas. Erosion rates up to 100 tons of soil per hectare/year have been registered. The growing awareness of the problem, followed by the spread of soil conservation practices, especially the diffusion of zero tillage practices, has mitigated the problem that remains however a serious one.

As for the assessment of the problem, the main agricultural research institutions have performed experiments designed to accurately measure erosion rates for different types of soil and in different conditions. The knowledge they provide enables the experts to make fairly accurate erosion estimates for the main agricultural regions of the country. Nevertheless, such estimates cannot provide an adequate basis for a systematic and regular set of erosion indicators regionally and/or cultures focused.

This knowledge however does provide the means for the use of a predicting model based on an adapted USLE such as that that has been developed by the Agronomical Institute of Campinas – IAC. In addition, and differently from the EU case where each country has its own specific information gathering system, in Brazil national institutions as EMBRAPA (Brazilian Enterprise of Agricultural Research) and IBGE (Brazilian Institute of Geography and Statistics) could provide the necessary information. In especial, it can be relatively easy to overcome the difficulties concerning the systematic information gathering about the C and the P parameters as well as to organize regional model validation panels as IBGE has a long tradition and a very good networking structure for gathering agricultural information at municipal level.

Final Remarks

In EU dozens of agro-environmental indicators are in use and/or being developed. There are pressure indicators such as nutrients surplus (N balance and risk of P pollution) related to mineral fertilizers

consumption indicator; pesticide risk indicator related to consumption of pesticides indicator; soil erosion related to soil cover indicator; ammonia and other greenhouse gases emissions; water abstraction; and intensification/extensification.

However, there are not enough state indicators for as to cover all the degradation problems of the agro-ecosystem resulting from environmental pressures resulting from the predominant agricultural practices due to the difficulties (and cost) to produce the information for that. Nonlinear degradation paths explain much of these difficulties to have accurate degradation indicators.

There are state indicators of environmentally sound agricultural/livestock patterns and practices such as high nature value farmlands (HNV), specialization, livestock patterns and tillage practices. There is also a committing indicator that indicates the share of agricultural area enrolled in agro-environmental measures in the UAA (utilized agricultural area).

There also general landscape state indicators like cropping patterns (the respective shares of arable land, permanent grassland and land under permanent crops in the UAA), and landscape state and diversity.

This last one more or less encompasses the other state indicators. It assumes that farmers play a crucial role in transforming, managing and maintaining landscapes. It has three components, each describing a very different aspect of the agrarian landscape:

- the physical structure of the agricultural landscape, intended as land cover and its spatial organization as a product of land management;
- the hemeroby state as a proxy for the influence exerted by farming practices on land cover and state;
- the societal awareness of the landscape, as the society perceives, assesses and values landscape quality, plans, manages, and uses the landscape for productive or non-productive purposes.

Monitoring these three components will indicate if the trend in landscape structure leads to a higher homogeneity or diversity; how trends in farming practices influence the hemeroby index; if society is becoming more aware of the services the agrarian landscape provides.

Clearly the structure of this composed indicator reflects a pre-analytical vision that sees the agricultural production in a broader ecosystem context where biodiversity is the key value, implicitly seen as a proxy for ecosystem resilience.

In Brazil it would be feasible to build a simpler state indicator, a kind of an improved committing indicator, to taken into account a changing agricultural landscape scenario towards a more or less resilient agro-ecosystem. Instead of a committing indicator that monitor just changes in the share of agricultural area enrolled in agro-environmental measures in the UAA, it would monitor the respective shares the agricultural area under different agro-ecosystem models, which would be ranked accordingly to different resilience levels. The agro-environmental measures adopted would be evaluated accordingly to agro-ecological models.

Endnotes

1 Main sources: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Category:Environment and Projeto EcoAgri. Bases para o Desenvolvimento Sustentável da Agricultura em São Paulo. Projeto Temático FAPESP, 2003-2007.

2 ROMEIRO, Ademar Ribeiro ; MAIA, Alexandre Gori ; JUSTO, Manoel Carlos Duarte de Mello. Uma proposta de gestão econômico-ecológica à agroindústria suinícola do oeste catarinense. Revista de Política Agrícola, v. 3, p. 108-118, 2011.

3 See Projeto EcoAgri. Op.cit.

Plenary Session 4

Rural Development in the 21st Century: Policy Options and Data Gaps

Organizer: Gero Carletto, The World Bank and Flavio Bolliger, IBGE

Chair: Gero Carletto, The World Bank

More than a decade of publication of the "State of Food Insecurity in the World" and two international Symposia hosted by FAO (in 2002 and in 2012) have made it clear that the international community still lacks adequate means to comprehensively, timely and effectively monitor the various manifestation of Food Insecurity.

As the new Post-2015 Development Agenda is being shaped, it is clear that Food and Nutrition Security will take centre stage as one of the fundamental goals to be pursued. The need to reach agreement on reference methods and data to monitor food and nutrition security is thus extremely pressing for the international community.

This session aims at presenting the state-of-the-art in terms of food security and nutrition statistical assessment, to distil a set of best practice to be applied to the task of monitoring the phenomenon and evaluating the impact of policies.

Possible topics for papers include:

- What is Food Security? From conceptual frameworks to operational definitions.
- Monitoring multidimensional phenomena. Scorecards and indexes of food security.
- Food Security Experience Scales vs. Food Consumption scores.
- Measuring nutritional adequacy at the household and at the aggregate level.
- Impact of macroeconomic shocks on food security: how to combine the right model with the proper data.

Speakers:

- Mary Bohman (ERS/USDA), "Rural Development Policy Issues and Data Needs"
- Pietro Gennari (FAO), "Rural Statistics: current gaps and improvement perspectives"
- William Martin (The World Bank and International Association of Agricultural Economists), "Agricultural Statistics for Development"
- Maximo Torero (IFPRI), "Rural Development in the 21st Century: policy options and data gaps"

Summary:

The presentations from the panellists highlighted the key challenges and best practices in collecting rural data and in using them for policy analysis. Each panellist focused on his/her particular areas of interest/expertise to analyze what has worked and what has not.

After describing some recent not so successful efforts in producing international rural statistics, Pietro Gennari tried to identify the reasons why rural statistics, despite being so important, currently are not regularly produced even in developed statistical systems. In order to address this situation he outlined an international agenda to improve rural statistics and its links with the Global Strategy. He then concluded providing some technical proposals to increase the availability of rural data which will be studied by the GS research program (i.e. including rural area as a planned domain in the sampling design in order to produce separate estimates; increasing the sample size of rural areas; producing direct estimates as averages of multiannual data; collecting integrated data through multipurpose surveys; applying small area estimation techniques using auxiliary variables from administrative sources; integrating ex-post different domain-specific surveys through imputation or a model-based approach).

Will Martin discussed the emerging policy issues and data needs on rural areas from an economist perspective (price data, statistics on sources of income, urbanization and the changing concept of rurality, etc.). He also suggested that the International Association of Agricultural Economists and the ISI Committee on Agricultural Statistics strengthen their collaboration and become partners in producing and analyzing policy-relevant data on agriculture and rural development.

Maximo Torero presented two IFPRI initiatives which link local market information and price data to the social and economic status of households.

Mary Bohman presented the US experience in using rural data and the lessons that can be relevant to countries at different levels of development. She also discussed what have been and continue being some of the key data challenges in countries like the US, and how can the diffusion of technology to survey operations can help with this problem.

The panellists agreed that one thing that can be done in the short-term to obtain additional information on the urban-rural divide, is to re-process available survey data and to use model-based approaches. Moreover, they concurred that some of the technical proposals to improve rural statistics in the longer term, especially improving the design of multipurpose integrated surveys, will need to be pursued in the context of the research programme of the GS. An important action, as a prerequisite for the availability of international comparable data, would be to reach a consensus within the context of the UN Statistical Commission on the international definition of rural areas.

Lastly, the International Association of Agricultural Economists and the ISI Committee on Agricultural Statistics will organize a joint conference in Milan in 2015 on the methodology for measuring the impact of statistics on policy/decision making.

Plenary Session 5

Food Security: Food Insecurity in the New Development Agenda: global assessment of local inequalities

Organizer: Carlo Cafiero, FAO/ESS

Are our statistical systems ready to help our policymakers address the rural development challenges of the 21st century? Climatic change and soil erosion are rapidly changing the agro-ecological environments within which the rural population operates but, at the local level, information on these and other phenomena remains largely missing, or not fully integrated with the existing data systems. Rural and urban populations alike are facing higher and more volatile food prices but, as painfully evident during the last food crises, the existing systems remain highly inadequate to timely and accurately monitor their evolution and consequences and how policies can mitigate some of the negative effects by improving the resilience of the rural poor. Rural incomes are increasingly diversified beyond agriculture but statistical systems, as well as local and international institutions, continue to have primarily a sectoral approach. Furthermore, the unrelenting and inevitable urbanization, and the resulting demographic changes in rural areas, call for a better understanding of the rural-urban flows of factors, goods and people and of the resulting transformation in terms of market demand, farm structure and distribution of resources, including land. These are just a few examples of the dramatic transformation unfolding in rural areas across the globe. They transcend agriculture and a sectoral view of the issues. Informing our future policies requires new institutional frameworks, tools and methodologies that enable analysts to capture and analyze the increasing complexity and interrelatedness of rural development, in order to monitor production capacity and the environmental sustainability of current and future policies. By recognizing many of the constraints that plague the current statistical systems, the Global Strategy to Improve Agricultural and Rural Statistics already takes a bold approach by proposing a paradigm shift in the way we collect and use agricultural statistics. Implementing it remains a challenge nonetheless. In this plenary session, some of the leading rural development specialists will debate the most pressing issues rural development faces and identify the key data gaps and missing tools so as to enhance data producers' awareness and ability to generate better statistical data to inform policy-making. The panel will be followed by an open floor discussion during which participants will be able to put forth their views and elicit responses from the panelists.

Speakers:

- Mark Nord (USDA/ERS), "Lessons from 15 Years of Monitoring Household Food Security in the United States: extension to low-income countries"
- Joachim De Weerdt (EDI), "Measuring Hunger through Household Consumption and Expenditure Surveys"
- Carlo Cafiero (FAO), "Global Monitoring of Food Insecurity in a Policy Relevant Manner: debunking myths and presenting hopes. Lessons from 40+ years of experience at FAO"

Technical Sessions

APN 1
Environmental Issues

Organizers: Eszter Horvath, UNSD and Johan Selenius, EUROSTAT

Chair: Johan Selenius, EUROSTAT

This session will focus on statistical and institutional dimensions for integrated agri-environmental statistics following the presentations in the APN plenary session. Moreover, the presentations will reflects on the various stages of statistical development in developed and developing countries. It will cover basic agricultural and environment statistics that feed into the analysis of agriculture-environment relationships and related frameworks through the compilation of agri-environmental indicators. This integrated analysis is to be facilitated with the application of the System of Environmental-Economic Accounts (SEEA), the accounting framework for linking agri-economic activity and other human activity with the environment.

Papers:

- Maurice Juma Ogada, Wilfred Nyangena (Kenya), "Technical Efficiency of Kenya's Smallholder Food Crop Farmers: do environmental factors matter?"
- Adrian Leip, Wolfgang Britz, Claudia Bulgheroni et al. (Italy), "CAPRI: a spatial assessment tool for agri-environmental indicators in the EU"
- Robert Mayo, Carl Obst (FAO), Gary Jones (IMF), "Application of the System of Environmental Economic Accounting (SEEA) Central Framework and SEEA Experimental Ecosystems Accounting at FAO: preliminary findings and ongoing work"

Agricultural Statistics Relevant to the Environment	Work related to improving the usefulness of "traditional" agricultural statistics for environmental analyses.
Environment statistics related to agriculture	Work related to statistics on various topics, such as land use and –cover, water use, energy use, air emissions, wastewater and waste, nutrient balances, biodiversity, natural disasters and extreme events.
Sustainable Production and Consumption	Work related to farm management practices, farming systems, organic and integrated production, etc.
Agri-environmental indicators	Work related to indicators by various themes farm management, nutrient use, pesticide use, water use, soil quality, water quality, land cover, use and conservation, greenhouse gas emissions, biodiversity, landscape, wildlife habitats.
Accounting Framework (development of System of Environmental Economic Accounts for Agriculture and Rural Development (SEEA Agri, update of SEEA Forestry and update of SEEA Fisheries)	Work related to the development and proposed update of integrated presentations of input-output tables and asset and functional accounts in the SEEA related to agriculture, forestry and fisheries to further the coherence of agri-environmental statistics and indicators using common concepts definitions and classifications.

Technical Efficiency of Kenya's Smallholder Food Crop Farmers: do environmental factors matter?

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Abstract

Smallholder agriculture dominates Kenya's agricultural landscape, accounting for 75% of total agricultural output and 70% of the marketed agricultural produce. They produce 70% of the maize, 65% of the coffee, 50% of the tea, 80% of the milk, 85% of the fish and 70% of the beef. As a result, the government of Kenya, with the support of development partners, has invested in production and dissemination of productivity-enhancing technologies such as high-yielding varieties and inorganic fertilizers. Adoption of these technologies has remarkably improved especially in the maize sub-sector. However, productivity has been declining or, at best, stagnating. Productivity is attributable to not only technological improvements but also technical efficiency. Consequently, this study sought to determine the technical efficiency of the country's smallholder food crop farmers.

The study used a two-stage non-parametric approach on household panel data to estimate the efficiency levels of the smallholders and establish the sources of its variation across households. Controlling for endogeneity and incorporating Geographic Information System-derived measures of environmental factors in the analysis, the study finds that technical efficiency differentials are influenced by environmental factors, production risks and farmer characteristics. The policy implication is that the country has room to improve agricultural productivity by addressing environmental and farm-level constraints. Viable options include switching from rain-fed to irrigated agriculture, entrenching land tenure security, improving transport network among farm communities and setting up smallholder credit schemes.

Keywords: farm efficiency; non-parametric approach; Kenya.

1. Introduction

Kenya's smallholders have impressively improved maize varieties and inorganic fertilizer (Olwande, Sikei and Mathenge, 2009; and Republic of Kenya, 2011). However, yields have either stagnated or declined (Karanja, Renkow and Crawford, 2003; Republic of Kenya, 2007; Gitau et al., 2008; Pelrine, 2009). While technical change is important in influencing productivity, the efficiency with which it is executed is even more important (Lovell, 2003). Consequently, this paper sought to measure the technical efficiency (TE) of the smallholders and to establish the factors that explain its variation across households. Unlike the previous studies in Kenya which have analysed technical efficiency based on a single crop output (see Kirimi and Swinton, 2004; Kibaara, 2005; and Nyagaka et al., 2010), this study considered multiple outputs because smallholders are mainly mixed croppers whose efficiency could be underestimated through single crop approach.

2. Brief Literature Review

There are two approaches to estimation of TE: Parametric and non-parametric. Parametric approach decomposes deviations from the frontier into the statistical noise and farm/firm-specific inefficiency whereas non-parametric approach assumes that all the deviations from the frontier are due to the farm/firm's inefficiency (see Battese and Coelli, 1992; Coelli, Rao and Battese, 1998). Results of the two approaches, however, do not differ significantly (Abdourmane, Bravo-Ureta and Teodoro, 2001; Coelli, Sandura and Colin, 2002). However, if the functional form of the production technology is clearly known, parametric analysis performs better than non-parametric analysis. The reverse is true when the knowledge about the underlying technology is weak (Banker *et al.*, 1985; Gong and Sickles, 1992; Sharam *et al.*, 1999). Because the functional form of the production function of the smallholders is not likely to be clearly understood, this study used Data Envelopment Analysis (DEA), a non-parametric approach.

Broadly, factors that influence farmer efficiency may be summarized into agent and structural (Van Passel *et al.*, 2006). Agent factors are those associated with the farm manager such as education level, age and social capital. Structural factors are either on-farm (e.g. farm location, farm type, farm size, fertility and drainage) or off-farm such as policy, infrastructure and upstream and downstream relations. Brazdik (2006) groups these factors into three broad categories: farm-specific variables (intensity of inputs like labour, fertilizers and seeds; farm size; organizational structure such as tenure; crop variety), economic factors (prices of inputs), and environmental factors (wet-dry period, village). Most studies have examined the influence of farm-specific and economic factors on farm efficiency. Environmental factors, however, remain less explored. Controlling for these factors in analysis of sources of technical efficiency of smallholders improves precision of the results (Sherlund, Barret and Adesina, 2002). This study bridges this gap.

3. Methodology

The study used a 2-stage DEA. DEA constructs a convex hull around the observed data points in a non-parametric manner (Fare, Grosskopf and Lovell, 1994). The technically efficient units lie on the frontier while the relatively less efficient ones lie below the frontier. Thus, the distance to the frontier measures the inefficiency level of a given unit. The study used the DEAP Version 2.1 for panel data (Coelli, 1996). The programme computes total factor productivity (TFP) change, technical efficiency change, and scale efficiency change. TFP, often called the Solow residual, is part of the output that is not explained by the quantity of inputs used. Rather, it arises from efficiency and intensity with which the inputs are utilized. TFP change is the increase or decline of output relative to a given level of inputs. It has two sources, technological change (innovation) and technical efficiency change. Notice that technological change implies that output change is attributed to change in production technology and technical efficiency change implies that output changes because of changes in management practices as all inputs and the technology remain unchanged.

The second stage was meant to explore the relationship between farm-level technical efficiency and other variables that were likely to influence it. Some of these factors were neither inputs nor outputs of the production process but rather conditions encountered by the farm decision makers such as weather, input prices or farm-level characteristics. The stage was not only meant to identify the explanatory variables but also to verify the consistency of the DEA results (Cooper, 1999). Random Effect (RE) Tobit was used in this second stage.

4. Data

The data used for this study were drawn from the Tegemeo household survey panel data for 2004 and 2007. The data were collected during a collaborative study between the Tegemeo Institute of Egerton University, Kenya, and Michigan State University (MSU) of the United States with funding from the United States Agency for International Development (USAID)-Kenya. Output variables were maize and other crops planted with it on the same piece of land. The other crops were beans, vegetables and fruits although most households planted beans. All the outputs were measured in kilogrammes per acre. Inputs were the seed quantities (kilogrammes) per acre, labour measured in man-days per acre and fertilizer quantities measured in kilogrammes per acre.

5. Results and Discussion

Summary of the results is shown in Table 1. Among the indicators included are: Mean SE for the individual years, mean TE scores for the individual years and what they would have been relative to technologies in the comparator years, and TFP growth between the years and the various sources of this growth.

Table 1: DEA results for the smallholder food crop farmers in Kenya.

Year	CRS TE relative to 2004 technology	CRS TE relative to 2007 technology	SE	VRS TE
2004	0.29	0.24	0.58	0.62
2007	0.44	0.27	0.56	0.59
Productivity Changes				
Mean effch	**Mean techch**	**Mean pech**	**Mean sech**	**Mean tfpch**
0.970	1.425	0.912	1.063	1.382

effch = technical efficiency change (catch-up); techch = technological change (innovation);
pech = pure technical efficiency change; sech = scale efficiency change; tfpch = malmquist total factor productivity change

On average, SE was 58 per cent and 56 per cent for 2004 and 2007, respectively. Scale inefficiency was, therefore, an important source of farm inefficiency among the smallholders. The results also showed that, between 2004 and 2007, TE dropped from 62 per cent to 59 per cent. Notice that TE change arises from two components: pure technical efficiency change and scale efficiency change. Because scale efficiency improved by 6.3 per cent, the drop in technical efficiency was largely attributable to pure technical efficiency change which dropped by 8.8 per cent in the same period. TFP and technological progress (innovation) improved by 38.2 per cent and 42.5 per cent, respectively. This implied that TFP growth between 2004 and 2007 was largely due to adoption of improved technologies and environmental factors rather than improvement in TE of the smallholders. This was consistent with mean CRS TE of the 2007 technology relative to the 2004 technology. These estimates were higher than what Kibaara (2005) found for smallholder maize farmers but lower than what Nyagaka *et al.* (2010) found for smallholder potato producers in Kenya. Nevertheless, the smallholders were still less technically efficient. For instance, the 2004 output could still have been produced even if inputs were reduced by 38 per cent while the 2007 output could still have been produced even if inputs were reduced by 41 per cent.

Farmer characteristics (age, credit, amount of crop income, social capital, use of hired and child labour, intensity of manure use, level of adoption of improved inputs, and credit access), production risk (expected yield) and production environment (crop farm size, annual rainfall amount, mean annual temperature, water-retaining capacity of the soil, land tenure security, and proximity to market and access road) affected technical efficiency of the smallholder food crop farmers in Kenya.

The results of the quadratic terms showed that farmer experience (as measured by the age of the farmer), annual rainfall amount and the plot size managed by the farmer had curvilinear effects on the TE of the smallholder food crop farmers. For each additional year of farming experience, the TE-Farmer age slope decreased by 0.0001. While the initial rise of TE with age could be attributed to experience in farming, the reversal could be attributed to the unwillingness of the older farmers to embrace technological change (Parikh, Farman and Shah, 1995). The optimal farmer age was computed at 40 years. This is consistent with Liu and Zhuang (2000) and O'Neill, Leavy and Mathews (2001). Liu and Zhuang (2000) noted that the direct relationship between technical efficiency and farmer age would reverse among the Chinese farmers once the farmer attained 40 years while O'Neill, Leavy and Mathews (2001) noted the turning point to be 49 years among the UK farmers.

The slope of TE-annual rainfall amount curve decreased by 0.00000119 for every additional mm of annual rainfall amount while TE-plot size slope decreased by 0.001 with every extra acre of land that the smallholders brought under crop cultivation. Optimal landholding size was found to be 30 acres which indeed is beyond the range currently defined as smallholding. The initial positive relationship between plot size and TE can be attributed to economies of scale such as ability to fully utilize household labour or to absorb bulky output-enhancing inputs and opportunity to apply mechanized production (Ray, 1998; Wadud and White, 2000) while the negative relationship that sets in later is attributable to diseconomies of scale such as complexities involved in the management or over-stretching of the household resources. Interpretation of the rest of the results was based on average marginal effects (Table 2).

On average, the effect of age on the TE of the smallholders was found to be weak and negative. One more year of farming experience reduced the TE of the farmer by about 0.1 per cent. This could be attributed to the unwillingness of older and more experienced farmers to accept new and more efficient production techniques (Parikh, Farman and Shah, 1995).

Households which accessed credit were associated with lower TE than those which did not seek credit at all. Their TE score was 3.41 per cent lower. This is inconsistent with Binam *et al.* (2004) and Kibaara (2005). Most probably the credit allowed the households to diversify away from agriculture, making supervision of farm activities less intensive. Alternatively, credit directed to agriculture may have eased resource-constraints among the farmers, leading to over-application of farm inputs. This may also explain the negative correlation between social capital and TE. A household's participation in one more social group lowered its TE score by 2.68 per cent. Social groups are known to be sources of rotational farm labour and credit among smallholder farm households (Ogada, Nyangena and Yesuf, 2010) which may lead to over-employment of farm labour. Participation in many social groups may also commit more of the farm household's time to the

Table 2: Marginal Effects of the Tobit Results.

Variable	Marginal Effect	Z-score
Farmer Characteristics		
Age (in years)	-.000947*	1.68
Gender of head (dummy: 0=female; 1=male)	-.002855	-0.15
Upper primary education (4-8 years of school)	-.015980	-0.97
Post primary education (more than 8 years)	-.019175	-0.88
Size of household (No. of members)	-.002057	-0.69
Needed but did not receive credit ●	-0.0019	-0.12
Received credit ●	-0.0341***	-3.56
Income from non-crop sources (in Kshs)	4.00D-08	0.96
Crop income (in Kshs)	3.40D-07***	3.07
Social capital (No. of social groups)	-0.0389 ***	-6.24
Hires farm labour ■	-0.0439***	-4.08
Uses Child labour ■	-0.0330***	-3.62
Intensity of manure use (Kgs of manure)	0.00003***	4.42
Partial adoption of inorganic fertilizers and improved maize varieties	-0.2388***	-14.78
Full adoption of inorganic fertilizers and improved maize varieties	0.0848***	7.04
Production Risks		
Expected Yield	-0.0003***	-8.99
Yield Variability	2.52D-09	0.17
Production Environment		
Plot size under crops (acres)	0.0166***	3.37
Land under other activities (acres)	0.0012	1.38
Annual rainfall amount (mm)	0.00058***	4.53
Average annual temperature (°C)	0.1046** *	4.49
Soil water-retention (dummy:0=good; 1=poor)	-0.0585 ***	-5.15
Tenure security (dummy:0=insecure;1=secure)	0.0223 **	2.19
Distance to the nearest road (km)	-0.0059**	-2.06
Distance to the nearest market	-0.0195***	-6.55
Wage rate to farm worker (Ksh/day)	0.0004*	1.65
Number of observations	**2334**	

***, ** and * indicate significance at 1per cent, 5per cent and 10per cent, respectively; ● means reference category is those who never sought credit; ■ means reference category is use of home adult labour.

extent that supervision of farm activities is reduced, making use of farm inputs less efficient. Alternatively, participation in many social groups may overload the farmer with agricultural information that making decision with regards to input use is adversely affected.

Use of hired and child labour in crop production were found to lower TE scores. Households that engaged hired labour had 4.4 per cent lower TE scores than households that engaged adult family labour in their production. Households that engaged child labour had 3.3 per cent lower TE scores than their counterparts that relied on adult family labour. The negative correlation between hired labour and TE may be explained in terms of seasonal labour scarcity among farm households such that households that depend on hired labour may not get it at the most appropriate time. Moreover, family labour may undertake quality work even without supervision. This indeed negates the notion that farmers in developing countries are inefficient because of their over-reliance on family labour (Dhungana, Nuthall and Nartea, 2004). It may also explain the positive relation of farm labour wage rate to TE because higher wage rate is a disincentive to hiring of farm labour. Negative correlation between use of child labour and TE is most probably attributable to lack of experience in caring for crops and combining input.

Manure is important in improving soil condition especially where farmers may not access inorganic fertilizers in sufficient quantities. This is normally the case with smallholder households. This explains the relationship between intensity of manure use and TE of the smallholders. Applying one extra kilogramme of manure to an acre of cropped land raised the TE of the smallholders by 0.003 per cent. A plot with more manure would be more fertile and therefore the results are not surprising. Similar results were found by Binam *et al*. (2004).

Households that were more dependent on crop agriculture, as reflected by the amount of income received from crops, were more technically efficient. A 1 per cent increase in the amount of income that a household received from crops led to 3.40D^{-07}per cent improvement in the household's TE. Most probably this may be attributed to the ability of such households to reinvest part of their crop income in improved agricultural inputs. A related finding was that households that adopted improved maize varieties and inorganic fertilizers as a complete package were 8.5 per cent more efficient while partial adopters were about 24 per cent less efficient than the non-adopters. Similar roles of improved agricultural inputs have also been noted by Kibaara (2005), Brazdik (2006) and Chirwa (2007).

Expected higher yields were found to be associated with lower TE. An increase of expected crop yield by 1 per cent lowered the TE of the smallholders by 0.0003 per cent. This possibly suggests that smallholders are wasteful of inputs as long as they are realizing higher gross returns. Perhaps they are unable to realize that the same level of returns could be realized at lower input levels. Yield variability, however, had no influence on the TE of the smallholders. Previous studies have not explored the effect of production risks on TE and therefore this is an important contribution of this study.

On average, the effect of land size on farmer efficiency was positive. An increase of the size of a household's land under crop cultivation by 1 acre was found to enhance the farmer TE by 1.7 per cent. This is at variance with Mochebelele and Winter-Nelson (2000) who found no relationship between farm size and technical efficiency of the smallholders in Lesotho but coincides with Sherlund *et al.* (2002). As noted by Townsend *et al.* (1998), the effect of farm size on farm efficiency is not consistent. For instance, in Brazil (Igliori, 2005) and the UK (Thirtle and Holding, 2003), large farms have been found to be more efficient while in Ireland (O'Neill, Leavy and Mathews, 2001) and Philippine (Herdt and Mandac, 1981) they have been found to be less efficient.

Both annual rainfall amount and mean annual temperature were positively correlated with TE. An increase in annual rainfall amount by 1 mm, improved TE score of the smallholders by 0.058 per cent while an increase in average annual temperature by 1°C improved TE score by 10.6 per cent. Smallholders rely on rain-fed agriculture and most parts of the country receive sub-optimal rainfall, particularly for maize production. Thus, the positive correlation of farmer TE and annual rainfall amount is not surprising. A closely related factor is the water-retaining capacity of the soil. TE of smallholders whose plots were characterised by soils with low water-retaining capacity was 5.9 per cent lower than that of those whose plots had higher water-retaining capacity. Low water-retention subjects crops to moisture stress and leads to low yields unless high rainfall is experienced. Such soils are also heavily leached and may require more intensive application of yield-enhancing inputs.

Secure land tenure had a positive effect on TE of the smallholder food crop farmers. TE of farmers with secure land tenure was 2.3 per cent higher than that of their counterparts with insecure land tenure. As documented by Ogada, Nyangena and Yesuf (2010), secure land tenure promotes investment in soil and water conserving structures at farm level. This is likely to increase output even with lower units of input.

Proximity to market and motorable road led to higher TE. A household that was 1 kilometre (KM) closer to a motorable road had 0.59 per cent higher TE score than its equivalent which was 1 KM further. At the same time, a household that was 1 KM closer to a market had 1.95 per cent higher TE score than its equivalent which was 1 KM further. This relationship is straight forward. Farm households that lie closer to roads and markets are able to source inputs more easily and at lower transaction cost. Such households also have ready markets for their farm products. Thus, profit motivation and easy access to inputs would drive up TE. Similar results have been noted by Binam *et al.* (2004), Owuor and Ouma (2009) and Nyagaka *et al.* (2010). Closeness to market may also offer alternative employment opportunities to absorb excess labour from the farms.

6. Policy Implications

A number of policy options can be inferred from the above findings. Foremost, reliance on rain-fed agriculture hurts the efficiency of the smallholders. Thus, the government of Kenya should invest in

development, expansion and maintenance of irrigation infrastructure. Agricultural input and output marketing infrastructure should also be improved by the government.

As the government promotes adoption of modern inputs, traditional environment friendly inputs like organic manure should not be ignored. They should indeed be used as important complements to the modern inputs. Used in sufficient quantities, these organic inputs are capable of effectively replacing the modern inputs. Hence positive attitude towards them by the farm households should be cultivated.

Other issues that may need to be addressed include: landholding size, land tenure security, farm labour supply or mechanization, agricultural credit and production risks.

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CAPRI: a spatial assessment tool for agri-environmental indicators in the EU

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Abstract

The agro-economic model CAPRI has been extended to provide a spatial assessment tool for agri-environmental indicators in the EU. Currently, CAPRI covers a full activity- and product-based GHG accounting system, calculates nitrogen balances and differentiated emissions of reactive nitrogen (N2O, NH3, NOx, NO3). For a recent assessment on the 'greening of the CAP' (European Commission 2011) additional indicators have been included, such as the risk of soil erosion, biodiversity friendly farming practices, farmland bird index, agricultural landscape structure, and an indicator related to environmental compensation zones. All indicators are provided at the regional scale (NUTS2) and at the high-resolution scale (HSMU). As an example we show assessments carried out in the frame of the European Nitrogen Assessment.

Keywords: agro-economic model; agri-environmental indicators; CAPRI; gross nutrient balance; greenhouse gases.

1. Introduction

Agri-environmental indicators are suitable instruments to identify agri-environmental problems, such as hot-spots, and to monitor changes in environmental quality and in the efficiency of agri-environmental policies (Commission of the European Communities 2006).

Quantifying agri-environmental indicators is a challenging task, in particular for large and heterogeneous regions such as the area covered by EU-countries and if high spatial resolution is required. Indeed, many agri-environmental threats ask for indicators at high spatial resolution or at scales that are different from administrative entities. Reliable agri-environmental indicators hinge on the availability of high-quality input data, which in those cases where national-scale data are insufficient often poses considerable problems.

The agro-economic model for agriculture CAPRI includes agricultural supply models at the level of administrative regions, linked to a global market model (Britz & Witzke 2012). CAPRI simulations were used to inform policy development in the EU, such as the 2003 CAP reform, the 2008 health check, etc. CAPRI is linked to multiple databases, a.o. EUROSTAT national and regional production statistics, and has a unique module to prepare a set of complete and consistent regional data.

During the last decade, CAPRI was continuously extended towards the integration of agri-environmental indicators in the modelling framework. In particular, this implied the development of a spatial layer into which regional data are downscaled. Many agri-environmental indicators are depending on local environmental conditions and require the availability of data at high resolution. Also, it allows the quantification of indicators through linkage with biophysical models (Leip et al. 2008) or using detailed meta-models (Britz & Leip 2009).

Currently, CAPRI covers a full activity- and product-based GHG accounting system, calculates nitrogen balances and differentiated emissions of reactive nitrogen (N2O, NH3, NOx, NO3). The CAPRI-RD research project (2009-2013) included additional, such as the risk of soil erosion, biodiversity friendly farming practices, farmland bird index, agricultural landscape structure, and an indicator related to environmental compensation zones which were recently used for an assessment on the 'greening of the CAP' (European Commission 2011).

2. Method

2.1 The CAPRI model

The *Common Agricultural Regionalised Impact Analysis model* (CAPRI, see also http://www.capri-model.org/) is a modelling framework consisting of four blocks around a global, spatial, partial equilibrium (PE) model with a focus on Europe specifically designed to analyse CAP measures and trade policies for agricultural products and assess their impact on income, markets, trade, and the environment (Britz & Witzke 2012).

The CAPRI economic module consists of two interlinked agricultural components, a supply module

and a market module, such that production, demand, trade and prices can be simulated simultaneously and interactively (see Figure 1; Britz & Witzke 2012), and recently a third multi-sector component based on regional Computable General Equilibrium models. The market module considers bi-lateral trade flows and attached prices as well as the relevant policy instruments (e.g. bi-lateral tariffs, the Tariff Rate Quota (TRQ) mechanism and, for the EU, intervention stocks and subsidized exports). The supply module maximises regional agricultural income at given prices and subsidies, subject to constraints on land, policy variables and feed and plant nutrient requirements in each region. The supply module is linked to external data bases, such as the EUROSTAT statistical database. The two core modules interact iteratively via prices and quantities for about 50 primary and processed agricultural products to determine equilibrium.

Major outputs of the core module include crop and livestock activity levels, yields, input use (pesticides and fertilisers), greenhouse gas emissions, nutrient emissions and farm income at regional level.

Overall, the four blocks can be defined as follows (see Figure 2):

1. **Data Base Block**, giving the link to various sources of statistical and expert information. The databases include a global database (incl. also bi-lateral trade and tariff data), the national database for European countries, a regional database in EU27+ at NUTS2 (incl. also farm data), and a spatial database at the level of 'homogeneous spatial mapping units' (HSMU[1]). The data base block includes also tools to (i) remove inconsistencies and data gaps in the national database (CoCo); (ii) to downscale national data to the regional scale and amend them with available regional information and (iii) disaggregate activity data and farm input to the spatial level.
2. The core economic modules consist of two blocks, the Baseline **Block** providing a reference point for ex-ante impact analysis. The supply and market modules are calibrated to results of the reference run.
3. The second block of the economic core model is the **Scenario Block**, simulating counter-factual policy scenarios, iterating between the market and the supply modules.
4. **Post-processing** provides the quantification of economic and environmental indicators (for environmental indicators see Section 2.3) and supports result analysis by disaggregation or aggregation of data to spatially relevant scales (see section 2.2), aggregation over products and activities, products or activities or by decomposition of results.

For data exploitation, analysis and presentation a Java-based Graphical User Interface **(GUI)** is inherent part of the CAPRI modelling framework providing "user-friendly" options to use each of these modelling blocks and tools for the exploitation of the results in terms of tables, maps, or figures. The GUI allows analysing the *ex post* and *ex ante* impact of agricultural systems and policies on income, market, trade, and the environment.

Figure 1: The four model blocks of the Common Agricultural Regionalised Impact Analysis model (CAPRI, see also www.capri-model.org/) modelling framework: the Data Base Block, the Baseline Block, the Scenario Block, and the Post-processing Block.

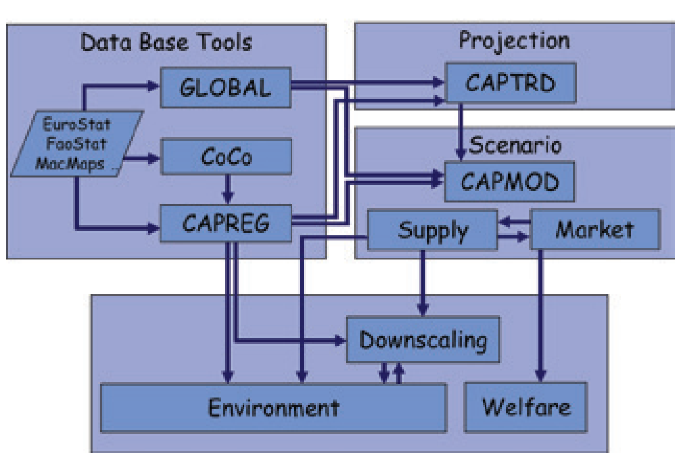
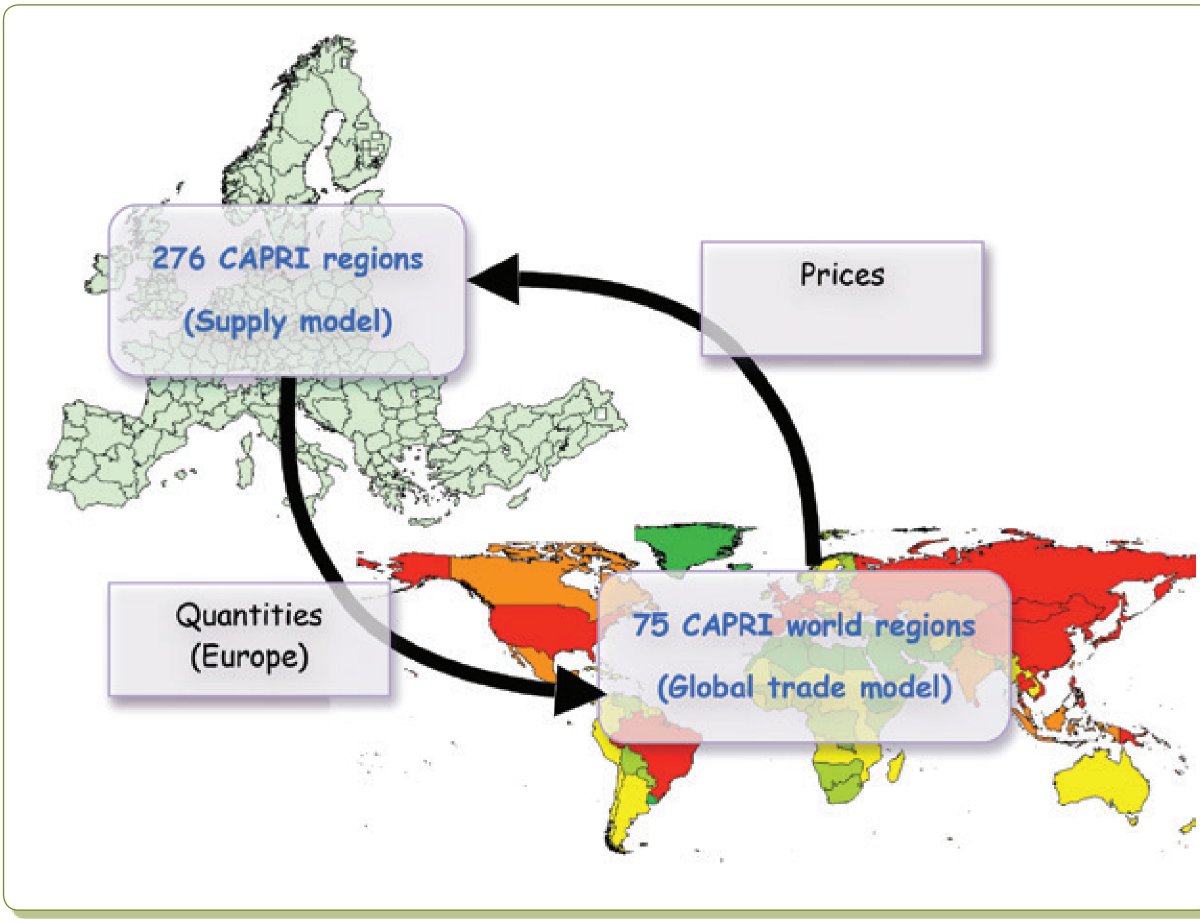


Figure 2: CAPRI economic core models run iteratively between supply of 276 European regions and a global market mode covering 75 CAPRI world regions to determine prices for >50 primary and >30 secondary commodities.



2.2 The CAPRI spatial layer

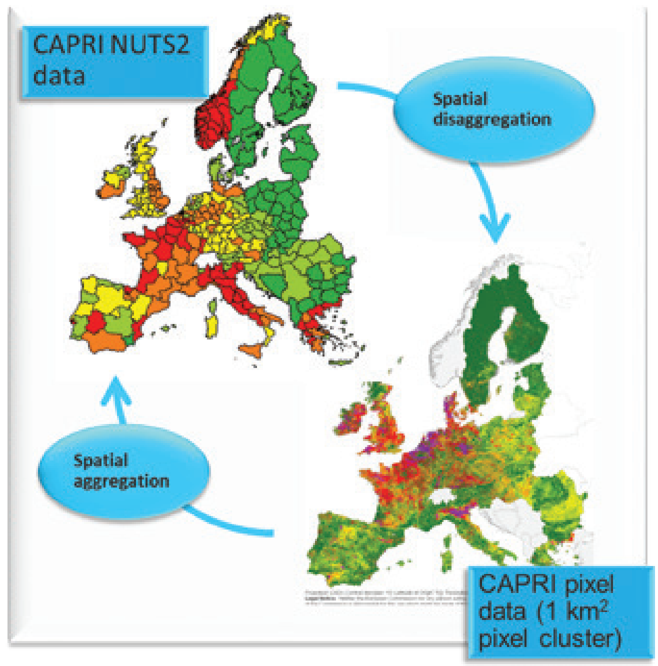
In many cases, the calculation of the agri-environmental indicators requires data at a higher spatial resolution than the core CAPRI model can provide. For this purpose, an additional module, the CAPRI spatial disaggregation module, is dedicated to the disaggregation of the outputs obtained from the core model. The CAPRI land use module takes land use and farm input data at regional level, and disaggregates this information with the help of explanatory variables (such as land use related to soil quality, climatic conditions and topographic parameters) to each single grid cell. In order to calibrate the statistical disaggregation model (a local multinominal logit model, see Lamboni *et al.* 2012), ground truth data covering the explanatory variables is needed. LUCAS data (Kasanko *et al.* 2010) are essential to provide this observational data that allows to make the link between the agricultural use and the environmental conditions in a certain point (Leip *et al.* 2008). Detailed information on the specific algorithm here can be found in Kempen et al. (2005a, 2005b) and Lamboni et al. (2013, 2012).

A priori estimates (mean and variance) for land use shares obtained from logit model are used in a second step in a Bayesian 'Highest Posterior Density' (Heckelei *et al.* 2008) estimator to provide a posteriori land use shares consistent with regional data for ex post or ex ante assessment or scenario analysis (Britz *et al.* 2011; Leip *et al.* 2011c) (see Figure 3).

Once crop shares are estimated in the spatial units, other parameters can be added, as described in Britz and Leip (2009):

- **Crop yield** is estimated by combining regional production data and productivities in the spatial calculation unit incorporating information on potential irrigated and rainfed crop yields (Genovese *et al.* 2007) and irrigation shares (Siebert *et al.* 2005).

Figure 3: CAPRI provides mutually consistent data at national, regional, and pixel layer.



- **Animal stocking densities** for 13 ruminant and non-ruminants animal types considering the possibility of fodder transport across the borders of the individual HSMUs.
- **Manure nitrogen application rates** taking into account nitrogen losses from animal housing and manure management systems, which are estimated according to the MITERRA-EUROPE (Velthof *et al.* 2009)and **G**reenhouse Gas and **A**ir Pollution **In**teractions and **S**ynergies (**GAINS**) (Klimont & Winiwarter 2011) models.
- Nitrogen input from crop residues, biological fixation and atmospheric deposition. **Application rates of synthetic fertilizer nitrogen**, based on the difference between the crop nutrient need and all non-mineral nitrogen sources, corrected by typical loss rates, and a factor based on soil properties.

2.3 The CAPRI environmental indicator framework

The CAPRI framework allows quantifying a large range of agri-environmental indicators[2]. Agri-environmental indicators are suitable instruments to identify agri-environmental problems, such as hot-spots, and to monitor changes in environmental quality and in the efficiency of agri-environmental policies (Commission of the European Communities 2006). In Europe, 28 agri-environmental indicators (AEI) are proposed for monitoring the integration of environmental concerns into the Common Agricultural Policy (CAP) of the European Union[3]. Another collection of AEI is given in the frame of Common Monitoring and Evaluation Framework (CMEF) for monitoring and evaluation of all rural development interventions[4].

From this list of AEI, some were selected and implemented in CAPRI based on the relevance for policy areas (such as climate change and the 'greening' of the Common Agricultural Policy) and feasibility of implementation.

Some agri-environmental indicators are calculated at the regional scale (NUTS2) and disaggregated to the pixel scale using dedicated dis-aggregation modules (Nitrogen surplus, GHG emissions). Most 'greening' indicators (Biodiversity-Friendly Farming Practices, Environmental Compensation Zone, Farmland Bird Index, Agricultural Landscapes,

Risk of soil erosion by water), however, need to be estimated at the high resolution, and indicators at the regional scale are provided using various aggregation methods. These range from calculation simple averages over probability distributions to the use of thresholds (e.g. area above or below 0.5 and 5 t $ha^{-1} yr^{-1}$ erosion).

Gross Nutrient Surplus

The Gross Nitrogen Budget (GNB-N[5,6]) lists nitrogen inputs to agricultural soils and nitrogen outputs removed from the soil. The main result from the GNB-N is the Gross Nitrogen Surplus (GNS) which is calculated as the difference between total N inputs and total N outputs (Eurostat 2013). The surplus includes all losses to the environment from animal housing and manure management systems, grazing, and soils. The GNS can also be expressed in kilogrammes of nitrogen per hectare (kg N/ha), by dividing the surplus by the area over which the GNB-N is assessed. The GNB-N provides insight into links between agricultural nitrogen use and losses of nitrogen to the environment. A persistent surplus indicates potential environmental problems, such as ammonia emission (contributes to acidification, eutrophication and atmospheric particulate pollution), nitrate leaching (resulting in pollution of drinking water and eutrophication of surface waters) or nitrous oxide emissions (a potent greenhouse gas). A persistent deficit indicates the risk of decline in soil fertility and potential for reduced crop yields.

Greenhouse gas emissions

Greenhouse Gas (GHG) emissions from agriculture[7,8] are calculated on the basis of the source category 'Agriculture' defined in the IPCC guidelines. Included are methane (CH4) and Nitrous oxide (N_2O) emissions from agricultural activities (housing, manure management, fertiliser application, soil cultivation). GHG emissions are also calculated using a life-cycle approach and reported as emission intensities (kg CO2eq per kilogram of product) (Weiss & Leip 2010).

Biodiversity-Friendly Farming Practices (BFP)

The concept of 'Biodiversity-Friendly Farming Practices[9]' refers to the causality between certain types of farming activity and their potential impacts on biodiversity. This is closely linked to the High Nature Value (HNV) farmland and is therefore a key indicator for the assessment of the impact of policy interventions with respect to the preservation and enhancement of biodiversity, habitats and ecosystems dependent on agriculture and of traditional rural landscapes.

It is not possible to model directly HNV farmland areas within CAPRI as they are not yet uniquely defined at EU level, but the contribution that agricultural management can make to biodiversity maintenance or enhancement can be estimated through CAPRI variables. Therefore the BFP indicator provides qualitative information about the impact of farming practices on biodiversity.

Environmental Compensation Zone (ECZ)

The indicator provides information on the proportion of agricultural land that is not currently used for production as defined by 'land that was previously set-aside', fallow land based on available CAPRI crops nomenclature. This indicator is a first and imperfect proxy to assess the impact of the 'Ecological Focus Area' brought forward by the European Commission as a means of greening Direct Payments under the CAP 2014-2020[10]. This indicator is measured as the proportion of Environmental Compensation Zones on: a) Utilised Agricultural Area (UAA) and b) arable land.

Farmland Bird Index (FBI)

The Farmland Bird index (based on EUROSTAT FBI indicator[11]) is an aggregated index of bird population estimates from a selected group of breeding bird species dependant on agricultural land-use for nesting or feeding. This index is calculated at national scale. A score of 100 is recorded for the reference year (normally the first year of the bird survey for which it is possible to calculate the indicator) and is re-calculated at each survey in order to monitor changes.

Agricultural Landscapes

The CAPRI 'Agricultural landscapes'[12] describes agricultural landscape structure through (i) Dominance and internal structure of the agrarian landscape in the context of the wider landscape matrix; (ii) the degree of naturalness, which indicates the degree of influence on land cover and state due to human (agricultural) activities; (iii) the interest and perception that society has for the agrarian landscape.

The final result is a qualitative zoning where the agricultural landscape is dominant and diverse or dominant and characterised by few crops (i.e. rice fields, vineyards, olive groves etc.), as opposed to areas of more mosaic landscapes (i.e. alpine pastures, urban fringe etc.).

Risk of soil erosion by water

The Soil Erosion indicator[13] developed for CAPRI provides an estimate of the risk of soil erosion by water. Following the Revised Universal Soil Loss Equation (RUSLE), the indicator predicts the potential average annual rate of erosion on a unit of land based on rainfall pattern, soil type, slope length, crop system and management practices.

3. Example application: Gross Nutrient Budget & Nitrogen Indicators

The following pictures show two examples, i.e. N-input to agricultural soils and N_2O emissions from all anthropogenic sources. Both examples have been calculated as contribution to the "European Nitrogen Assessment" (Leip *et al.* 2011a; Sutton *et al.* 2011). The first example is a disaggregation of regional data obtained by the core CAPRI model. This disaggregation to grid cells is done through the above-mentioned land use model part calibrated with LUCAS data. The second example uses this spatially disaggregated data to feed into a meta-model for N_2O emissions from agricultural soils and combining this with other agricultural N_2O sources (manure management) which have also been disaggregated and non-agricultural sources (forests, energy, ...) obtained from other data bases (INTEGRATOR model, EDGAR). The map shows total N_2O emissions as the sum of these emission sources. The pie diagram shows the contribution of each emission source to the total emissions in EU27. The bar chart finally shows level and contributions re-aggregated to country level.

A pilot project on regional nitrogen budgets is currently carried out in cooperation between the Joint Research Centre, Eurostat and four countries (France, Germany, Hungary, and Italy) in order to assess differences between the GNS calculated with CAPRI and by the countries. Current reporting of nitrogen budgets from Member States occurs at the national level. For policy making, a higher resolution, matching with legislative and environmental boundaries (nitrate vulnerable zones, watershed) rather than administrative boundaries (country) is required. Nitrogen budgets are calculated using the mass-flow approach, IPCC emission equations, and endogenous estimations of feed intake and nitrogen excretion based on available feed and product statistics (Leip *et al.* 2011b, 2011c). During the pilot project (year 2013), nitrogen budget estimates from CAPRI are compared with those obtained from official national entities at country- and regional level (where available) to assess the feasibility of using CAPRI for the estimation of regional N-budget. If successful, the data can be further disaggregated to obtain N-budget maps in consistency with national estimates. These maps will be linked to the land use maps obtained through the disaggregation.

Figure 4: Nitrogen input to agricultural soils in EU-27 for the year 2002.

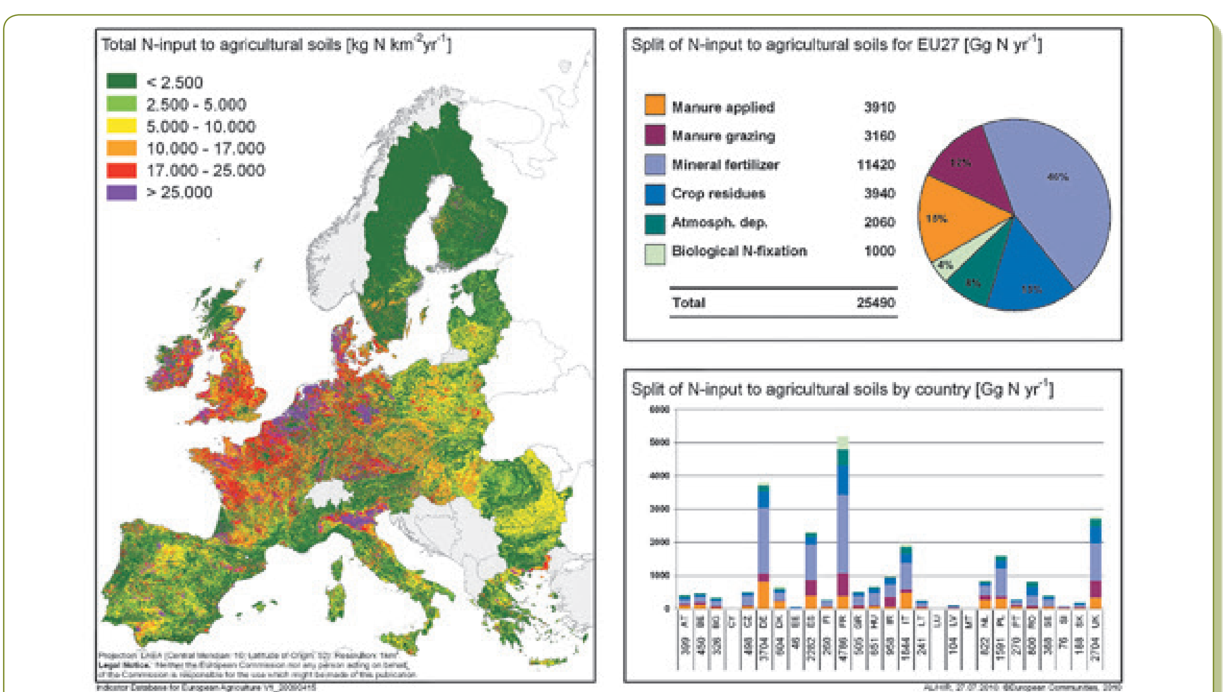
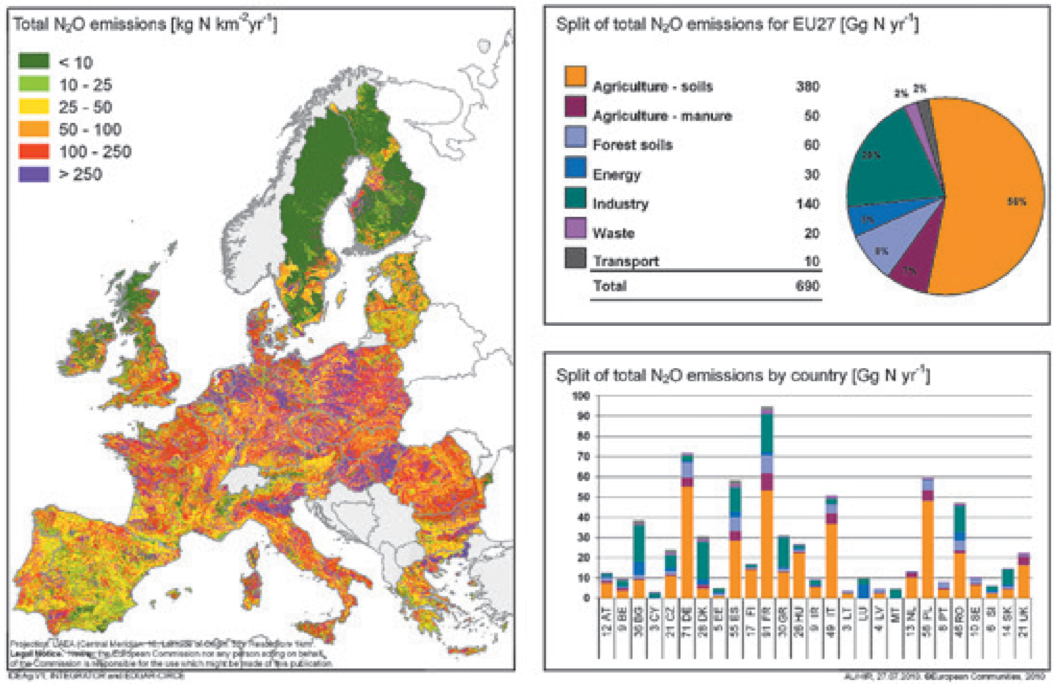


Figure 5: Total N2O emissions in EU-27 around the year 2000.



4. Summary and Conclusion

The CAPRI modelling framework provides a suitable platform for the quantification of agri-environmental indicators for monitoring environmental pressures from agricultural activities. However, CAPRI allows also ex ante assessment of the Common Agricultural Policy of the European Union and other policies affecting agricultural production in Europe.

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Endnotes

1 Homogeneous Spatial Mapping Units are derived from four delineation maps on a 1 km x 1 km grid: soil, slope, land cover and administrative boundaries (Leip *et al.* 2008).

2 See CAPRI fact sheets (Terres *et al.* 2013).

3 http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Agri-environmental_indicator_%28AEI%29.

4 http://ec.europa.eu/agriculture/rurdev/eval/index_en.htm.

5 Eurostat AEI 15 (pressures and risks: Pollution): http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Agri-environmental_indicator_-_gross_nitrogen_balance.

6 CMEF objective related baseline indicator 20: water quality: Gross Nutrient Balances.

7 Eurostat AEI 19 (pressures and risks: Pollution): http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Greenhouse_gas_%28GHG%29.

8 CMEF objective related baseline indicator 26: Climate change/air quality: gas emissions from agriculture.

9 The BFP indicator is linked to: CMEF baseline (#18) 'Biodiversity: HNV farmland and forestry'; CMEF impact (#8) indicator 'Maintenance of HNV farmland and forestry'; EUROSTAT AEI #23 'High Nature Value Farmland' [COM(2006)508].

10 No direct linkage with CMEF indicators as this indicator did not exist for the 2007-2013 RD reporting period. Compensation Zone for arable land.

11 The FBI is also part of EUROSTAT structural indicator; EUROSTAT Agri-Environmental Indicator #25 'Population trends of farmland Birds'; OECD indicator 'Environmental Performance of Agriculture in OECD Countries Since 1990'.

12 The CAPRI 'Agricultural landscapes' indicator is a proxy for the Eurostat Agri-Environmental Indicator #28 Landscape State & Diversity [COM(2006)508].

13 Eurostat Agri-Environmental Indicator # 21 Soil Erosion [COM(2006)508].

Application of the System of Environmental Economic Accounting (SEEA) Central Framework and SEEA Experimental Ecosystems Accounting at FAO: preliminary findings and ongoing work

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Abstract

The FAO Global Strategy to Improve Agricultural and Rural Statistics (GS) seeks to achieve a significant improvement in the quality, reliability and cost-effectiveness of agricultural statistics in developing countries. Identifying appropriate indicators and collection methods for agri-environmental data is directly related to implementing the System of Environmental-Economic Accounting 2012: Central Framework (SEEA-CF). There are also synergies with several other GS thematic domains including:

- Improving the methodology for data analysis, "to inform policy decisions and monitor their impact on household incomes, rural development, and the environment";
- Improving the methodology for using administrative data, by identifying "where, how, and under which conditions administrative data can be used for producing agricultural, rural, and agri-environmental statistics";
- Creating an appropriate reference framework for mainstreaming agriculture into the national statistical systems, which overlaps with country-level SEEA-CF implementation and its recognition that the development of an accounting framework, the establishment of the relevant statistical infrastructures, and the organization of information are key tasks that cannot be completed within a single agency.

Moreover, the thematic domains of Better integration of geographic information and statistics (connecting economic and social indicators to land use), Improving the methodology for using remote sensing (land use and land cover monitoring), and; Identifying the most appropriate master frame for integrated surveys (the capability to link the farm characteristics with the household and then connect to both the land cover and use dimensions); pertain directly to application of the accounting framework proposed in SEEA Experimental Ecosystem Accounting, which provides a complementary organisation of environmental-economic data to that outlined in the SEEA-CF. This paper will outline on-going work by FAO, in collaboration with national authorities and international partners, to advance SEEA methodology for the compilation of internationally comparable environmental-economic accounts for the agriculture, forestry, and fisheries sectors. Emphasis is placed on describing the on-going development of a data management and analysis application in FAOSTAT aligned with the SEEA-CF as well as a set of SEEA-based indicators that can support monitoring the development outcomes articulated in FAO's five strategic objectives.

Keywords: System of Environmental-Economic Accounting; agriculture; forestry; fisheries; SEEA-AGRI; FAO strategic objectives; FAOSTAT.

1. Introduction

The endorsement of the System of Integrated Environmental and Economic Accounting (SEEA) Central Framework by the United Nations Statistical Commission in March 2012 provided the first international statistical standard for environmental-economic accounting. This standard is an important step forward in integrating information on economic activity and the environment to better understand implications pertaining to the sustainability of different patterns of production and consumption. This paper describes work being

initiated by the Statistics Division of FAO to develop an extension to the SEEA Central Framework that captures the specific relationships between the agricultural sector and the natural environment. This is defined as the System of Environmental-Economic Accounting for Agriculture (SEEA-AGRI). Within this framework, agriculture is interpreted in the broad sense as all activities related to crops, livestock, forestry and fisheries with a primary and intensive use of environmental goods and services. This is different from other extensions (subsystems) of the SEEA Central Framework in the sense that rather than focusing on one specific *resource* (such as water, or energy), SEEA-AGRI focuses on a *group of activities*, and considers the relationship between these activities with the related environmental assets.

The paper provides a brief overview and discussion of some of the key issues that emerge for the construction of such a system. It is organized in five sections. The first three sections explain the need and merits of an integrated approach as well as the linkages with other complementary systems. Section four defines the aim and scope of the proposed framework and in section five the preliminary development is outlined and points with regard to the approach and feasibility of country implementation of the SEEA-AGRI are discussed.

2. The need of an accounting framework for agriculture and the environment

The System of National Accounts (SNA) consists of a coherent, consistent and integrated set of macroeconomic accounts which constitutes the primary source of information about the economy and is now widely used for analysis and decision-making in virtually all countries. While it provides practical measures of macroeconomic performance, the SNA does not incorporate the full costs and benefits to society of economic activities. One of the main shortcomings of the SNA is that the inputs from the environment to the economy and the effects of economic activity on the environment have not been readily identifiable within the economic accounts generated. The SEEA Central Framework augments traditional national accounts to integrate economic and environmental statistics in an internationally agreed manner that allows for an evaluation of the environmental sustainability of economic activity.

There are two main groups of reasons that justify the use of an accounting framework for agriculture and the environment based on the SNA/SEEA structure: reasons related to the need to unravel the relationships between agriculture and the environment, and reasons that deal with the methodological and statistical enhancements to be derived from exploiting an established analytical accounting framework.

When exploring the ***relationships between agriculture and the environment***, conventional accounts only cover the economic performance and functions of agriculture as reflected in market activities and their evolution over time. In that context, the SEEA Central Framework is a useful tool for organising additional information to evaluate the environmental sustainability of those industries and activities making extensive use of natural resources, either as inputs or as sinks. On the one hand, the relationship between the environment and agriculture is such that natural environments provide a form of infrastructure and a flow of economically valuable and critical environmental assets such as land, soil and water to agricultural activity. On the other hand, agricultural activities may contribute significantly to soil erosion, land degradation and water quality changes.

An important distinction to be made is between those assets that can be attributed to agriculture, and those that cannot. From there, two types of accounting adjustments may be distinguished for agricultural assets. The first would focus on the services derived from the land based stock of assets (habitat and species, landscape, etc). The second would consider the impact of agricultural activities on the ability of these assets to provide environmental services (e.g. sink functions), either by modifying the quality or quantity of the assets being considered.

From a ***methodological perspective***, applying the SEEA Central Framework to agriculture will help improve the conceptual basis and analytical capability of agriculture statistics, which is the goal of the Global Strategy to Improve Agricultural and Rural Statistics (GS).[1] The SEEA-AGRI can play an important role in many aspects relating to the implementation of the GS, among others, three are of special importance. First, adopting a macroeconomic accounts approach for developing a statistical framework has the advantage of applying a set of SNA-based standard classifications upon

which consistent and comprehensive sets of data series can be compiled. Second, the resulting accounts can provide a complete set of variables for identifying and designing a core and minimum set of agricultural indicators, aligned with the SEEA Central Framework, and applicable across a wide range of developing and emerging market economies. Third, a macroeconomic accounts approach for a statistical framework also responds to the need of having a multipurpose information system that can be used to combine and harmonize data from various surveys, censuses and administrative sources together into an integrated database that supports policy making and analysis.

3. Integrating agriculture activities in one framework

Primary activities rooted in the physical environment (e.g. agriculture, forestry and fishing), are often major sources of countries' wealth. Agriculture as defined by the International Standard Industrial Classification of All Economic Activities (ISIC) includes the exploitation of vegetal and animal natural resources, comprising the activities of growing of crops, raising and breeding of animals, harvesting of timber and other plants, animals or animal products from a farm or their natural habitats. ISIC revision 4, Section A, is divided in three Divisions: (01) Crop and animal production, hunting and related service activities; (02) Forestry and logging; and (03) Fishing and aquaculture (UNSD, 2008).

There are at least two important reasons for the inclusion and integration of agricultural activity in one accounting framework. The first is that *the three Divisions under ISIC revision 4, Section A represent activities that are major users of one or more environmental assets*, in particular soil, water, biological resources, land and ecosystems. These activities as a whole (including livestock grazing in the case of agriculture and aquaculture in the case of fishing) might occupy a significant portion of the economically available (exploitable) land in developing countries.[2] Furthermore it is not unusual to find farms that are engaged in more than one of these activities and it is not uncommon for agricultural surveys and censuses to include some information about these activities. As a result, the benefits of evaluating and monitoring the rational and sustainable use of the environment vis-à-vis these activities in an integrated accounting framework is invaluable for medium to long-term policy formulation for agricultural, land use and related environmental and ecosystem issues.

The second reason is that *the three Divisions under ISIC revision 4, Section A are strongly related to basic population needs* (food, energy, shelter and other raw materials). Thus, it is strongly advisable to explore the potential of the SEEA Central Framework to agriculture in order to include and address important issues related to food security. The need for integrated and cross sector information that can be useful for decision making in a complex and globalized world is a challenge that can, in large part, be addressed from an extension of the SEEA Central Framework to agriculture.

Also, the three Divisions in Section A cover activities that are the source of employment for large sections of countries' populations, especially in rural areas. Information on the sustainability of these activities thus relates directly to the potential to the sustainability of employment of these people.

The SEEA-AGRI envisaged by FAO would have the potential to consistently analyse important trends and give insights about relevant environmental, economic and social issues such as the increase of water demand and abstraction, land use changes, forest clearing, etc., at the macro and national level. Furthermore this information could be related to the physical food balances and other types of analysis elaborated by FAO in order to assess the impact of such phenomenon on food security.

4. Scope and coverage of SEEA-AGRI

The SEEA-AGRI can be defined as a comprehensive and standard satellite account for the integration of agricultural and environmental data based upon internationally agreed concepts, definitions, classifications and inter-related tables and accounts that are universally relevant, regardless of the stage of economic development reached by the country.

The SEEA-AGRI aims to translate policy issues into data needs and requirements in a standard and coherent manner by:

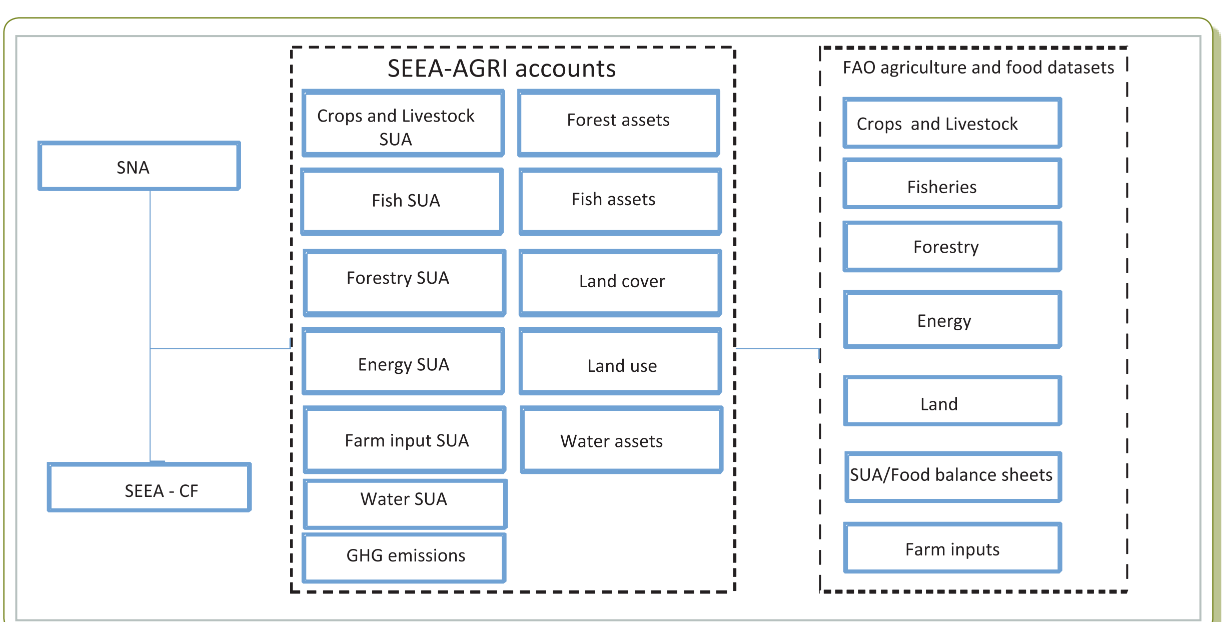
- Enhancing the use of existing agricultural statistics and related common frameworks (supply and utilization tables and food balances, etc.) through the integration of basic statistics consistent with the SNA;

- Providing a consistent, comprehensive, and coordinating framework to link data collected by different surveys, censuses and administrative sources together to build up an integrated database;
- Providing a sound basis for the measurement of a set of economic, social, and environmental indicators for agriculture and rural development aligned with FAO's narrow and broad definitions of agriculture, respectively;
- Providing a framework to expand the analytical capabilities of the original FAO SEAFA and related past FAO initiatives (Fishery and Forestry Accounts);
- Providing a framework that links to other SEEA subsystems being articulated by other agencies (Ecosystems, Water, Energy, etc.).

When looking at agricultural activities within the evolving SEEA-AGRI, agriculture interpreted in a broader sense (i.e. crops, livestock, forestry and fisheries), can be placed at the centre of the analysis, allowing for the assessment of the interactions with other sectors, but concentrating on looking at the particular indicators pertaining to environment-economy relationships. This framework can be considered an extension or application of the SEEA Central Framework, one with a primary and intensive use of environmental goods and services (Figure 1). This is different from other subsystems of the SEEA in the sense that rather than focusing on one specific *resource*, it focuses on one *group of activities*, and considers the relationship between these activities and the related environmental assets. Thus, specific aspects of other, more resource based accounts (e.g. water accounts) are used in the SEEA-AGRI.

As shown in Figure 1, on one side, the SEEA-AGRI links to the SNA and SEEA Central Framework and its strengths while providing new elements of analysis which are not necessarily incorporated in the Central Framework (in figure 1 only some specific SEEA and some existing FAO accounts and datasets are shown). In turn, the SEEA Central Framework and its other subsystems provide elements that are of interest for the SEEA-AGRI (e.g. water abstraction and consumption for agricultural activities). On the other side, FAO's datasets and frameworks, mainly Production, Resources, Food Balance Sheets (FBS) and Supply and Utilization Accounts (SUA), among others, may be completely integrated in the SEEA-AGRI tables and accounts. Furthermore, previous SNA-based FAO efforts (e.g., System of Economic Accounts for Food and Agriculture (SEAFA)) may be conceptually incorporated into SEEA-AGRI. The relationship of the agriculture related accounts (SEAFA, SUA, FBS) and the environmental related accounts (e.g., SEEA-Water, SEEA-Ecosystems, and FAO's recent work on Agri-Environmental

Figure 1: The SEEA-AGRI using SNA/SEEA and FAO datasets.



Indicators) highlight crosscutting themes that can be addressed when integrating the frameworks.

In order to achieve a well-articulated SEEA-AGRI that allows for the broadening of analysis through physical and hybrid supply and use tables, covering flows of products, residuals, natural resources and ecosystem services, the subsystem should take into account different categories of accounts of the Central Framework design:

- **Asset accounts.** These incorporate different natural assets and its changes during the accounting period in physical and monetary values. They are relevant to the measurement of sustainable development from a natural capital perspective. They also help to determine where income is arising from the use of resources and how it is apportioned between the extractor and the owner. Thus, they are relevant to the intra- and inter-generational equity issues of sustainable development. Development of the following asset accounts is sprogressing: forest assets account, fish asset account, water asset account; land cover and land use accounts.

- **Flow accounts.** These are divided into physical flow accounts and combined presentations. They provide information at the industry level (or finer depending on data availability) about the use of materials as inputs to production and the generation of pollutants and solid waste. The objective is to see the extent to which agricultural activities are dependent on particular environmental inputs and the sensitivity of the environment to particular agricultural activities. The individual SUA proposed also permit examination of issues such as food and water security and might be extended to include information related to access to water and energy for example. The following flow accounts are being prepared: Crops and livestock SUA, Fish SUA, Water SUA, Energy SUA, Farm input SUA, Forestry SUA and GHG Emissions. Combined presentations are formed from structuring information from these various SUA by type of activity and also introducing other relevant data such as output, value added and employment.

For the accounts just mentioned, in many cases, measurement in physical as well as in monetary values is possible, but in other cases (i.e. most of the agri-environmental services valuation) valuation is still a subject under discussion, noting that combined indicators are usually possible within the framework.

The various accounts will be integrated with the work on Agri-enviornmental indicators, as the indicators for the most part will flow from the accounts.

5. SEEA-AGRI developments

The United Nations Committee of Experts on Environmental Economic Accounting (UNCEEA) and the London Group on Environmental Accounting (LG) are the best forums for review and discussion towards development of agri-environmental accounting.[3] In that context, FAO Statistics Division is working with the LG — establishing a SEEA-AGRI Subgroup — to advance (and mainstream) the methodologies on environmental-economic accounting to food and agricultural statistics and the related databases maintained across FAO. The development of the SEEA-AGRI is supported by establishment of a working sub-group under the umbrella of UNCEEA/LG and a FAO-specific interdepartmental Task Force that will work to address specific issues and take the leading role in developing guidelines and recommendations. The SEEA-AGRI development strategy has been presented and discussed at the UNCEEA, London Group, the FAO regional statistical meetings such as the Asia and Pacific Commission on Agricultural Statistics (APCAS) and the FAO-OEA/CIE-IICA Working Group on Agricultural and Livestock Statistics (IICA).

Within this framework the SEEA-AGRI should ensure consistency in the classifications, concepts, definitions and policy applications through extensive and timely consultations with partner countries and at the international level. This collaboration with national experts and other specialists will facilitate piloting the SEEA-AGRI among selected countries in Africa, Asia, and the Latin America/Caribbean region. These possible country applications of an evolving SEEA-AGRI will assist in addressing those methodological aspects that still need to be resolved within the SEEA Central Framework in the context of countries where data are not necessarily accessible in terms of quantity and quality. The initial work involves relying on current data collected and available to FAO (mainly internal FAO datasets, sourced from national statistical reporting to FAO). This approach to developing the initial tables will provide us with a good indication of the possibilities of putting together the SEEA-AGRI from current data.

Development of the SEEA-AGRI accounts: The following Flow accounts are being prepared: Crops and livestock SUA; Fish SUA, Water SUA, Energy SUA, and Farm input SUA. The accounts follow the standard SEEA-Central Framework structures and principles. The various SU accounts will follow the general structure of that illustrated for maize in Table 2. These accounts are currently being prepared for all crops and livestock products for all countries and from the year 2002 to currently available data. Asset accounts: Forest Assets account; Fish Assets account; Water asset account; Land cover and land use accounts are also being prepared.

Once each of these accounts has been populated during an initial phase using data in existing FAO datasets a full stock-taking of data issues, conceptual and methodological problems is to be undertaken. Further phases in the SEEA-AGRI will be planned on the basis of these assessments.

An important aspect to be investigated is the coherence between information from an asset perspective and from a flow perspective and across different information within the same activity. For example, investigation will be needed of coherence between land use, production statistics, water use and energy use for different crops. A strength of the SEEA is the provision of an integrated framework for data confrontation. In this context, reviewing, revising and expanding the definitions and classifications used in relevant FAO datasets is an essential element of FAO efforts aimed at developing a SEEA-AGRI framework.

Similarly, a stock taking and evaluation of developing and emerging market country specific examples in terms of Agriculture, Forestry, and Fisheries accounts, respectively, that can inform and serve as an input to SEEA-AGRI development will be conducted. Alignment with other SEEA extensions and relevant regional (e.g., E.U.) work will also be established. This involves development of the related physical flow, environmental activity, and asset accounts for land, water and energy, as relevant, along with a preliminary articulation of an integrated presentation of these. Where appropriate, relevant elements of the additional portions of the SEEA, namely Experimental Ecosystem Accounting and relevant thematic documents - SEEA Water and SEEA Energy - will be used to expand and elaborate on the methodological guidance included in the SEEA Central Framework. A key feature of this initiative is the leveraging of diverse FAO datasets, datasets maintained by national authorities available on-line, and data of other international organizations and their standardization to common SEEA-related concepts and definitions pertaining to the agriculture sector, broadly defined as crops, livestock, aquaculture and agroforestry.

Pilot application and feedback: FAO will work with pilot countries from various regions. Pilot applications will illustrate the data demands, technical capabilities, and the analytical possibilities to be derived from the *minimum required, recommended,* and *desired* SEEA-AGRI datasets to be outlined in the final document prepared.

It is expected that a final draft SEEA-AGRI will be ready by the end of 2014 and then be submitted to the FAO governing bodies and subsequently to the United Nations Statistical Commission.

One of the characteristics of the SEEA is its implementation flexibility. A core *minimum required* dataset for agriculture should be conceived as a complete system which is internally consistent with the Central Framework, but designed such that it can be implemented equally well in part or in whole. Depending upon the specific issues faced, a country may choose to implement only a selection of the accounts included in the SEEA-AGRI. Even if a country desires eventually to implement the full *desired* dataset system, it may decide to focus its initial efforts on those accounts that are most relevant to the issues it wishes to address.

One of the main concerns is that a great deal of data may be required to implement the accounts pertaining to a *minimum required* dataset SEEA-AGRI and these data may not completely exist in many developing and emerging market countries. The FAO Global Strategy to Improve Agricultural and Rural Statistics (GS) will be developing Agri-Environmental indicators linked to recommended core data collections and these will need to be harmonized with the SEEA-AGRI developments. Furthermore, the accuracy of the data collected is usually filled with uncertainties. These are known shortcomings of the basic data and core indicators currently provided by countries already managed at the global level by FAO and published through FAOSTAT.

The proposed scope and coverage of the SEEA-AGRI being developed will benefit from contributions from countries and users, especially with regard to the development of indicators for specific Agri-enviornmental policy issues. The authors welcome such contributions in the development of the SEEA-AGRI.

Table 1: The SEEA-AGRI and the linkages with the dimensions of the Global Strategy to Improve Agricultural and Rural Statistics.

Dimensions of agricultural statistics data requirements	Asset accounts (SNA	Flow accounts	Expenditure and transaction accounts	Macroeconomic aggregates and indicators
Economic dimension				
Crops and livestock Forestry and logging Fishing and aquaculture	Product stocks and resource stocks, as well as capital stock such as equipment, buildings, irrigation systems.	Inputs for production, outputs production, agroprocessing, prices, finalconsumption. Value of imports and	International transfers, government expenditures, aprivate expenditures, rural expenditure, infrastructure expenditure.	GDP and NDP for the agricultural sector
Environmental dimension Water	Changes in water quality, changes in water availability	Abstraction and consumption of water by the agricultural sector and subsectors. Flows of pollutants emissions	Expenditures according to CEPA and CEM. Economic instruments and environmental transactions within the agricultural sector.	Adjustments of the macroeconomic aggregates. Depreciation by depletion, degradation and defensive expenditures accrued to the agricultural sector. Intensity and efficiency indicators of resourse use.
Land cover and use	Changes in land cover and land use (possible to register ecosystems associated with land). Changes in landscape.	Agricultural sector land use according to subsector.		
Energy	Use of stocks of agriculture food product land for biofuels.Energy plantations	Biofuels production and consumption. Firewood use.		
Climate change	Associated with land cover and land use. Changes within agriculture (i.e. from crops to livestock)	Emissions of GHGs and energy supply and use for the agricultural sector. Firewood use.		
Soil	Changes in soil composition and attributes	Soil losses and gains according subsectors.		
Wastes		Generation of waste and disposal of wastes from agricultural activities		
Biodiversity	Changes in biodiversity due to agricultural activities.	Activities within the sector that contribute to biodiversity maintenance.		
Social dimension				
Food security	Food availability, household capital stocks	Food consumption in terms of calories and nutrients available and consumed.	Public investments	Efficiency indicators and indicators of wellbeing.
Poverty reduction		Income of rural households from the agricultural sector		
Risk and vulnerability	Capital stocks	Commodity prices.		
Gender		Sex distribution factors.		

Based on WB, UN, FAO (2011).

Table 2: Crops and Livestock Supply Utilisation Account example (1,000 tonnes).

Product	Output		Total	Import	**Total Supply**	Intermediate consumption						Household consumption	Waste	Stock	Export	**Total Use**
	Ag. Industry	Manu. Industry	Output			Agricul. Ind. **(Feed)**	Seed	Energy Use	Manu. Industry	Processing	Other uses	Food		Variation		
Maize	376	N.A.	376	1	377	293	1		132				0	-55	6	377
Maize (processed)	N.A.	132	121	24	156						9	112	11			156

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Endnotes

1 See www.fao.org/economic/ess/ess-capacity/ess-strategy/en/.

2 The SEEA identifies as an environmental asset agricultural land distinguishing between i) cultivated land (for temporary crops, for permanent plantations, for kitchen gardens and temporarily fallow land); ii) pasture land (improved and natural); and iii) other agricultural land. Additionally, the SEEA recommends compiling information about irrigated land in order to establish water abstraction from agricultural production, even if this abstraction may not be associated to an economic or market transaction.

3 Additional information on the London Group and the UNCEEA in: http://unstats.un.org/unsd/envaccounting/londongroup/ http://mdgs.un.org/unsd/envaccounting/ceea/default.asp.

APN 2

Understanding the Nexus Gender-Agriculture through Better Data

Organizer and chair: Talip Kilic, The World Bank

As stated in the World Bank's World Development Report Gender Equality and Development, "While a great deal has been learned about what works and what does not when it comes to promoting greater gender equality, the truth remains that progress is often held back by the lack of data..." (World Bank, 2012). As a consequence of these data shortcomings, it is not uncommon to find unsubstantiated claims in the literature about the importance of women in the economy. This is particularly true in agriculture, where our understanding of women's role in the sector and the constraints they face in production vis a vis men remains rather limited.

The aim of this session is to present recent theoretical and empirical contributions to the field of gender analysis in an attempt to shed lights on the nexus between gender and agriculture. Papers documenting methodological innovation in the collection of gender-disaggregated data are welcome, together with empirical research highlighting the analytical advantages of collecting gender-disaggregated data, with a particular focus on agriculture.

Papers:

- Gbemisola Oseni, Paul Corral, Markus Goldstein et al. (USA), "Explaining Gender Differentials in Agricultural Production in Nigeria"
- Alberto Zezza (Italy), "Of Men, Women, and Livestock. Gender Differences in the Ownership and Management of Livestock in Sub-Saharan Africa"
- Esha Sraboni, Hazel Malapit, Agnes Quisumbing et al. (Bangladesh), "Women's Empowerment in Agriculture: what role for food security in Bangladesh?"
- Cheryl Doss, Chiara Kovarik, Amber Peterman et al. (USA), "Gender Inequities in Ownership and Control of Land in Africa: myth and reality"

Explaining Gender Differentials in Agricultural Production in Nigeria

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USA

Abstract

This paper uses data from the General Household Survey Panel 2010/11 to analyze differences in agricultural productivity across male and female plot managers in Nigeria. The analysis utilizes the Oaxaca-Blinder decomposition method, which allows for decomposing the unconditional gender gap into (i) the portion caused by observable differences in the factors of production (endowment effect) and (ii) the unexplained portion caused by differences in returns to the same observed factors of production (structural effect). The analysis is conducted separately for the North and South regions, excluding the west of the country. The findings show that in the North, women produce 28 percent less than men after controlling for observed factors of production, while there are no significant gender differences in the South. In the decomposition results, the structural effect in the North is larger than the endowment at the mean. Although women in the North have access to less productive resources than men, the results indicate that even if given the same level of inputs, significant differences still emerge. However for the South, the decomposition results show that the endowment effect is more important than the structural effect. Access to resources explains most of the gender gap in the South and if women are given the same level of inputs as men, the gap will be minimal. The difference in the results for the North and South suggests that policy should vary by region.

Keywords: agricultural productivity; gender gap; decomposition; Nigeria.

1. Gender differences in agricultural productivity

Across Sub-Saharan Africa, a range of empirical studies have found that female farmers have lower yields than male farmers. A number of reports have documented this pattern and sought to explain it (SOFA, 2011, WDR 2012). Taken together, these studies suggest constraints in every step of the production process. First, women are likely to have less land to cultivate than men, and when they do, tenure security may be weaker. Second, their access to technology, information, and agricultural extension tends to be more limited compared to men. In growing crops, women are more prone to be constrained in their access to inputs, resulting in lower levels of fertilizer, labor, and other inputs than is optimal. Management of plots may reveal constraints as well – ranging from lower levels of education to trying to juggle dual roles as farm manager and household manager.

Although this is the general perception, the reality is more nuanced with some studies finding females to have lower average productivity than males while others find no significant differences between the two groups (see Croppenstedt et al., 2013). In many instances, back of the envelope calculations show that if you normalize inputs (taking into account access to land and productive inputs), the gender gap almost always disappears (WDR 2012). These findings indicate that women are not worse farmers, but just face certain constraints that limit their productivity. However, these types of calculations do not take into consideration that returns to productive inputs also matter. Men and women could have access to the same quantity of inputs, but with different returns.

Empirical issues complicate our understanding of the link between gender and agricultural productivity. A large proportion of the studies use the gender of the household head as the gender identifier while fewer studies have been able to examine the differences in productivity at the plot level. The latter approach allows researchers to match the characteristics of the individual in the household managing plot activities to the input use and productivity of the plot. Defaulting to the household head when plot level information is not available may mask some gender differences in productivity as it is possible for other members of the household to be responsible for the day-to-day decision making on the plot other than the household head. In a study of Ugandan households, Peterman et al. (2011) conducted a sensitivity analysis comparing plot level with household head level data and found that significant gender differences at the plot level disappear at the household head level. The authors speculate that this suggests gender differences in agricultural productivity may not be revealed at

higher levels of aggregation that do not correspond to the basic decision making unit in specific farming systems. Kilic et al. (2013) is one of the few studies that have used nationally representative data to examine gender differences in agricultural productivity at the plot level. In their analysis on Malawi, they find that female managed plots are 25 percent less productive compared to male managed plots.

There is strong evidence to suggest that women have significantly less access to productive assets, such as land, credit, extension services, fertilizer, and agricultural machinery (WDR 2012). However, the evidence on the significance of this differential access in accounting for gender productivity gaps is mixed, and further research is needed to examine the extent to which the differential quantity of inputs/outputs used/produced by female and male farmers (such as land) and gender differences in input prices may impact productivity gaps. Also, it seems likely that the choice of unit of analysis (gender of household head or gender of plot farmer/owner) has significant impact on study results, with plot level analysis appearing to capture more of the gender productivity gap.

In this paper, we examine gender-based productivity differences in Africa's most populous country, Nigeria. We bring to bear a nationally representative data set to examine first, if such a cross-gender productivity differential across plots exists in Nigeria, and second, to examine which factors in the production process seem to be driving it. Nigeria represents a particularly interesting case due to differences in the North and South regions of the country. The analysis is conducted separately for these regions based on the hypotheses that agro-ecological and socioeconomic conditions differ so substantially that gender differences are also likely to vary. To carry out this analysis, we utilize the Oaxaca-Blinder decomposition method which allows us to decompose the gender gap into (i) the portion due to observable differences in the factors of production (endowment effect) and (ii) the unexplained portion due to differences in returns to the same observed factors of production (structural effect). This method further allows us to identify the contribution of each of the factors of production to (i) and (ii).

The few studies on Nigerian gender differentials have focused on particular states or regions of the country and most have used household level data (Peterman et al., 2011; Timothy and Adeoti, 2006; Oladeebo and Fajuyigbe, 2007). Peterman et al. (2011) use data collected as part of an evaluation of the second phase of the World Bank sponsored National Fadama Development Project covering 12 Fadama states in northern Nigeria. Using household level data, the authors find persistent lower productivity among female headed households, even when accounting for a range of socio-economic variables, agricultural inputs and crop choices (Peterman et al., 2011). They also found that the results vary across crops as well as by agro-ecological zone in Nigeria and inclusion of biophysical characteristics, suggesting either cultural or regional gender differences or crop-specific comparative advantages that interact with productivity and gender. Timothy and Adeoti (2006) use a Cobb-Douglas production function to analyze data on cassava farmers in Ondo and Ogun states in Nigeria and their results suggest that while female farmers are more economically efficient than male farmers, male farmers have higher average technical and allocative efficiency than female farmers. While the study by Oladeebo and Fajuyigbe (2007) conducts its gender analysis at the plot level, the study was carried out exclusively on data for the tropics in Osun State, South-western Nigeria. The authors found that women farmers are more efficient technically than men farmers with mean technical efficient indices of 0.904 and 0.897 respectively, but the difference is not significant.

In this study, we find that women in the North produce 28 percent less than men after controlling for observed manager characteristics and factors of production—a result that is very similar to the Peterman et al (2011) who find a 32 percent difference. In our decomposition results, we find that the unexplained portion of the gender gap in the North is bigger than the explained portion at the mean. Although women in the North have access to less productive resources than men, the results indicate that even if provided with the same level of inputs, significant differences may still emerge. Of course women in the North will definitely benefit from additional inputs, like fertilizer and labor, if their land size were to remain the same.

In the South, even though we find an unconditional gap of 24 percent between the productivity of male and female plot managers, this disappears once we control for observed factors of production and becomes statistically insignificant. This result mirrors the lack of statistically significant differences found by Oladeebo and Fajuyigbe (2007) in South-western Nigeria. When we decompose differences, in the South we find that the endowment effect is more important than the structural effect. Access to resources explains

most of the unconditional gender gap in the South, and if women are given the same level of inputs as men, the gap diminishes. In general, while men may use more fertilizer and labor on their agricultural plots than women, they do not seem to be using enough proportional to their land size. Women could do with more inputs like fertilizer and labor and if not for the large diseconomies of scale in land size, the gap between men and women would be much wider.

The remainder of the paper is organized as follows. Section 2 briefly notes the context and data used in the analysis, providing descriptive statistics for the North and South. Section 3 provides an assessment of gender differentials following common approaches to discerning the source of male and female productivity differences. Section 4 provides insight into the relative importance of different factors in explaining gender differences using a Oaxaca-Blinder decomposition. These differences are explored more fully in Section 5 using a re-centered influence function (RIF) which examines this differential across the distribution. Robustness checks of the results are presented in Section 6 and conclusions in section 7.

2. Context and data

According to the Nigeria National Bureau of Statistics (NBS), agriculture employs about 60 percent of working population and contributes about 40 percent to GDP. With a population of almost 160 million people, Nigeria has 91.1 million hectares of land with agriculture taking up 83.6 million hectares of which 33.8 percent is arable land, 2.9 percent is permanent crops, 13 percent is forest or woods, 47.9 percent is pasture, and 2.4 percent is irrigated (Phillip et al., 2009). Nigerian agriculture is characterized by small scale farmers, who mostly practice subsistence farming with little commercialization, producing common food crops such as millet, maize, sorghum, cassava, yams, and beans.

Nigeria is divided into six geopolitical zones[1], three in the North (North east, North west and North central) and three in the South (South east, South west and South south). Agriculture is more common in the north with over 80 percent of households engaged in the sector compared with about 50 percent of households in the south. Although Nigeria has recorded increasing agricultural growth in the past decade, much of the growth has been attributed to the farming of larger tracts of land by commercial farmers rather than increased productivity among small farms. According to the latest poverty reports, 46 percent of the country can be classified as poor and the poverty incidence is highest in the agricultural sector (Phillip et al, 2009).

Like many other countries in Africa, women in Nigeria have broadened and deepened their involvement in agricultural production in recent decades (WDR, 2008). Although men dominate the sector in Nigeria, a large share of women also participates across the agriculture value chain; as they are involved in production, processing, and sales. Overall, 48 percent of female headed households participate in the agriculture sector and, in the rural areas; almost 70 percent of female headed households are involved in the sector[2]. While there is debate in the general literature on gender and agricultural productivity as to the contribution of the differential use of inputs in explaining productivity gaps, it is certainly true across a range of countries that women tend to have lower levels of usage of various productive assets (see for example Croppenstedt et al. 2013). This is also true in the case of Nigeria. Despite their significant role in agricultural production, earlier work on Nigeria has shown that women have relatively limited access to agriculture land and lower levels of inputs and use of extension services compared with men (Phillip et al., 2009).

Taken together, these constraints could limit women's productivity relative to men. For instance, lower access to credit is thought to impact women's ability to engage in more productive irrigation farming, as this requires more expensive equipment and labor (Porter and Philips-Howard, 1997). In addition, women's lower levels of agency and decision-making power may negatively impact their ability to benefit from their activities in the agriculture sector, as well as in other areas of their lives.[3]

To assess these gender differences, this paper uses data from the General Household Survey-Panel (GHS-Panel) conducted in 2010/11 by the Nigeria National Bureau of Statistics (NBS) in collaboration with the World Bank Living Standard Measurement Study (LSMS) team. The GHS-Panel survey is modeled after common LSMS surveys and is representative at the national, zonal and rural/urban levels. The total sample is made up of about 5,000 households, out of which about 3,000 are agricultural households, covering all thirty-six states in the country and the Federal Capital Territory, Abuja.

One of the main objectives of the GHS-Panel is to improve agriculture data collection in Nigeria by collecting information at disaggregated levels, including at the crop, plot, and household levels. Households were visited at two points in time; right after planting (post-planting visit) and right after harvest (post-harvest visit). During the visits, information was gathered on the household demographic structure, education, labor, assets, and farm and nonfarm income generating activities. One of the advantages of the agriculture modules in the survey is that they allow us to identify the manager of each individual plot farmed by the household. When combined with the demographic and other types of information in the household modules, we are able to determine the gender and socio-economic characteristics of each manager instead of simply using the household head as the default plot's manager. Handheld Global Positioning System (GPS) devices were used to collect information on plot sizes and the location of households, which allows not only a more accurate measure of land size but an ability to link the data with geospatial variables from other data sources.

The analysis in the paper focuses on 2,431[4] agricultural households farming 4,240 plots with GPS plot measurement over 100 square meters and information on plot manager's age and education level. Of the 4,240 plots, 15 percent were managed by females.[5] It is also common for plot managers to manage multiple plots, with 65.7 percent of managers managing more than 1 plot. Not unexpectedly, this is more common for male managers.[6] Table 1 shows the distribution of the plot manager's gender by the six geopolitical zones in the country. As seen from the table, there are more female managers in the Southern zones compared to the Northern zones. The South East zone has the highest proportion of female managers and the North West zone has the lowest proportion.

Given the few female managed plots in the North West and South West in our sample, our analysis excludes the West of the country. We also exclude Niger and Abuja states because there are no female managed plots in our sample in these two states, reducing our sample size to 2,995 plots. In addition, our preliminary analysis shows significant differences between the North and South of the country, reflecting the general socioeconomic and agro-ecological differences across the two regions. For these reasons, we analyze the North and the South separately given the expectation that they differ.

Although agriculture production information was collected at the crop level, the crop harvest values are aggregated to the plot level in order to estimate production for each plot. Productivity is measured as the monetary (Naira) value of all crops grown on the plot under the manager's purview.[7] Table 2 presents the average productivity for male and female managers in Nigeria and separately for the North and South regions. Tables 3 and 4 provide the summary statistics of the value of plot harvest per hectare, the relevant explanatory variables, and the results of the test of mean difference between the male and female managers for the included North and South regions, respectively.

North Central and North East

Looking at the North Central and North East regions (Table 3), the value of harvest on male managed plots is higher (₦134,689) and significantly different from the value of harvest on female managed plots (₦50,629). However, when we control for plot size by putting the value per hectare, the difference is not as wide (but still statistically significant at the 10 percent level) with average male value of harvest per hectare at (₦454,075) compared with female managed plots at (₦293,688). This can be viewed as the unadjusted gender gap observed in the North where productivity of female managed plots is 35 percent lower than that of male managed plots. This difference is what we would like to explain in the subsequent analysis.

Differences in productivity may be due to differences in characteristics of male and female managers and in Table 3, we observe statistically significant differences between managers in a host of socio-demographic characteristics. Female managers are more likely to be non-Muslim, have less years of schooling, more likely to live in households with a smaller adult labor pool (ages 12-60) and also have fewer child dependents. Differences can also be observed in plot sizes with female managed plots 42 percent smaller on average than male managed plots. The average plot size of female managed plots is 0.5 hectares, while that of male managed plots is 0.9 hectares.

Another reason for differences in productivity may be in the use of inputs. In terms of non-labor inputs, male managers are more likely than female plot managers to employ the use of fertilizer, herbicide and pesticide on the plots they manage. The incidence of fertilizer use is 40 percent for male managed plots compared to 19 percent for female managed plots. The quantities of fertilizer used on

male managed plots are also larger than those on female managed plots. However when we normalize by plot size, the difference is no longer statistically significant. The log value of agriculture capital per hectare[8] owned by households of male managers is 15 percent higher than the value of the capital owned by households of female managers but the difference is not significant. Given these factors, it is surprising to find that, female managed plots are more likely to grow cash crops[9] than male managed plots with 17 percent of plots managed by females growing at least one cash crop compared to 13 percent of male managed plots, but the difference is not significant.

Labor inputs are categorized into family (men, women, and children) and hired labor (men, women, and children). Male managed plots are more likely to use male family labor (85 percent) than female managed plots (48 percent). They also get more days of male labor on average, but this difference is not significant once we control for plot size. On the other hand, female managed plots are more likely to use female family labor (73 percent) compared with male managed plots with 52 percent. Female managed plots also get more days of female family labor than male managed plots, even when controlling for plot size. In terms of labor from outside of the household, female plot managers are more likely to use male hired labor. Once we normalize for plot size, however, male plot managers use more male hired labor than female plot managers, but the difference is not significant.

South East and South South

Although for the South East and South South regions we also observe differences in value of harvest per hectare favoring male managed plots (Table 4), the difference is not statistically significant. However, we still want to understand the factors influencing where differences do occur and again provide descriptive statistics of the characteristics of managers and input use.

In the two southern regions, female plot managers are more likely to be non-Muslim and have less years of schooling compared with male managers. Male managers are more likely to be from households with larger family sizes and have significantly more household adult male and female labor pool.

Unlike the North sample, significant differences in the land size managed by male and female plot managers are not found. On average, male managers are from households who used extension services and have higher value of agricultural capital. While we do find that men are more likely to use herbicide, we find no differences in fertilizer, herbicide or pesticide use per hectare between male and female managed plots. However, we do find significant differences in the use of labor. Male managed plots are more likely to use male family labor and have significantly more days of male family labor compared with female managed plots. Although, female managed plots are more likely to use female family labor, there is no statistically significant difference between days of female family labor used on plots between the two groups. For hired labor, male managed plots are more likely to use hired male labor and have significantly more days of hired male and female labor. However, once we normalize for plot size, these differences in days of hired labor are no longer statistically significant.

3. Assessing gender differentials

The traditional method for examining differences in agriculture productivity between men and women is by estimating a yield function that models the value of output per hectare as a function of a set of factors that influence production as well as an indicator of the gender of the plot manager (Quisumbing, 1996). The motivation for taking this approach is to determine if any differences between male and female managed plots can be explained through factors other than gender (although they may, in turn, be driven by gender relations). A common approach in the literature is to use the gender of the head as the gender indicator, but with the GHS-Panel data we are able to identify the gender of each plot manager within a household. This allows the use of the manager's gender rather than that of the household head who may not be the primary decision maker on the plot. We examine the yield function for plot i under the management of plot manager j:

$$y_{ij} = \alpha + \gamma g_j + \sum_{h=1}^{H} \pi_h c_{jh} + \sum_{k=1}^{K} \varphi_k l_{ijk} + \sum_{q=1}^{Q} \omega_q s_{ijq} + \sum_{r=1}^{R} \rho_r x_{ijr} + \sum_{t=1}^{T} \theta_t z_{ijt} + e_{ij} \quad (1)$$

Where y is the natural logarithm of plot i's harvest value per hectare obtained by manager j, α is the unknown constant term to be estimated, g is the manager's gender (gender dummy), c is the set of H individual characteristics of manager j, l is the set of the K plot characteristics, s is the set of Q cropping strategies, x is the set of R inputs utilized on the plot, z is the set of T different labor types used on the plot, and e is the random error term assumed to be independently and identically distributed as $N(0, \sigma^2)$.

The gender of the plot's manager is the variable of interest. In our initial multivariate examination, we use a progressive approach (including additional control variables to the model in each step) to try and explain the gender difference in productivity. The logic of this approach is to identify if and how each set of factors influences the conditional gender differential. The initial step (step zero), which we refer to as the naïve regression, only considers the manager's gender as the sole covariate regressed against the value of the plot's harvest with no location fixed effects. The first step includes state fixed effects to control for location differences. The second step includes the manager's characteristics, such as age, education level, household aged labor, and participation in non-farm activities. The third step includes the plot size and plot characteristics. The fourth step includes the cropping strategies adopted by the manager (cash crop grown on the plot and number of crops grown on the plot). The fifth step adds the quantity of inputs into the model. Finally, family and hired labor are added to the model in the final step.

Following the previously reported evidence suggesting regional variation in the gender productivity relationship, the model is estimated for the North and South regions separately. The results are displayed in the same order as described in the preceding paragraph for the North and South in Tables 5 and 6, respectively. The first seven columns display the step-wise results of the pooled sample. For comparison, and as a reference for the subsequent analysis, columns 7 and 8 show the results for male and female managed plots separately.

North Central and North East

In column zero of Table 5, the result of the naïve regression estimating the effect of the manager's gender on productivity show no statistically significant difference in productivity between male and female managed plots. The inclusion of the state fixed effects (column 1) or of the manager's attributes (column 2) also indicate no statistically significant differences between the two groups. Statistically significant differences in productivity emerge in column 3 after plots' sizes are included. The effect of land size and land size squared are both negative and strongly significant, indicating that productivity declines with land size. This follows the common inverse relationship between land size and productivity observed in other studies (e.g. Carletto et al., 2013). As can be seen in Figure 1a and in the mean land values in Table 3, female managed plots are smaller than those managed by men. Once we control for land size, we see a difference in productivity indicating that gender differences observed in the North are masked in our initial regressions because women manage smaller size plots.

Although this conditional gender gap observed after controlling for land reduces in size when we add other key factors of production such as labor, capital and other inputs (columns 4-6), the gap still persists. In column 6, we observe a conditional estimated gender gap of 27.4 percent for the North. We find that the number of adults in the household (both male and female) have positive effects on productivity. As expected, the quantity of fertilizer used and the value of agriculture capital owned by the household also have positive associations with productivity. Amongst the labor inputs, days of hired male labor is positively related to agricultural productivity. Interestingly, we find that growing only one crop on a plot (as opposed to multi cropping system) is associated with significantly lower productivity.[10]

In columns 7 and 8 we display the results of the female managed plot sample and male managed plot sample respectively. Overall the results of the individual regressions point to fundamental differences in the factors that influence productivity on male and female plots in these two regions of northern Nigeria. Age appears to have a positive and significant effect on productivity on female managed plots, but the effect becomes negative for older women. However, the age of the manager does not appear to be important for yields on male managed plots. Being a non-Muslim female manager has a sizeable and negative effect on productivity on female plots but the effect is not significant for male managed plots[11]. The number of adults in the household is found to have a positive and significant effect on male agricultural productivity but is not statistically significant for females. Growing a cash crop has a positive and significant coefficient for female managed plots but it is not significant for males while growing only one crop on the plot has a negative effect for the male sample but is not significant for females. Although the quantity of fertilizer used is positive for both male and female managed plots, fertilizer is not significantly related to productivity on female managed plots. The use of purchased seed has a significant negative effect on male agricultural productivity but is not significant

for female managed plots. While the effect of agriculture capital and days of hired male labor is positive and significant for both male and female managed plots, the returns to both covariates is higher for female managed plots.

South East and South South

The analysis of gender differences in the South present a different picture than the North. First, the results of the naïve regression for the South (Table 6, column zero) show that male managed plots have higher productivity than female managed plots and the gender coefficient is statistically significant at the 10 percent level. Yet, the results are not statistically significant in any of the other specifications. The inclusion of state fixed effects (column 1) reduces the magnitude of the gender difference and makes it insignificant suggesting gender differences are a remnant of regional variation in productivity. The inclusion of additional variables in this case does not unmask underlying gender differences.

Column 6 shows the full model with all the key factors of production. The number of adult females in the household has a negative effect on productivity but we find a positive effect for adult males in the household. As expected, log of land size in hectares has a negative effect on productivity showing the same diseconomies of scale observed in the North sample. As with the Northern sample, growing only one crop on the plot is associated with significantly lower productivity. The coefficients of log of quantity of fertilizer and herbicide used per hectare are positive and have a statistically significant relationship with productivity. However, the log of pesticide per hectare has a negative association with productivity. We also find that the log of agricultural capital per hectare has positive relationship with productivity. The only labor input with a statistically significant effect for the pooled southern sample is log of male family labor days per hectare which has a positive relationship with productivity.

Columns 7 and 8 of Table 6 show the results for female only and male only sample in the South, respectively. As with the results for the northern regions of Nigeria, in the South we do find fundamental differences in relationships on male and female plots. The number of adult males in the household has a positive effect on productivity but only for the male sample. For the female managed plot sample, we find that plot distance to the household has a positive effect on productivity. This is probably because plots farther from the household are more likely to be bigger compared to those closer to dwellings. Log of fertilizer and herbicide use per hectare are positive and statistically significant for both male and female managed plots but the effect is larger for male managed plots. The coefficient of log of pesticide use per hectare has a negative effect for male managed sample but it is not significant for the female managed sample. In terms of labor inputs, we find the log of male family days per hectare and hired male labor per hectare to be positive and statistically significant for male managed plots but no labor input was significant for the female managed sample. Although these differences emerge, in contrast to the North, in this case, the differences do not appear to translate into significant overall gender differences in productivity.

4. Decomposing gender differentials

The previous analysis helps to identify the factors that explain the difference between productivity on male and female managed plots, but does not isolate the relative importance of the different factors. To gain insights into the importance of these factors, we follow Kilic et al. (2013) and decompose the yield gap using the Oaxaca-Blinder decomposition method[12] as described in Blinder (1973) and Oaxaca (1973). This model allows for the quantification of the contributions of the explanatory variables to the productivity differential for male and female managed plots. In the absence of an advantage to any particular group, the expected values for the coefficients for each group must be the same. Therefore, the only source for observed yield differences between groups should be based on differences in inputs or characteristics.

If the covariates from our aforementioned production function (equation (1)) are taken as a single (N[13]x1) vector X[14] that encompasses the above mentioned explanatory variables except for the plot manager's gender, the expected harvest value per hectare on a plot for a manager of either gender ($g = m, f$) is:

$$E(y_g) = \alpha_g + E(X_g)'\beta_g \quad (2)$$

Where g is used as a subscript to designate male (m) or female (f) plot manager. The intercept term is α and β[15] is a ($N\times1$) vector of the slope parameters (coefficients) corresponding to each explanatory variable. Note that the above equation assumes that $E(e_g) = 0$. The mean outcome difference between

male and female plot managers may now be expressed as the difference between the expected plot harvest values for each gender. The difference (i.e. gender gap) is:

$$Gap = E(y_m) - E(y_f) = \alpha_m + E(X_m)'\beta_m - \alpha_f - E(X_f)'\beta_f \quad (3)$$

Oaxaca (2007) comments on the importance of determining the source of the gap which comes from differences in the characteristics (i.e. explanatory variables) and the amount attributable to the parameter gap. Obtaining the "two fold" difference requires including in the above equation the nondiscriminatory coefficients, as noted by Jann (2008). The nondiscriminatory coefficients are those obtained from the pooled (i.e. combined) expected plot harvest value, which also includes the gender dummy (g). The gender dummy incorporates the possibility of each gender's plot harvest value lying on a different curve (Jann, 2008). The pooled expected plot harvest value (y_{ij}) is then:

$$E(y_{ij}) = E(y) = \alpha + \gamma g + E(X)'\beta^* \quad (4)$$

where β^* is the vector of nondiscriminatory coefficients. This is the methodology preferred by Jann (2008) for obtaining the nondiscriminatory coefficients. Fortin (2006) comments that this is compatible with the practice of including a dummy variable denoting the group of interest in a pooled regression, in order to investigate the difference between groups as in equation (1). By including this result into the gap equation it is possible to obtain the "two-fold" decomposition:

$$Gap = Q + U \quad (5)$$

Where Q is referred to the part "explained" by the group differences in the explanatory variables (Jann, 2008). Fortin et al. (2011) refer to this as the composition effect and is equal to:

$$Q = \left[E(X_m)' - E(X_f)'\right]\beta^* \quad (6)$$

According to Jann (2008) the remaining part (U) is the "unexplained" part and this is attributed to discrimination (or differences in returns). The reason for referring to it as "unexplained" is due to there being a possibility of omitted variables and thus bias in the estimates (Oaxaca, 2007). Fortin et al. (2011) also refer to this portion (U) as the structure effect, which is equal to:

$$U = (\alpha_m - \alpha) + [E(X_m)'(\beta_m - \beta^*)] + (\alpha - \alpha_f) + \left[E(X_f)'(\beta^* - \beta_f)\right] \quad (7)$$

This equation can be subdivided into two distinct parts. One part quantifies the discrimination in favor of one group (or the structural advantage), in this case males:

$$U_m = (\alpha_m - \alpha) + [E(X_m)'(\beta_m - \beta^*)] \quad (7a)$$

The other part, which quantifies the discrimination against (or the structural disadvantage) the other group, in this case females:

$$U_f = (\alpha - \alpha_f) + \left[E(X_f)'(\beta^* - \beta_f)\right] \quad (7b)$$

This method then discerns the portion of the gap which may be due to differences in inputs or characteristics, and the differences due to the structural effect. The structural effect permits the disaggregation of a possible advantage for males and a possible disadvantage for females. Thus, the method estimates a yield structure which is not obligatorily identical to that of either group (Oaxaca, 2007).

As with the previous analysis, the decomposition model is estimated for the North and South regions separately. The results are displayed in Tables 7 and 8, respectively, with results shown for the mean gender differential, the aggregate decomposition and the detailed decomposition.

North Central and North East

Given the change from a small insignificant gender gap in the unconditional (naïve) regression to a conditional gap of 27.4 percent when we control for the key factors of production, understanding the factors that are associated with this gap is important. Although the decomposition results do not offer a causal effect of the covariates on productivity, it allows us to delve deeper into how different factors contribute to the gender gap.

The estimates in Table 7 are a function of the mean differences reported in Table 3 by the gender of plot manager and the pooled regression coefficients reported in column 6 of Table 5. The observed mean gender gap (same as the naïve regression result) of about 4 percent (in favor of male managed plots) is not significant. However, aggregate decomposition components; the portion of the gap due to the differences in average characteristics from Table 3 (endowment effect as shown in equation 6) and the portion due to differences in returns shown in columns 7 and 8 of Table 6 (unexplained factors as shown in equation 7) are both significant. So for the North, in the decomposition result we find the explained portion is -24 percentage points (statistically significant) due to difference in endowments and unexplained portion is 27.4 percentage points (statistically significant).

Gender disparities in the North are driven more by the unexplained factors than by the observed characteristics. The unexplained portion is further disaggregated into the male structural advantage (equation 7a) and female structural disadvantage (equation 7b).

To understand the factors that contribute the most to the different components of the gap, we start with the endowment effect which as mentioned previously is the portion of the gap that is due to differences in levels of observed variables of male and female managed plots. In the disaggregated panel (Table 7, Panel C), we can identify the variables that contribute the most to the endowment effect. A positive coefficient widens the gender gap while a negative coefficient reduces the gender gap.

In the summary statistics table (Table 3), we observed that men tend to live in households with a larger household adult labor pool, have higher incidence of fertilizer use, and are more likely to use hired labor than female managers. Not surprisingly, we find that these factors contribute positively to the endowment effect and thus widen the gender gap. Since women have smaller plot sizes (Table 3) and we find an inverse relationship between land and productivity (Table 5), this contributes negatively to the endowment effect and thus reduces the gap. In fact, land is the factor that contributes the most to the endowment effect. Overall, this reinforces the earlier observation that the gender difference is masked in an overall analysis because women manage much smaller plot sizes, which generally have higher productivity.

Moving on to the unexplained portion of the gap which shows the return to each factor of production, we find that overall, the returns to factors of productivity is lower for women. Older women seem to face a substantial disadvantage. Similar effects are found for older males, but the effects are not as large. While female managers tend to be older, there is no immediate explanation for the source of this disadvantage. However, it is worth noting that female managers are more likely to be widowed and hence older. Since we are controlling for inputs, we can rule out any direct contribution from inputs such as the quantity of land, command over labor, and other inputs. Thus, whatever is driving this disadvantage must stem from some more indirect source. This finding could benefit from further research. Being a non-Muslim female manager in the North also shows a positive contribution to the structural disadvantage, thus widening the gap. Further examination (not shown here) shows that this is possibly capturing location-specific effects since many of the non-Muslim female managers in the North reside in enumeration areas where few Muslims reside.

Participation in a nonfarm activity has a negative coefficient for female structural disadvantage. In Table 3, we did not find a significant difference in nonfarm participation for male and female managers but it appears that the return to participation in these activities generates a higher return in agriculture for women than it does for men, thus working towards reducing the gap. Looking at the number of adult females in the household, women appear to have a lower return to more adult females in the households than men, and this widens the gap. Women have higher returns from growing cash crop, planting multiple crops on their plots, and using purchased seeds than men, thus working towards reducing the gender gap. Given these results, an expansion of commercial agriculture, including cash crops, would have a positive overall impact on women's production and, all else equal, would help to close the production gap.

In summary, women in the North lack an adequate adult labor pool, could do with more fertilizer, and more hired labor. Given the large diseconomies of scale observed, if women in the North farmed the same plots size as men, the gap would be bigger, all else equal.

South East and South South

Table 8 presents the decomposition results for the South on the differential in log of value of output per hectare between male and female managers. The estimates are a function of the mean differences reported in Table 4 and the pooled regression coefficients in column 6 of Table 6. Although once we control for factors of production, we do not observe a statistically significant difference in productivity of male and female managed plots in the South, it is still important to decompose the unconditional gender gap of 24 percent (statistically significant at the 10 percent level) to understand the factors that contribute to the gap. The aggregate endowment effect is significant but the portion of the gap due to unexplained factors is not significant. The gender differences in South are largely driven by endowments effects unlike our findings in the North that were more driven by the structural effect.

Looking at the disaggregated decomposition of the endowment effect, we find that household adult

female size contributes negatively to the endowment effect, thereby reducing the gap. In Table 4 we found that male managed plots in the South are bigger than plots managed by female managers but the difference was not statistically significant. However, as in the North, land contributes negatively to the endowments effect and has the most sizable effect of all the covariates. The log of herbicide use per hectare widens the gap and contributes positively to the endowment effect. In the summary statistics of Table 4, male managed plots do have more access to these factors than female managed plots. We also observe strong location effects contributing positively to the endowment effect in the South, thereby widening the gap (this comes from the state fixed results which are not displayed in the table due to space constraints).

In the structural effects disaggregated results, we find that age squared has a sizable positive and significant contribution to the female structural disadvantage, thus widening the gap. Further examination suggests this may be capturing the effect of being a widow. As in the North, most of the female managers in the South are widowed and the widows are more likely to be older. The child dependency ratio contributes positively to male structural advantage and widens the gap – that is, males seem to get a higher return from having more children relative to adults than women do. We also find that schooling contributes negatively to the male structural advantage. While the summary statistics indicate that men have higher levels of education than female plot managers in the South, this result indicates that that schooling is giving them a lower return relative to women.

In summary, even though having more female adults in the households reduces the gap, we find that having more days of female family labor widens the gap. Women in the South could also do with more herbicide. Moreover, older women in the South appear to be at a disadvantage. On the other hand, males with higher education are relatively disadvantaged, while those with more children in their household are at more of an advantage.

5. Re-centered influence function (RIF) decomposition

The Oaxaca decomposition detailed above provides results for the average plot manager, and thus provides a mean outcome difference between male and female managers. While having this provides an average relationship, we would like to observe how the relationship differs across the distribution. A regression method proposed by Firpo, Fortin and Lemieux (2006) permits evaluation of the relationship across the distribution in a manner that is similar to a standard regression except that the dependent variable is replaced by the re-centered influence function of the statistic of interest. This model can be used to infer the impact of the independent variables on a specific statistic. The re-centered influence function (RIF) is defined as:

$$RIF(y;v) = v(F_y) + IF(y:v)$$

Where y is the dependent variable to be replaced by the estimated $RIF(y;v)$, here y can be replaced by either y_{ij}, y_m or y_f depending on our need[16], $v(F_y)$ is the distributional statistic of interest, in this case quantiles. The last term to the right ($IF(y:v)$), is the influence function corresponding to an observed value of y for the distributional statistic $v(F_y)$ and is equal to:

$$IF(y;v) = \frac{\tau - \mathbf{1}\{y \leq v(F_y)\}}{f_y(v(F_y))}$$

Where τ is the quantile of $v(F_y)$, $f_y(v(F_y))$ is the density of the marginal distribution of the dependent variable (y), and $\mathbf{1}\{y \leq v(F_y)\}$ is an indicator function equal to 1 if the term inside the brackets is satisfied and 0 if not.

Firpo et al. (2006) lay out the methodology in order to compute the RIF and proceed to run the regressions detailed above replacing the dependent variable with the RIF values. Initially the RIF must be estimated separately for each gender. The RIF is calculated using the calculated sample quantile and the estimated density at the point utilizing kernel density methods. Once the estimated RIF is obtained, it is used as the dependent variable in the Oaxaca decomposition detailed above.

North Central and North East

Table 9 presents the RIF results for the North and includes the results of the mean decomposition from Table 7 for comparison. We find significant results across many of the deciles for the endowment and female structural advantage components just as in the mean decomposition. In general, the endowment effect increases across the agricultural productivity distribution. The effect is not significant for the lower part of the distribution, becomes significant

with estimated values in the range of -0.18 to -0.24 for the 30th to 70th percentile and then increases even more in the highest two deciles (-0.30 and -0.42). The share attributable to the female structural disadvantage varies in significance. In the middle of the distribution (40th to 60th percentile), it is significant and in the range of 0.21 to 0.34 and again is large and significant at the highest percentile of the distribution. At the 50th percentile (median), the share of the gap attributable to female structural disadvantage exceeds that of the endowment effect. However, for the highest decile, the endowment effect exceeds the female structural disadvantage component of the gender gap. This suggests that among the more productive women in the North, resources (rather than the return to resources) matters more.

Table 10 presents the detailed RIF decomposition results for only the 10th, 50th, and 90th percentiles to conserve space. One key finding in the endowment effect for the North is that women's land sizes are so much smaller than men's that the negative contribution of log of land in hectares to the endowment effect overshadows the positive contributions of other factors, thus significantly diminishing the gap between male and female managed plots. Similar to the findings in the mean decomposition, log of fertilizer use per hectare contributes positively to the endowment effect thus widening the gap and is statistically significant for all deciles except for the highest decile. In addition, male hired labor contributes positively to the endowment effect all across the distribution while male adult labor pool in the household contributes significantly to the endowment effect at the 10th, 40th (not shown), and 90th percentile. These findings are similar to what we find at the mean indicating that fertilizer and male labor are the main factors that favor male productivity and if not for the large diseconomies of scale in land size, the gap between men and women will be much wider.

Looking at the female structural disadvantage, the effect of age squared found at the mean is also found at the lowest deciles but from the median and higher, it is no longer significant indicating that at the higher productivity deciles, older women face less of a disadvantage compared to the lower deciles. The non-Muslim effect observed at the mean decomposition is not significant for any individual decile. At the top two deciles, the household female adult pool contributes positively to the male structural advantage and female structural disadvantage, thus widening the gap. Interestingly, from the median upwards, log of herbicide use per hectare contributes negatively to female structural disadvantage indicating that returns to herbicide use is higher for women and is significant for the top 5 deciles except for the last.

South East and South South

Table 11 presents the aggregated RIF decomposition results at the mean, and at each decile of the productivity distribution for the South. The portion of the gap attributable to the endowment effect varies across the agricultural productivity distribution, with a large significant positive endowment effect in the lowest three deciles (0.75 to 0.92) a moderate significant effect in the middle of the distribution (0.20 to 0.42) and an insignificant effect in the highest three deciles. This is unlike the findings in the North where the endowment effect tends to be largest at the higher end of the agricultural productivity distribution.

Table 12 presents the detailed RIF decomposition at the 10th, 50th, and 90th percentiles (to conserve space). Across the productivity distribution, household adult female pool coefficient is statistically significant and contributes negatively to the endowment effect for the top two deciles, thereby reducing the gap. As expected, log of land owned in hectares contributes negatively to the endowment effect at all points in the agricultural productivity distribution. However, the effect is highest for the lowest decile and reduces along the productivity distribution. Just like in the mean decomposition, the coefficient of log of herbicide use per hectare is statistically significant and contributes positively to the endowment effect across the productivity distribution except at the 40th and 90th percentiles. We have similar findings for the log of female family labor days per hectare which is statistically significant across the distribution except for the top two deciles and widens the gender gap.

At the 10th percentile, child dependency ratio contributes positively to male structural advantage and female structural disadvantage thereby widening the gender gap. Male managed plots tend to benefit more from having more children in the household than female managed plots. At the median, we find that schooling contributes negatively to both male structural advantage and female structural disadvantage. However, similar to our findings at the median, men get a lower return to schooling relative to women thus reducing the gap.

6. Robustness checks[17]

One of the violations of the assumptions of the decomposition method is omitted variable bias. There may be some unobservable characteristics that jointly determine agricultural productivity and the gender of the plot manager and other covariates. Given the limitation associated with using a cross sectional data and unavailability of an adequate instrumental variable, we follow Altonji et al. 2005 to assess the possibility of omitted variables. This is done by including additional covariates grouped by topic to our base model to test for the robustness of our specification. The expectation is that if the coefficients of the variables in our base model including the dummy variable for gender are largely unaffected, then it is unlikely that any unobservable characteristics not accounted for in the model will affect our main results. The following additional covariates were included (i) additional manager characteristics, (ii) additional plot characteristics, (iii) geospatial variables, (iv) crop fixed effects and (v) community level variables.[18] The results for the pooled regression, female only, and male only are presented in Tables 13-15 for the North and Tables 16-18 for the South, respectively. Largely, we found the estimates to be consistent in significance and sign across all models suggesting the robustness of our main results.

We carried out further robustness checks by looking at the sample of managers who grow certain common crops in the North (maize, sorghum and beans) and South (maize, cassava, and yam) using the quantity of harvest in kilogram. In the North we found that amongst managers growing maize, women produce 40 percent less than men. The estimates for the other crops were statistically insignificant.

As mentioned in the review of evidence, many studies examine gender differences in productivity using the gender of the household as the gender identifier. We explore the possibility that headship could affect productivity differences and thus examine the gender differences between plot managers who are also heads of households.[19] Again, this analysis is conducted separately for the North and the South (excluding the West) and corresponds to sensitivity analysis of column 1-6 of tables 5 and 6. We find that women plot managers who are also heads of households are 40.2 percent less productive than male managers who are also head of households. The gender difference is not significant for the South. Alternatively, we aggregated our analysis to the household level assigning the characteristics of the head. We found a much bigger gap at the household level in the North with a gap of 50 percent.[20] This could indicate that female managers in female headed households are worse off than female managers in male headed households. The difference remains insignificant for the South.

Given that 56 and 34 percent of male managers and female managers manage at least two plots respectively, we also examine productivity differences at the manager level by aggregating yield for each manager. We find that the gender differences are higher at the manager level compared with the plot level for the North. In the North region, male managers are 37.5 percent more productive than female managers while the results for the South are still insignificant even at the manager level.

7. Conclusion

In this paper, we examine gender-based productivity differences in Nigeria using a nationally representative data set. We examine if there are productivity differentials across male and female managed plots as well as which factors in the production process seem to be driving them. Given that agro-ecological and socioeconomic conditions differ so substantially across the North and South these are analyzed independently. Our analysis indicates that after controlling for observed manager characteristics and factors of production women in the North produce 27.4 percent less than men. We find that the unexplained portion of the gender gap in the North is bigger than the explained portion at the mean suggesting that even if provided with the same level of inputs, significant differences between the productivity of men and women would still emerge. This does not mean that women would not benefit from additional inputs, but that this will not completely make up differences.

In the South, statistically significant differences between the productivity of male and female plot managers productivity are not found once we control for observed factors of production. When the conditional differences are decomposed, we find that the endowment effect is more important than the structural effect indicating that access to resources explains most of the gender gap. In the South then, if women are given the same level of inputs as men the gap diminishes. Even though men use more input than women in general, women have smaller land plots

and, as is generally the case on smaller plots, tend to use inputs at a higher proportional rate. If women's access to land assets were similar in the South, the gap between men and women would be much wider.

Overall, the results confirm our hypotheses that gender relationships differ across the North and South. The results mirror those found by Peterman et al. (2011), who found differences in the gender productivity link across agro-ecological zone in northern Nigeria, and Oladeebo and Fajuyigbe (2007) who find no statistically significant difference in the South-West. As such, it suggests that policy should also vary by region. In particular, in the North it suggests not only providing greater input access to women but also exploring further the reasons for different returns to factors of production for women. In the South, again provision of inputs may help improve female agricultural productivity.

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Endnotes

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All tables and figures have been removed due to space restrictions. The complete paper can be found at the conference website.

1 State distribution within the zones: South West - Oyo, Osun, Ogun, Lagos, Ekiti, Ondo; South-South - Cross-River, Akwa- Ibom, Rivers, Bayelsa, Edo, Delta; South East - Enugu, Anambra, Ebonyi, Abia, Imo; North Central - Plateau, Kwara, Niger, Kogi, Benue, Nasarawa, FCT Abuja; North East - Borno, Yobe, Bauchi, Gombe, Taraba, Adamawa; North West - Jigawa, Katsina, Kano,Kaduna, Kebbi, Sokoto, Zamfara.

2 These figures are from the GHS-Panel survey 2010/11 implemented by the NBS.

3 See Ani (2003) and Damisa and Yohanna (2007) for analysis on effect of decision making on agricultural activity in Nigeria.

4 We limited the sample to households that were present in both the post planting and post-harvest visit of the GHS-Panel 2010/11 (There are about 4-5 months between visits). Furthermore, we focused on the agricultural households for which complete information of GPS plot measurement and production estimates are available. We dropped plots of less than 0.1 hectares and all plots in Enugu state due to issues with the GPS land measurement in that state.

5 For almost all the male managed plots (98.7%), the manager is also identified as the head of the households. However, for female managed plots, only for 52.1 percent of plots are also the head of the households.

6 67.8 percent of male managers claim at least 2 plots compared with 52.9 percent of female managers.

7 The Naira value of harvest on each plot was calculated by multiplying the quantity of harvest in kilograms of each crop on the plot by the median sales value of the crop in each local government area (LGA) and aggregating to the plot level. In cases where we don't have enough observations in the LGA, we use the value at the next geographical level, zone, state and country as needed. For our main dependent variable, value of harvest per hectare, we divide the value of harvest by the GPS reported plot size.

8 Agriculture capital is measured as the monetary value of all agriculture assets owned by the household of the manager. The agriculture assets include tractor, plough, trailer/cart, ridger, planter, pickup truck, harvester, water pump, sprinkler, sprayer, outboard motor, canoe, boat, fishing net, wheel barrow, cutlass, hoe, and others. It should be noted that agriculture capital is collected at the household level and plot managers from the same households will have the same value for agriculture capital. There are 77 households in the sample that have both male (with 127 plots) and female plot managers (with 91 plots).

9 Cash crops include groundnut, cotton, cocoa, rubber, cotton and oil palm.

10 Use of purchased seeds also has a negative and significant effect on productivity. It should be noted that using purchase seeds is not an indication of using improved seeds. The only meaning to be assigned to it is that at least some of the seeds used on the plot were purchased rather than received free of charge or from leftovers.

11 We discuss below why this may be related to geographical features rather than religion per se.

12 See Kilic et al. 2013 for a detailed discussion on the assumptions of the Oaxaca decomposition methodology.

13 $N=H+K+Q+R+T$

14 $c,l,s,x,z \subseteq X$

15 $\pi, \varphi, \omega, \rho, \theta \subseteq \beta$

16 When estimating the RIF decomposition, the same procedure as in the Oaxaca decomposition is followed, except that in the estimations of the different dependent variables of the decomposition we substitute the relevant dependent variable with the RIF for the same variable.

17 Detailed results are available upon request.

18 The additional manager characteristics include hospitalization of manager in the past year, manager reported having difficulties with movement, manager has ability to sell plot, and relationship to the household head. The additional plot characteristics are presence of tree crop on plot, type of tenure of plot, and dummy to denote whether plot is irrigated or not. The geospatial variables include mean temperature of wettest quarter, annual precipitation (mm), plot's slope percentage, plot's elevation in meters, and potential wetness index. Dummies were included for each type of crop cultivated by the household in which the manager resides. Community level variables included are better credit availability compared to 5 years ago, presence of an agricultural cooperative in the local community, and occurrence of adverse shock to agriculture in the community.

19 Note, we did not assign gender of head to all plots owned by the household, but rather limit the sample to plot managers who are also heads of the household.

20 We lost lose some plots at the household level because of incomplete data.

Of Men, Women, and Livestock. Gender Differences in the Ownership and Management of Livestock in Sub-Saharan Africa

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Abstract

A vast and growing amount of literature exists that documents gender inequalities in nearly all aspects of livelihoods management, from access to education to asset acquisition, wage differentials, and beyond. The livestock sector is no exception, in that women are disadvantaged relative to men in terms of herd size, managerial roles, scale of production, and access to industrial value chains (FAO 2011). At the same time, given the role of livestock as an insurance mechanism, a store of wealth and a potentially sustainable income generating activity (FAO 2009), the livestock sector can serve as an important source of livelihoods, and a potential pathway out of poverty for rural women (IFAD 2011).

This growing literature is a sign of how gender issues in agriculture have attracted an unprecedented wave of attention in recent year. The production of gender disaggregated data on agricultural production, however, has lagged behind. This lack of progress is particularly notable for Sub-Saharan Africa (a region where according to many the quality and quantity of agricultural statistics has been steadily declining in the last two decades), and with relation to livestock issues (which systematically attract less attention than crop statistics, even within the agricultural statistics community).

The dearth of gender disaggregated data has been acknowledged by and has affected the analysis the FAO's and World Bank's flagship reports on gender in recent years (FAO, 2011; World Bank, 2011). This paper draws on six recent nationally representative household surveys, to shed new light on the gender differences in the ownership and management of livestock assets in Sub-Saharan Africa. The six countries jointly represent about 45 percent of the population and a similar share of the estimated cattle, sheep and goat inventories in Sub-Saharan Africa (FAOSTAT online).

The surveys (from Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda) are part of the Living Standard Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) project, a long term effort to improve the quality and availability of micro-level living standard and agriculture data in Africa, which is making an explicit effort to integrate gender in data collection, as well as to improve the livestock modules of national household surveys. Traditionally the only gender analysis of agricultural issues possible with national multi-topic surveys was drawing on the comparison of male and female headed households. This new generation of multi-topic surveys includes more detail on the individual level ownership and management of livestock (alongside other agricultural activities).

Preliminary evidence shows clear gender differences in ownership of livestock, with women much less likely to own livestock, particularly large stock (e.g. cattle), and on average owning fewer livestock than men. More surprising results however also emerge from the data, such as the finding that, conditional on owning livestock (or certain types of livestock) women do not necessarily own fewer livestock, and are as if not more market oriented than male livestock owners. Our exploration of the data also reveals that women managing livestock earn less from their livestock, manage considerably lower numbers of the main livestock species, with the exception of poultry, and have significantly lower levels of usage of key inputs such as labor, fodder, and vaccinations.

The paper presents novel, systematic evidence on the patterns of livestock ownership across gender lines, the differences in herd structure between male and female owners, and reviews the emerging systematic patterns in terms of access to both input and output markets. The paper also reviews the shortcomings of the available data for more in-depth analysis of gender issues, and proposes an agenda for further work on improving this crucial aspect of survey design, which is also one of the priority areas identified in the Global Strategy Action Plan.

Endnote

The author did not authorize publication of full paper.

Women's Empowerment in Agriculture: what role for food security in Bangladesh?

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Abstract

While Bangladesh has experienced steady advances in food production through the adoption of agricultural technologies, it has yet to overcome chronic food insecurity. In South Asia, the low status of women and gender gaps in health and education contribute to chronic child malnutrition and food insecurity, even as other determinants of food security, such as per capita incomes, have improved. Renewed interest in agriculture as an engine of inclusive growth, and specifically in women's empowerment has highlighted the need to develop indicators for measuring women's empowerment, examining its relationship to various food security outcomes, and monitoring the impact of interventions to empower women.

This paper presents how a recently developed index, the Women's Empowerment in Agriculture Index (WEAI), can be used to assess the extent of women's empowerment in agriculture, to diagnose areas where gaps in empowerment exist, and to examine the extent to which improvements in the underlying indicators in these areas can improve food security. The WEAI is a new survey-based index that uses individual-level data collected from primary male and female respondents within the same households. Using nationally representative data from the 2012 Bangladesh Integrated Household Survey (BIHS) conducted by the International Food Policy Research Institute, this paper examines the relationship between women's empowerment in agriculture and two measures of food security at the household level, per adult equivalent calorie availability and household dietary diversity. Although the index is composed of two components measuring the five domains of empowerment (5DE) and the gender parity index (GPI), in this paper we only use the 5DE subindex. We decompose the 5DE to identify in which of the five domains disempowerment is most acute, and the specific indicators which comprise those domains. Because empowerment itself is endogenous, we use instrumental variables regression to examine the relationship between various measures of women's empowerment (the aggregate women's empowerment score (5DE) as well as the individual indicators) and measures of household food security.

Our results, which take the endogeneity of empowerment into account using instrumental variables methods, show convincingly that empowering women increases both calorie availability and household dietary diversity in rural Bangladesh. We also find that empowerment gaps are greatest in terms of leadership in the community and control and access to resources. Analyzing these domains further in terms of their component indicators, we find that increasing the number of groups in which women actively participate and increasing their control of assets are positively associated with both food security outcomes. Results regarding credit decision-making are ambiguous because seeking credit is not necessarily a sign of empowerment in this context, given that wealthier households may be able to self-finance and that microfinance groups target poor women as their clients.

Keywords: women's empowerment; food security; Bangladesh.

1. Introduction

While Bangladesh has experienced steady advances in food production through the adoption of agricultural technologies, it has yet to overcome chronic food insecurity. In South Asia, the low status of women and gender gaps in health and education contribute to chronic child malnutrition (Smith et al. 2003) and food insecurity (von Grebmer et al. 2009), even as other determinants of food security, such as per capita incomes, have improved. Renewed interest in agriculture as an engine of inclusive

growth and specifically in women's empowerment has highlighted the need to develop indicators for measuring women's empowerment, examining its relationship to various food security outcomes, and monitoring the impact of interventions to empower women.

This paper presents how a recently developed index, the Women's Empowerment in Agriculture Index (WEAI) (Alkire et al. 2013), can be used to assess the extent of women's empowerment in agriculture, diagnose areas where gaps in empowerment exist, and examine the extent to which improvements in the underlying indicators in these areas can improve food security. The WEAI is a new survey-based index that uses individual-level data collected from primary male and female respondents within the same households, and is similar in construction to the Alkire-Foster (2011) group of multidimensional poverty indices. Although it was initially developed as a monitoring and evaluation tool for Feed the Future programs, the WEAI is also a useful diagnostic tool for policymakers, development organizations, and academics seeking to inform efforts to increase women's empowerment. The WEAI was developed and tested between 2011 and 2012 using three country pilots in Bangladesh, Guatemala, and Uganda (Alkire et al. 2013); this paper will represent the first time it is being calculated using a nationally representative survey.

Using nationally representative data from the 2012 Bangladesh Integrated Household Survey (BIHS) conducted by the International Food Policy Research Institute, this paper examines the relationship between women's empowerment in agriculture and two measures of food security at the household level, per adult equivalent calorie availability and household dietary diversity. Although the index is composed of two components measuring the five domains of empowerment (5DE) and the gender parity index (GPI), in this paper we only use the 5DE subindex. We decompose the 5DE to identify in which of the five domains disempowerment is most acute, and the specific indicators which comprise those domains. Because empowerment itself is endogenous, we use instrumental variables regression to examine the relationship between various measures of women's empowerment (the aggregate women's empowerment score (5DE) as well as the individual indicators) and measures of household food security.

2. Background

2.1. Women's Empowerment and Food Security

Considerable evidence exists that households do not act in a unitary manner when making decisions or allocating resources (Alderman et al. 1995; Haddad, Hoddinott, and Alderman 1997). This means that men and women within households do not *always* have the same preferences nor pool their resources. The non-pooling of agricultural resources within the household creates a gender gap in control of agricultural inputs, which has important implications for productivity. Several empirical studies have found that redistributing inputs between men and women in the household has the potential for increasing productivity (Saito et al. 1994; Udry et al. 1995; Peterman et al. 2010; Kilic et al. 2013). Moreover, a growing body of empirical evidence suggests that increasing women's control over resources has positive effects on a number of important development outcomes, including food security, child nutrition, and education (Hallman 2003; Quisumbing 2003; Quisumbing and Maluccio 2003; Skoufias 2005). Although much of this evidence has emerged from observational studies, a systematic review of programs targeting transfers to women (Yoong et al. 2012) has found that these improve children's wellbeing, especially in the form of investments in children's health and education.

The linkages between women's *empowerment* and food security have been more difficult to quantify owing to the difficulty of measuring empowerment. Kabeer (1999) defines empowerment as expanding people's ability to make strategic life choices, particularly in contexts in which this ability had been denied to them. In Kabeer's definition, the ability to exercise choice encompasses three dimensions: resources, agency and achievements (well-being outcomes). The WEAI focuses on the 'agency' aspect as it is far less studied than resources such as income, or achievements such as educational levels. Moreover, while nationally representative surveys such as some demographic and health surveys (DHS) include a range of questions about decision-making within the household, these are typically confined to the domestic sphere and do not encompass decisions in the productive and economic spheres, nor do the surveys have identical questions for men and women (Alkire et al. 2013). Existing indices also do not capture control over resources or agency within the

agricultural sector, in which women account for 43 percent of the agricultural labor force in developing countries (FAO 2011a).

2.2. Measuring Women's Empowerment using the WEAI

The WEAI is an aggregate index, reported at the country or regional level, which is based on individual level data on men and women within the same households. The two sub-indexes of the WEAI measure: (1) the five domains of women's empowerment (5DE) and (2) gender parity (the Gender Parity Index, GPI).[1] The 5DE sub-index shows how empowered women are, capturing the roles and extent of women's engagement in the agricultural sector in five domains: (1) decisions over agricultural production, (2) access to and decision-making power over productive resources, (3) control over use of income, (4) leadership in the community, and (5) time use. It assesses the degree to which women are empowered in these domains, and for those who are not empowered, the percentage of domains in which they are empowered.[2] The GPI reflects the percentage of women who are as equally empowered as the men in their households. For those households that have not achieved gender parity, the GPI shows the empowerment gap that needs to be closed for women to reach the same level of empowerment as men. Using a survey method that goes beyond the traditional practice of interviewing only a household "head" (often a male) to interview both a principal male and principal female, the GPI permits the comparison of the agricultural empowerment of men and women living in the same household. Both measures, taken together, make up the WEAI. The aggregate index therefore shows the degree to which women are empowered in their households and communities and the degree of inequality between women and men in their households. Details regarding the construction and validation of the index can be found in Alkire et al. (2013). In this paper, we use individual measures of 5DE and its component indicators to investigate the relationship between women's empowerment in agriculture and food security; details are provided in the next section.

3. Data, Empirical Specifications and Variables

3.1. Data

The Bangladesh Integrated Household Survey (BIHS) was designed and supervised by researchers at the International Food Policy Research Institute (IFPRI) and conducted from December 2011 to March 2012. The BIHS sample is nationally representative of rural Bangladesh and representative of rural areas of each of the 7 administrative divisions of the country. To estimate the total sample size of 5,500 households in 275 primary sampling units (PSUs), BIHS followed a stratified sampling design in two stages—selection of PSUs and selection of households within each PSU—using the sampling frame developed from the community series of the 2001 population census. In the first stage, a total sample of 275 PSUs were allocated among the 7 strata (7 divisions) with probability proportional to the number of households in each stratum. Sampling weights were adjusted using the sampling frame of the 2011 population census. Our final estimation sample consists of 4195 households.[3]

The BIHS questionnaires include several modules that provide an integrated data platform to answer a variety of research questions, as well as separate questionnaires for self-identified primary male and female decision-makers in sampled households. Our study relied primarily on information concerning household demographics, educational attainment, occupation and employment, food and non-food consumption and expenditures, household level agricultural production and livestock holding, household assets, housing and amenities, and a detailed module on the WEAI.

3.2. Empirical Specification

To estimate the relationship between women's empowerment in agriculture and household food security, we estimate the following equation:

$$\mathbf{f} = \beta_0 + \beta_1 \textit{empowerment} + \beta_2 \mathbf{h} + \beta_3 \mathbf{c} + \varepsilon \qquad (1)$$

where $\mathbf{f}$ is a vector of food security outcomes, β_i are coefficients to be estimated, $\mathbf{h}$ is a vector of household level characteristics, $\mathbf{c}$ is a vector of community or village characteristics, and ε is an error term. Because it is likely that women's empowerment within the household might be affected by the same factors affecting the availability of food and dietary diversity, we use standard instrumental variables techniques to correct for potential endogeneity bias.

3.3. Outcome Variables

Per-adult equivalent calorie availability: Data on the quantity of household consumption of around 300

food items during the last 7 days was converted to daily calorie equivalents. The resulting calorie values were divided by the number of adult equivalents in a household, in order to obtain daily per-adult equivalent calorie availability values (Ahmed and Shams 1994).

Household dietary diversity: Several studies have demonstrated a strong association between dietary diversity and household food security (Hoddinott and Yohannes, 2002; Hatloy et al, 2000). Household dietary diversity is defined as the count of food groups consumed using the 7-day recall household food consumption data. Food was grouped into twelve categories: cereals, white tubers and roots, vegetables, fruits, meat, eggs, fish and other seafood, legumes and nuts, milk and milk products, oils and fats, sweets, and spices, condiments and beverages (FAO 2011b).

3.4. Key Independent Variables

Women's Empowerment in Agriculture Index: To measure women's empowerment in agriculture, we use the WEAI, computed using individual-level data collected from primary male and female respondents within the same households. As mentioned previously, in this paper we will be using only the 5DE component of the WEAI.

Table 1 presents the five domains, which comprise ten indicators. Each domain is weighted equally, as are each of the indicators within a domain. The 5DE sub-index is a measure of empowerment that shows the number of domains in which women are empowered. A woman is defined as empowered in 5DE if she has adequate achievements in four of the five domains or is empowered in some combination of the weighted indicators that reflect 80 percent total adequacy. The five domains of empowerment are defined as follows:

Production: This domain concerns decisions over agricultural production, and refers to sole or joint decision making over food and cash-crop farming, livestock and fisheries as well as autonomy in agricultural production.

Resources: This domain concerns ownership, access to, and decision-making power over productive resources such as land, livestock, agricultural equipment, consumer durables, and credit.

Income: This domain concerns sole or joint control over the use of income and expenditures.

Leadership: This domain concerns leadership in the community, here measured by membership in economic or social groups and comfort in speaking in public.

Time: This domain concerns the allocation of time to productive and domestic tasks and satisfaction with the available time for leisure activities.

Table 1: The 5 domains of empowerment in the WEAI.

Domain	Indicator	Definition of Indicator	Weight
Production	Input in productive decisions	Sole or joint decision making over food and cash-crop farming, livestock, and fisheries	1/10
	Autonomy in production	Autonomy in agricultural production (e.g. what inputs to buy, crops to grow, what livestock to raise, etc.). Reflects the extent to which the respondent's motivation for decision making reflects his/her values rather than a desire to please others or avoid harm	1/10
Resources	Ownership of assets	Sole or joint ownership of major household assets	1/15
	Purchase, sale, or transfer of assets	Whether respondent participates in decision to buy, sell or transfer his/ her owned assets	1/15
	Access to and decisions on credit	Access to and participation in decision making concerning credit	1/15
Income	Control over use of income	Sole or joint control over income and expenditures	1/5
Leadership	Group member	Whether respondent is an active member in at least one economic or social group (e.g. agricultural marketing, credit, water users' groups)	1/10
	Speaking in public	Whether the respondent is comfortable speaking in public concerning various issues such as intervening in a family dispute, ensure proper payment of wages for public work programs, etc.	1/10
Time	Workload	Allocation of time to productive and domestic tasks	1/10
	Leisure	Satisfaction with the available time for leisure activities	1/10

Source: Alkire et al. (2013).

A key innovation of the Index is that it identifies the domains in which women are disempowered as well as the relative degree of disempowerment. Figure 1 shows that the **leadership** and **resources** domains contribute most to women's disempowerment in rural Bangladesh, while Figure 2 shows the contribution of each domain indicator. We use this information to identify the key domains, and indicators within each key domain, on which to focus our analysis. *Group membership* emerges as the indicator that contributes most to disempowerment in the leadership domain and *access to and decisions on credit* as the most critical indicator for the resources domain. The credit indicator, however, may be problematic since it is not clear whether non-borrowers are truly credit constrained (they may not avail of credit because they have sufficient liquidity). In light of this issue, we also analyze the two other indicators for the resources domain, namely, *asset ownership,* and *rights over assets*. Based on this information, we use the following alternative measures of empowerment:

Aggregate empowerment score of primary female respondent: is the 5DE empowerment score of the female respondent in the household, which is the weighted average of her achievements in the ten indicators that comprise the five domains of empowerment in agriculture. This measure is increasing in empowerment, and ranges from 0 to 1.

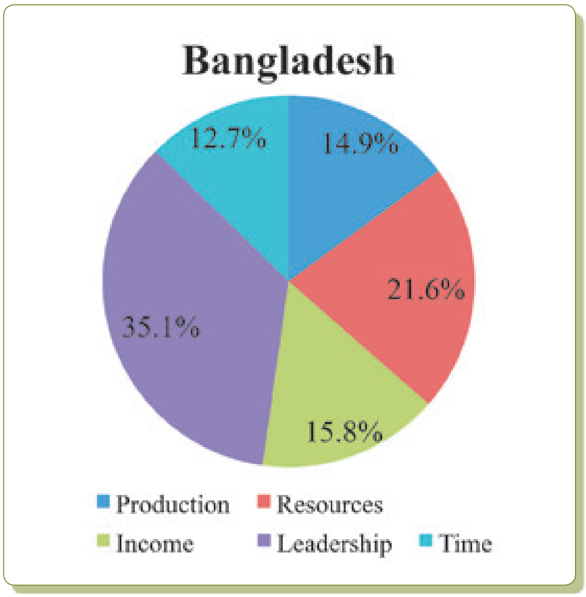
(Leadership domain, Group membership indicator) Number of groups in which woman is an active member: is the total number of groups in which the female respondent reports being an active member.

(Resources domain, Access to and decisions on credit indicator) Average number of decisions, concerning credit, taken by female: is the number of credit decisions that the female respondent has made solely or jointly, averaged over the lending sources used. For each of the five possible lending sources (NGO, informal, formal, friends/family, ROSCAs), the survey asks who made the decision to borrow and who made the decision on how to use the money/item borrowed.

(Resources domain, Asset ownership indicator) Number of assets woman has sole/joint ownership of: is the total number of asset types for which the female respondent reports sole or joint ownership.

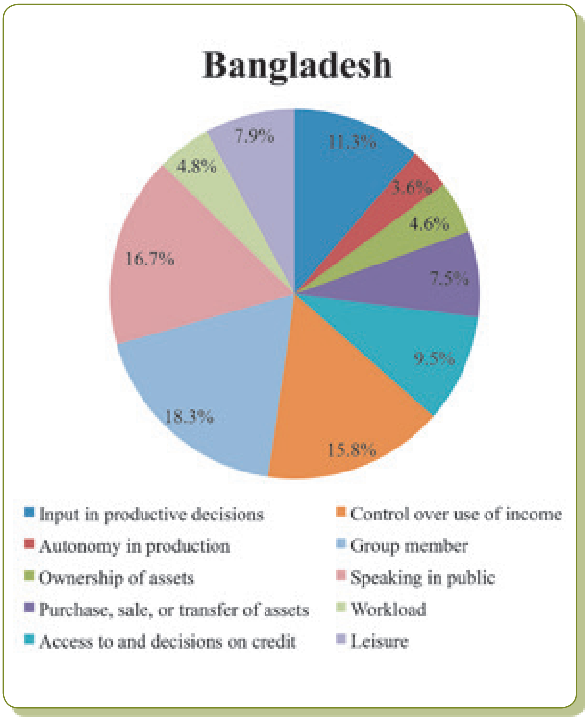
(Resources domain, Rights over assets indicator) Number of sole/joint decisions, concerning purchase/sale/transfer of assets, taken by woman: is the total number of decisions made solely or jointly by the female respondent, summed over all asset types. For each asset type, the survey asks who can decide whether to sell, give away, mortgage/rent, and purchase the asset.

Figure 1: Contribution of each of the 5 domains to the disempowerment of women.



Source: Sraboni et al. (2013).

Figure 2: Contribution of each of the 10 domain indicators to disempowerment of women.



Source: Sraboni et al. (2013).

3.5. Instruments

We use the difference in ages between the primary male and female decision-makers, and number of types of informal credit sources in the village as instruments for all of the empowerment indicators.[4] We do not include formal credit sources, because obtaining credit from these sources typically require collateral (which could be correlated with household wealth and could directly affect the outcomes being considered) nor NGOs because obtaining credit from NGOs is membership-based. The existence of a large number of informal credit sources could be indicative of both greater social capital within the community, which could influence a woman's decision to actively participate in a group, as well as the size of the informal credit market. The availability of a large pool of funds could thus facilitate decision-making concerning credit, and accumulation of assets by the borrowers. The differences in ages can reflect differences in human capital between the primary female and her spouse, and therefore reflect relative bargaining strengths (Quisumbing and Hallman 2005).[5]

We also instrument empowerment score as well as group membership using information on the number of community activities the woman participated in during the previous year; a woman who is more active in the community is more likely to be an active participant in groups.[6] The difference in recall period implies that the decision to participate in the mentioned activities was already given (exogenous) prior to the current decision to join (or maintain membership in) a group.

An additional variable- whether the homestead land has been inherited by the woman, is used to instrument for both ownership of and rights over assets. Inherited assets have been previously used as a bargaining measure in the literature (Quisumbing 1994, Quisumbing and Maluccio 2003). While inherited land is arguably endogenous, inherited homestead land is much less likely to be correlated with the error term.

3.6. Other Independent Variables

Other independent variables include age, age-squared and years of schooling of the household head[7], household size and proportion of males and females in various age groups (with males aged 60 and above as the excluded category). The occupation of the household head is accounted for using dummy variables for two types of primary occupation: farming and trading. We also include the price of rice as a control variable, since rice is the staple food in Bangladesh, accounting for a fifth of all spending of an average rural household, 35 percent of food expenditure, and 71 percent of total calorie intake (Ahmed et al 2013). The number of dairy cows owned by a household is expected to affect the food security outcomes through the pathway of production and consumption of milk and milk products, as well as household wealth. Three other variables are used as indicators of the socioeconomic status of the household: the amount, in decimals, of cultivable land owned by the household, a dummy for whether the household has access to electricity, and a dummy for whether it owns at least one tube well. We also include diversity in food crop production (that is, the total number of food crops produced by the household) as a control[8]. If households consume some of the food that they produce, then more diverse agricultural production is expected to increase dietary diversity at the household level. A change in total number of food crops produced may also alter calorie availability of producer households through explicit or implicit change in household income. Division dummies are included to control for location specific effects. Summary statistics of all the variables used are presented in Table 2.

4. Results

4.1. Women's Empowerment and Food Security

Columns 1 and 3 of Table 3 present the OLS coefficient estimates of the determinants of per-adult equivalent calorie availability and household dietary diversity respectively. These estimates show that the female empowerment score is highly significant and positively correlated with both per adult equivalent calorie availability and dietary diversity at the household level. In columns 2 and 4, after instrumenting for both potentially endogenous variables (empowerment and food crop production), the estimates show a similar pattern, with the IV estimates being larger than the OLS estimates. These results, together with the good performance of the instruments in general using standard IV diagnostics, suggest that household diet diversity and calorie availability increase if the primary female decision-maker is more empowered; the larger IV coefficients suggest that neglecting endogeneity of empowerment may underestimate the impact of increasing women's empowerment on these food security outcomes.[9]

Moving on to the individual indicators, in Table 4 we find that women's group membership is positively and significantly correlated with both per adult

equivalent calorie availability and dietary diversity. This implies that increasing the number of groups in which women actively participate has a positive impact on household food security outcomes. In Table 5, the OLS coefficient estimates (columns 1 and 3) for women's decision-making concerning credit are insignificant, but IV estimates emerge as positive and significant, suggesting that women's decision-making concerning credit is significant and positively correlated with the food security outcomes (columns 2 and 4). Since the weak-identification test results suggest that the instruments used for this particular model are weak, we take these results with caution. An underlying problem with using decisions on credit as an indicator of empowerment in this context is that wealthier people may not need to avail of credit (because they can self-finance) and that many microfinance activities are targeted to poorer women in Bangladesh.

The OLS and IV coefficient estimates of women's ownership of assets (presented in Table 6) and rights over assets (Table 7) are significantly positive, implying that female ownership of and control over major household assets has a role to play in improving household food security. Previous work in Bangladesh has demonstrated that greater resource control by women is associated with improved child health (Hallman 2003); evaluations of the long-term impact of agricultural interventions have similarly showed that interventions targeted to women's groups have increased women's assets and improved nutritional status of women and girls (Kumar and Quisumbing 2010).

In the IV models, the effect of number of food crops produced by household on calorie availability at the household level is insignificant, but a strong and significant positive association between crop diversity and dietary diversity is evident; the more food crops the households produce, the higher their dietary diversity. The number of dairy cows owned has a significant positive impact on both household food energy availability and household dietary diversity in all models. Rice price is not significantly associated with household level food energy availability, but is strongly and positively associated with the household level dietary diversity. Households may respond to an increase in rice price by partially shifting consumption away from rice to other food items, which results in an increase in dietary diversity. Owned cultivable land is strongly associated with both household food energy availability and household dietary diversity in all models. A change in cultivable land ownership modifies household level calorie availability and dietary diversity through its wealth or income effect. However, the other two income-related variables—ownership of hand tubewell and access to electricity—appear to be important in significantly influencing household level food energy availability and dietary diversity only in certain models. Finally, consistent with the existing literature on human capital and household food security, education of the household head has a positive and significant relationship with both calorie availability and dietary diversity.[10]

5. Conclusion

This paper has demonstrated that a recently-developed index, the WEAI, can be used to assess the extent of women's empowerment in agriculture, identify areas where gaps in empowerment are most severe, and examine the relationships between specific indicators of empowerment and two food security outcomes: per adult equivalent calorie availability and household dietary diversity. Our results, which take the endogeneity of empowerment into account using instrumental variables methods, show convincingly that empowering women increases both calorie availability and household dietary diversity. We also find that empowerment gaps are greatest in terms of leadership in the community and control and access to resources. Analyzing these domains further in terms of their component indicators, we find that increasing the number of groups in which women actively participate and increasing their control of assets are positively associated with both food security outcomes. Results regarding credit decision-making are ambiguous because seeking credit is not necessarily a sign of empowerment in this context, given that wealthier households may be able to self-finance and that microfinance groups target poor women as their clients.

Our results also indicate that increasing crop diversity improves dietary diversity. The BIHS results show that about 77 percent of the total cropped area in Bangladesh is under rice cultivation, implying very little crop diversity. Our findings call for increased investment in agricultural research to enhance productivity of non-rice food crops such as pulses, vegetables and fruits, which would induce farmers to increase their production of these crops.

Table 2: Summary Statistics.

Variable	Obs.	Mean	Std. dev.	Min	Max
Dependent variables					
Per adult equivalent calorie availability	4195	3138	804.51	1185.94	9529.97
Household dietary diversity	4195	9.55	1.59	4	12
Empowerment variables					
Empowerment score of woman	4195	0.65	0.24	0.07	1
Number of groups woman is an active member of	4195	0.32	0.49	0	3
Average number of decisions over credit	4195	0.95	0.98	0	2
Number of assets woman has self/joint ownership of	4195	1.90	1.51	0	10
Number of self/joint decisions over purchase, sale or transfer of assets made by woman	4195	11.15	9.49	0	48
Other controls					
Age (in years) of household head	4195	44.74	13.49	20	95
Age-squared of household head	4195	2183.54	1318.87	400	9025
Years of education of household head	4195	3.20	3.96	0	16
Household head is farmer (=1, 0 otherwise)	4195	0.25	0.43	0	1
Household head is trader (=1, 0 otherwise)	4195	0.12	0.32	0	1
Household size	4195	4.30	1.53	2	17
Proportion of males 0-4 years old	4195	0.05	0.10	0.00	0.60
Proportion of males 5-10 years old	4195	0.07	0.12	0.00	0.60
Proportion of males 11-18 years old	4195	0.07	0.12	0.00	0.67
Proportion of males 19-59 years old	4195	0.25	0.13	0.00	0.75
Proportion of females 0-4 years old	4195	0.05	0.10	0.00	0.60
Proportion of females 5-10 years old	4195	0.07	0.12	0.00	0.50
Proportion of females 11-18 years old	4195	0.07	0.12	0.00	0.60
Proportion of females 19-59 years old	4195	0.28	0.12	0.00	0.75
Proportion of females 60 years and older	4195	0.04	0.10	0.00	0.67
Number of food crops produced by household	4195	1.08	1.36	0	11
Number of dairy cows owned	4195	0.62	1.12	0	9
Price of rice (in Taka)	4195	30.19	3.61	20	55
Ln (owned cultivable land+1)	4195	0.68	1.52	0.00	6.98
Access to electricity (=1, 0 otherwise)	4195	0.47	0.50	0	1
Owns hand tubewell (=1, 0 otherwise)	4195	0.25	0.43	0	1
Division dummy 1	4195	0.06	0.23	0	1
Division dummy 2	4195	0.13	0.34	0	1
Division dummy 3	4195	0.29	0.46	0	1
Division dummy 4	4195	0.13	0.34	0	1
Division dummy 5	4195	0.18	0.38	0	1
Division dummy 6	4195	0.15	0.36	0	1
Instruments					
Age difference (male-female)	4195	8.07	4.76	-15	40
Types of informal credit sources in village	4195	2.34	1.50	0	5
Whether female has participated in any community activity during last 1 year (=1, 0 if otherwise)	4195	0.47	0.50	0	1
Number of community activities woman has participated in last year	4195	0.85	1.17	0	7
Whether homestead land has been inherited by woman (=1, 0 if otherwise)	4195	0.03	0.18	0	1
Clay-loam soil (=1, 0 if otherwise)	4195	0.24	0.43	0	1
Sandy-loam soil (=1, 0 if otherwise)	4195	0.16	0.36	0	1
Percent of land irrigated by household	4195	39.66	42.32	0	100

Source: IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Table 3: Women's Empowerment Scores and Household Food Security Outcomes.

	Per adult equivalent calorie availability		Household dietary diversity	
Variable	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)
Empowerment score of woman	283.655***	1,133.135***	0.504***	2.074***
	(54.124)	(197.971)	(0.107)	(0.376)
Age (in years) of household head	21.125***	15.059**	-0.016	-0.029**
	(6.900)	(7.375)	(0.013)	(0.014)
Age-squared of household head	-0.176**	-0.115	0.000	0.000**
	(0.075)	(0.081)	(0.000)	(0.000)
Years of education of household head	11.943***	13.057***	0.074***	0.075***
	(3.588)	(3.673)	(0.006)	(0.007)
Household head is farmer (=1, 0 otherwise)	129.948***	138.533***	0.215***	0.171**
	(33.079)	(42.577)	(0.062)	(0.077)
Household head is trader (=1, 0 otherwise)	26.398	1.468	0.498***	0.462***
	(35.909)	(37.666)	(0.073)	(0.076)
Household size	-105.370***	-99.942***	0.078***	0.084***
	(10.349)	(10.821)	(0.018)	(0.020)
Proportion of males 0-4 years old	-758.544***	-803.255***	0.593	0.547
	(232.427)	(241.790)	(0.420)	(0.434)
Proportion of males 5-10 years old	-903.854***	-990.638***	0.459	0.322
	(217.761)	(226.289)	(0.374)	(0.388)
Proportion of males 11-18 years old	-990.073***	-1,069.477***	0.171	0.031
	(213.427)	(221.066)	(0.373)	(0.384)
Proportion of males 19-59 years old	-1,313.033***	-1,307.468***	0.559**	0.565*
	(179.218)	(183.990)	(0.283)	(0.293)
Proportion of females 0-4 years old	-885.690***	-869.089***	0.629	0.701
	(228.888)	(237.256)	(0.420)	(0.433)
Proportion of females 5-10 years old	-465.520**	-574.674**	0.579	0.387
	(223.544)	(231.496)	(0.384)	(0.397)
Proportion of females 11-18 years old	-354.555	-489.436**	0.770**	0.514
	(230.958)	(238.271)	(0.386)	(0.402)
Proportion of females 19-59 years old	-615.654**	-713.747***	1.036**	0.865*
	(258.171)	(265.924)	(0.448)	(0.465)
Proportion of females 60 years and older	-68.111	-123.622	0.391	0.313
	(286.197)	(294.660)	(0.465)	(0.482)
Number of food crops produced by household	50.706***	32.405	0.073***	0.100*
	(11.048)	(26.417)	(0.019)	(0.051)
Number of dairy cows owned	62.499***	51.176***	0.123***	0.089***
	(12.868)	(14.094)	(0.023)	(0.025)
Price of rice (in taka)	-3.262	0.686	0.029***	0.036***
	(3.956)	(4.129)	(0.008)	(0.008)
Ln (owned cultivable land+1)	37.528***	38.595***	0.045***	0.048***
	(9.652)	(9.872)	(0.016)	(0.016)
Owns hand tubewell (=1, 0 otherwise)	130.895***	61.002*	0.284***	0.142**
	(30.354)	(33.583)	(0.056)	(0.063)
Access to electricity (=1, 0 otherwise)	7.089	-21.754	0.416***	0.362***
	(25.487)	(27.115)	(0.050)	(0.053)
Division level fixed-effects	Yes	Yes	Yes	Yes
Constant	3,820.881***	3,382.509***	7.111***	6.312***
	(240.298)	(263.754)	(0.455)	(0.506)
Observations	4,195	4,195	4,195	4,195
F	23.777	23.013	34.287	32.838
Adjusted R2	0.191	0.140	0.179	0.130
Hansen J p, Ho: instruments valid		0.642		0.181
UnderID test p, Ho: underidentified		0.000		0.000
Weak ID test stat (Kleibergen-Paap rk Wald F)		49.480		49.480
Anderson-Rubin, Ho: endog vars irrelevant				
A-R wald test, p-value		0.000		0.000
A-R wald Chi2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Women's Group Membership and Household Food Security Outcomes.

	Per adult equivalent calorie availability		Household dietary diversity	
Variable	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)
Number of groups woman is an active member of	42.061	1,075.849***	0.124**	1.970***
	(26.111)	(224.583)	(0.050)	(0.421)
Age (in years) of household head	22.702***	10.795	-0.014	-0.037**
	(6.875)	(8.362)	(0.013)	(0.016)
Age-squared of household head	-0.192**	-0.055	0.000	0.000**
	(0.075)	(0.091)	(0.000)	(0.000)
Years of education of household head	11.813***	17.390***	0.074***	0.083***
	(3.607)	(4.393)	(0.006)	(0.008)
Household head is farmer (=1, 0 otherwise)	133.802***	268.762***	0.228***	0.411***
	(33.238)	(60.763)	(0.062)	(0.110)
Household head is trader (=1, 0 otherwise)	32.306	-21.804	0.506***	0.419***
	(36.208)	(48.862)	(0.073)	(0.091)
Household size	-107.334***	-113.165***	0.074***	0.060***
	(10.435)	(12.820)	(0.018)	(0.022)
Proportion of males 0-4 years old	-754.139***	-994.482***	0.590	0.196
	(232.482)	(275.634)	(0.420)	(0.495)
Proportion of males 5-10 years old	-884.360***	-1,105.770***	0.483	0.111
	(217.738)	(257.112)	(0.375)	(0.446)
Proportion of males 11-18 years old	-975.276***	-1,260.042***	0.184	-0.319
	(213.447)	(252.523)	(0.374)	(0.441)
Proportion of males 19-59 years old	-1,318.719***	-1,415.040***	0.544*	0.368
	(179.175)	(201.151)	(0.283)	(0.330)
Proportion of females 0-4 years old	-895.775***	-986.462***	0.607	0.485
	(229.129)	(270.023)	(0.420)	(0.484)
Proportion of females 5-10 years old	-439.143**	-682.098***	0.614	0.190
	(223.162)	(259.014)	(0.383)	(0.449)
Proportion of females 11-18 years old	-326.156	-738.897***	0.801**	0.057
	(231.384)	(273.480)	(0.386)	(0.473)
Proportion of females 19-59 years old	-588.815**	-728.778**	1.077**	0.837
	(258.257)	(292.920)	(0.448)	(0.513)
Proportion of females 60 years and older	-56.537	-215.056	0.404	0.145
	(286.336)	(324.585)	(0.465)	(0.537)
Number of food crops produced by household	54.931***	39.311	0.081***	0.111*
	(11.122)	(30.553)	(0.019)	(0.057)
Number of dairy cows owned	67.246***	84.110***	0.132***	0.149***
	(12.871)	(17.132)	(0.023)	(0.030)
Price of rice (in taka)	-4.167	6.217	0.027***	0.046***
	(3.970)	(5.178)	(0.008)	(0.010)
Ln (owned cultivable land+1)	38.024***	59.500***	0.047***	0.087***
	(9.671)	(12.012)	(0.016)	(0.021)
Owns hand tubewell (=1, 0 otherwise)	149.651***	30.234	0.312***	0.086
	(30.249)	(42.483)	(0.056)	(0.078)
Access to electricity (=1, 0 otherwise)	15.288	-19.932	0.428***	0.366***
	(25.607)	(31.863)	(0.050)	(0.060)
Division level fixed-effects	Yes	Yes	Yes	Yes
Constant	3,967.969***	3,990.729***	7.374***	7.425***
	(240.211)	(282.739)	(0.455)	(0.526)
N	4,195	4,195	4,195	4,195
F	22.935	18.350	33.353	25.647
Adjusted R2	0.186	-0.154	0.176	-0.126
Hansen J p, Ho: instruments valid		0.358		0.963
UnderID test p, Ho: underidentified		0.000		0.000
Weak ID test stat (Kleibergen-Paap rk Wald F)		10.650		10.650
Anderson-Rubin, Ho: endog vars irrelevant				
A-R wald test, p-value		0.000		0.000
A-R wald Chi2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Women's Decisions on Credit and Household Food Security Outcomes.

	Per adult equivalent calorie availability			
Variable	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)
Average number of decisions over credit	-2.090	761.715***	-0.021	0.700*
	(12.455)	(239.890)	(0.025)	(0.366)
Age (in years) of household head	23.274***	-4.578	-0.012	-0.041**
	(6.890)	(12.861)	(0.013)	(0.019)
Age-squared of household head	-0.198***	0.103	0.000	0.000**
	(0.075)	(0.139)	(0.000)	(0.000)
Years of education of household head	11.563***	21.814***	0.073***	0.082***
	(3.598)	(6.119)	(0.006)	(0.009)
Household head is farmer (=1, 0 otherwise)	128.207***	302.020***	0.208***	0.277**
	(33.317)	(88.001)	(0.062)	(0.132)
Household head is trader (=1, 0 otherwise)	34.632	-34.892	0.514***	0.465***
	(36.198)	(57.918)	(0.073)	(0.088)
Household size	-107.126***	-86.672***	0.074***	0.087***
	(10.410)	(16.386)	(0.018)	(0.023)
Proportion of males 0-4 years old	-743.008***	-1,319.234***	0.634	0.148
	(232.396)	(369.748)	(0.422)	(0.544)
Proportion of males 5-10 years old	-874.354***	-1,291.468***	0.521	0.164
	(217.739)	(321.904)	(0.376)	(0.465)
Proportion of males 11-18 years old	-962.289***	-1,488.979***	0.232	-0.255
	(213.560)	(329.195)	(0.375)	(0.484)
Proportion of males 19-59 years old	-1,314.386***	-1,455.650***	0.560**	0.419
	(179.205)	(232.740)	(0.283)	(0.322)
Proportion of females 0-4 years old	-891.350***	-1,253.972***	0.627	0.351
	(228.881)	(339.368)	(0.421)	(0.507)
Proportion of females 5-10 years old	-428.188*	-840.191**	0.655*	0.280
	(223.421)	(329.532)	(0.385)	(0.475)
Proportion of females 11-18 years old	-307.893	-828.317**	0.865**	0.362
	(231.138)	(342.500)	(0.387)	(0.496)
Proportion of females 19-59 years old	-582.599**	-797.320**	1.099**	0.914*
	(258.376)	(350.583)	(0.449)	(0.507)
Proportion of females 60 years and older	-49.395	-358.569	0.431	0.179
	(286.749)	(387.323)	(0.467)	(0.541)
Number of food crops produced by household	55.348***	-2.455	0.082***	0.125*
	(11.140)	(46.227)	(0.019)	(0.069)
Number of dairy cows owned	66.572***	93.092***	0.130***	0.133***
	(12.882)	(21.897)	(0.023)	(0.032)
Price of rice (in taka)	-4.622	5.849	0.026***	0.037***
	(3.976)	(6.221)	(0.008)	(0.010)
Ln (owned cultivable land+1)	37.143***	37.400***	0.045***	0.047***
	(9.678)	(12.745)	(0.016)	(0.018)
Owns hand tubewell (=1, 0 otherwise)	154.852***	59.978	0.329***	0.218***
	(30.062)	(49.316)	(0.056)	(0.072)
Access to electricity (=1, 0 otherwise)	16.870	-37.876	0.434***	0.382***
	(25.644)	(40.524)	(0.050)	(0.062)
Division level fixed-effects	Yes	Yes	Yes	Yes
Constant	3,967.278***	3,857.604***	7.374***	7.287***
	(240.411)	(331.101)	(0.455)	(0.505)
Observations	4,195	4,195	4,195	4,195
F	22.916	13.755	32.872	26.740
Adjusted R2	0.185	-0.578	0.174	-0.016
Hansen J p, Ho: instruments valid		0.661		0.354
UnderID test p, Ho: underidentified		0.000		0.000
Weak ID test stat (Kleibergen-Paap rk Wald F)		4.141		4.141
Anderson-Rubin, Ho: endog vars irrelevant				
A-R wald test, p-value		0.000		0.000
A-R wald Chi2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Note: Robust standard errors are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6: Women's Ownership of Assets and Household Food Security Outcomes.

	Per adult equivalent calorie availability		Household dietary diversity	
Variable	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)
Number of assets woman has self/joint ownership of	42.385***	183.860***	0.113***	0.204***
	(9.312)	(41.132)	(0.017)	(0.074)
Age (in years) of household head	21.170***	14.232*	-0.018	-0.025*
	(6.901)	(7.461)	(0.013)	(0.013)
Age-squared of household head	-0.177**	-0.106	0.000	0.000*
	(0.075)	(0.082)	(0.000)	(0.000)
Years of education of household head	10.152***	5.277	0.070***	0.065***
	(3.554)	(3.830)	(0.006)	(0.007)
Household head is farmer (=1, 0 otherwise)	129.496***	126.502***	0.215***	0.123
	(33.095)	(42.598)	(0.061)	(0.075)
Household head is trader (=1, 0 otherwise)	26.869	2.586	0.492***	0.492***
	(35.869)	(38.108)	(0.072)	(0.074)
Household size	-104.627***	-96.874***	0.081***	0.080***
	(10.260)	(10.873)	(0.018)	(0.020)
Proportion of males 0-4 years old	-740.155***	-721.910***	0.630	0.696
	(232.064)	(240.855)	(0.420)	(0.424)
Proportion of males 5-10 years old	-896.206***	-963.131***	0.455	0.446
	(217.832)	(227.365)	(0.375)	(0.382)
Proportion of males 11-18 years old	-992.371***	-1,087.361***	0.142	0.090
	(213.922)	(223.845)	(0.373)	(0.381)
Proportion of males 19-59 years old	-1,314.900***	-1,315.745***	0.555**	0.548*
	(178.796)	(183.180)	(0.283)	(0.287)
Proportion of females 0-4 years old	-903.165***	-935.337***	0.589	0.630
	(228.560)	(237.774)	(0.420)	(0.425)
Proportion of females 5-10 years old	-446.741**	-504.038**	0.597	0.574
	(223.750)	(232.166)	(0.384)	(0.391)
Proportion of females 11-18 years old	-357.497	-519.020**	0.723*	0.608
	(231.755)	(242.655)	(0.386)	(0.401)
Proportion of females 19-59 years old	-614.915**	-719.800***	1.009**	0.958**
	(258.895)	(271.148)	(0.449)	(0.461)
Proportion of females 60 years and older	-96.354	-247.898	0.300	0.240
	(286.370)	(298.324)	(0.466)	(0.482)
Number of food crops produced by household	50.267***	39.639	0.068***	0.152***
	(11.123)	(27.446)	(0.019)	(0.050)
Number of dairy cows owned	61.405***	42.614***	0.117***	0.084***
	(12.957)	(14.971)	(0.023)	(0.025)
Price of rice (in taka)	-4.148	-2.614	0.027***	0.029***
	(3.961)	(4.105)	(0.008)	(0.008)
Ln (owned cultivable land+1)	36.679***	35.225***	0.044***	0.044***
	(9.683)	(10.046)	(0.016)	(0.016)
Owns hand tubewell (=1, 0 otherwise)	141.849***	98.032***	0.293***	0.244***
	(29.971)	(32.503)	(0.055)	(0.057)
Access to electricity (=1, 0 otherwise)	9.215	-15.836	0.413***	0.397***
	(25.558)	(27.685)	(0.050)	(0.052)
Division level fixed-effects	Yes	Yes	Yes	Yes
Constant	3,956.755***	3,923.646***	7.344***	7.338***
	(239.188)	(246.925)	(0.453)	(0.457)
Observations	4,195	4,195	4,195	4,195
F	23.610	22.367	35.345	32.677
Adjusted R2	0.190	0.131	0.185	0.173
Hansen J p, Ho: instruments valid		0.691		0.697
UnderID test p, Ho: underidentified		0.000		0.000
Weak ID test stat (Kleibergen-Paap rk Wald F)		32.501		32.501
Anderson-Rubin, Ho: endog vars irrelevant				
A-R wald test, p-value		0.000		0.000
A-R wald Chi2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Women's Rights over Assets and Household Food Security Outcomes.

	Per adult equivalent calorie availability		Household dietary diversity	
Variable	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)
Number of self/joint decisions over purchase, sale or transfer of assets made by woman	8.001***	27.591***	0.019***	0.024*
	(1.456)	(6.448)	(0.003)	(0.012)
Age (in years) of household head	20.339***	13.802*	-0.019	-0.023*
	(6.865)	(7.274)	(0.013)	(0.013)
Age-squared of household head	-0.169**	-0.105	0.000	0.000*
	(0.075)	(0.079)	(0.000)	(0.000)
Years of education of household head	10.309***	7.364**	0.070***	0.069***
	(3.558)	(3.684)	(0.006)	(0.006)
Household head is farmer (=1, 0 otherwise)	121.946***	121.179***	0.196***	0.108
	(33.066)	(42.666)	(0.061)	(0.075)
Household head is trader (=1, 0 otherwise)	26.865	5.565	0.494***	0.505***
	(35.907)	(38.143)	(0.072)	(0.074)
Household size	-103.149***	-92.442***	0.084***	0.080***
	(10.320)	(11.263)	(0.018)	(0.020)
Proportion of males 0-4 years old	-768.640***	-837.073***	0.561	0.598
	(231.546)	(238.983)	(0.419)	(0.423)
Proportion of males 5-10 years old	-917.676***	-1,027.041***	0.410	0.417
	(217.052)	(225.593)	(0.373)	(0.382)
Proportion of males 11-18 years old	-1,017.029***	-1,149.217***	0.091	0.069
	(213.380)	(224.017)	(0.371)	(0.383)
Proportion of males 19-59 years old	-1,305.459***	-1,281.491***	0.578**	0.577**
	(178.450)	(180.657)	(0.282)	(0.283)
Proportion of females 0-4 years old	-911.948***	-970.849***	0.571	0.618
	(228.039)	(235.213)	(0.419)	(0.423)
Proportion of females 5-10 years old	-471.300**	-576.499**	0.544	0.532
	(222.956)	(229.806)	(0.382)	(0.391)
Proportion of females 11-18 years old	-358.701	-477.672**	0.733*	0.694*
	(230.479)	(236.930)	(0.385)	(0.394)
Proportion of females 19-59 years old	-617.510**	-704.371***	1.012**	1.007**
	(258.173)	(266.710)	(0.446)	(0.454)
Proportion of females 60 years and older	-88.098	-187.335	0.333	0.346
	(285.742)	(293.712)	(0.464)	(0.473)
Number of food crops produced by household	47.892***	14.034	0.064***	0.145**
	(11.138)	(31.362)	(0.019)	(0.058)
Number of dairy cows owned	59.631***	46.044***	0.114***	0.091***
	(12.993)	(14.629)	(0.023)	(0.024)
Price of rice (in taka)	-3.966	-2.564	0.028***	0.029***
	(3.962)	(4.078)	(0.008)	(0.008)
Ln (owned cultivable land+1)	34.428***	27.510***	0.038**	0.038**
	(9.668)	(10.180)	(0.016)	(0.016)
Owns hand tubewell (=1, 0 otherwise)	148.932***	138.605***	0.313***	0.291***
	(29.815)	(30.544)	(0.055)	(0.056)
Access to electricity (=1, 0 otherwise)	7.976	-13.434	0.412***	0.407***
	(25.576)	(27.336)	(0.050)	(0.052)
Division level fixed-effects	Yes	Yes	Yes	Yes
Constant	3,966.494***	3,962.527***	7.370***	7.384***
	(239.276)	(244.146)	(0.453)	(0.454)
Observations	4,195	4,195	4,195	4,195
F	24.050	22.874	36.003	33.352
Adjusted R^2	0.192	0.149	0.185	0.181
Hansen J p, Ho: instruments valid		0.312		0.215
UnderID test p, Ho: underidentified		0.000		0.000
Weak ID test stat (Kleibergen-Paap rk Wald F)		25.753		25.753
Anderson-Rubin, Ho: endog vars irrelevant				
A-R wald test, p-value		0.000		0.000
A-R wald Chi2 test, p-value		0.000		0.000

Source: Estimated by authors using data from the IFPRI Bangladesh Integrated Household Survey, 2011-2012.

Note: Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

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Endnotes

1 This description draws from Alkire et al. (2013).

2 "Empowerment" within a domain means that the person has adequate achievements or has "achieved adequacy" for that domain.

3 1072 observations were dropped, because the primary female respondent was either unavailable on the day of the interview, or did not respond to all of the WEAI survey questions. 227 observations were dropped because a female other than the primary female was interviewed [our focus is on the self-identified primary decision-maker, because we assume that it is she who plays a key role in household welfare]. 9 additional cases were dropped because of possible data entry errors in the demographic data.

4 The survey collected information on whether the following types of informal credit sources are present in the community- money lender within/outside village, shopkeepers who offer credit, agricultural input dealers who sell on credit and large farmers/traders who buy crops at a fixed forward price.

5 For households where information on the woman's spouse was not available (in female-headed households- where the male spouse is a migrant, or the female is widowed/separated), we considered the age difference to be zero.

6 The survey collected information on whether the woman has contributed money or time to the following community activities- building/maintenance of small wells or irrigation facilities, roads, development projects, local mosque or other religious structure, helping out other families with childcare, agricultural labor or care of a patient.

7 The household head is the self-identified primary decision-maker (in most cases, male) in the sample household.

8 A household's crop production decisions may be affected by the same factors that influence its calorie availability and dietary diversity, which could lead to endogeneity bias in our analysis. We use the following instruments at the farm level to identify production diversity: (a) whether or not the soil type is clay-loam, (b) whether or not the soil type is sandy-loam, and (c) the percentage of cropped land that is irrigated.

9 IV diagnostics are presented at the end of each table. The Anderson-Rubin test results imply that the endogenous variables are relevant. The overidentification and underidentification test results confirm that the instruments are valid and the models identified. The Kleibergen-Paap F-statistics show that the null hypothesis for weak instruments is rejected at the 5% (Tables 3, 6, and 7) and 10% level thresholds (Table 4). However the F-statistic in Table 5 fails to exceed the critical value of 4.79, which is associated with a bias relative to OLS of less than 30% (Stock and Yogo 2005). This suggests that the instruments used for women's decisions on credit may be weak.

10 Results for the other control variables will be presented in the full version of the paper.

Gender Inequalities in Ownership and Control of Land in Africa: myth and reality

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Abstract

Over the last decade, a variety of generalized claims have been made by stakeholders concerning women's land ownership, both globally and in Africa. Typically, these claims include statements with single statistics such as *"less than 2% of the world's land is owned by women"* or that women own *"approximately 15 percent in Sub-Saharan Africa."* These claims are problematic, as they are not substantiated by empirical evidence, do not reflect variations in land ownership across or within countries, acknowledge differences in land ownership regimes, or address comparative ownership by men in the same contexts. Neither do they address the difference between ownership and control of land. The lack of clear understanding behind statistics on gender and land also leads to a gap in clearly articulating a policy response to the potential inequalities faced by women and men. The objective of this paper is to explore, conceptually and empirically, the levels and relative inequalities in land ownership between women and men in African countries. The first section of the paper will engage in a conceptual discussion of how to measure gendered land outcomes, what ownership and control mean in different contexts, and why attention to these factors is important for development of gender and land statistics. The second section of the paper systematically reviews existing evidence from micro-level large sample studies by region to summarize recent trends in land access, ownership, and control by sex. The third section presents new statistics from a variety of nationally-representative and large-scale unpublished data on gender and land in Africa. Results will provide a nuanced understanding of the importance of measuring land indicators for gendered development in Africa and globally, and provide new statistics on a variety of land outcomes to aid stakeholders in the discussion of gender-land inequalities.

Keywords: gender; land; property ownership; bundles of rights; Africa.

1. Introduction

Claims that *"less than 2 percent of the world's land is owned by women"*[1] or that *"Women make up less than 5 percent of agricultural landholders in North Africa … and approximately 15 percent in Sub-Saharan Africa"*[2] are commonly found on development and advocacy websites, and in presentations and other literature. These generalized claims concerning women's land ownership are both global and specific to Africa. Some statements are slightly more nuanced, such as *"Women in the developing world are 5 times less likely than men to own land, and their farms are usually smaller and less fertile*[3]*"* or *"Less than a quarter of agricultural holdings in developing countries are operated by women. Low rates of female land ownership significantly obstruct access to financial assets, including credit and saving.*[4]*"* The majority of these claims either does not provide a citation or reproduces earlier citations, leading to a "myth" that we know the extent to which women are disadvantaged with respect to land ownership.

All of these statements convey the important generalization that there exist large gender inequities in ownership and control over an asset of primary importance, both globally and in Africa. After all, many myths contain an element of truth. However, using claims that are not substantiated by data or credible sources is problematic for a number of reasons (Cohen 2013). Historically, sex-disaggregated land ownership data were not typically collected, and thus, it would be near to impossible for these statistics to be substantiated.

While the data may have existed for a few case studies, it was not available on a nationally representative or large scale.

An effort to substantiate these claims raises a number of other concerns. The first challenge is the lack of a clear conceptualization of what 'women's property ownership' means. While deeds clearly identify an owner (or owners), many individuals in Africa have only partial ownership rights. Second, the single statistics that are used seem to imply that land is owned by individuals. Without further qualification, it is not clear how land that is owned jointly would be classified. Finally, any claim about the share of land owned by women needs to be made in comparison with that owned by men.

The lack of clear understanding and reproduction of statistics on gender and land is problematic in a number of ways. First, it leads to a gap in clearly articulating a policy response to the inequalities faced by women and men, both geographically and programmatically. Second, while reproduction of stark figures with shock value may attract the attention of an otherwise apathetic public, funder, or organization, it may endanger future efforts. Finally, it discourages further research and data collection specifically aimed at providing evidence for these already cited statistics.

This paper explores, both conceptually and empirically, the gender-land ownership "myth" using a range of data sources from Africa. The second section of the paper addresses the conceptual challenges of defining ownership, addressing issues of joint ownership, and creating comparable measures. The third section of the paper systematically reviews existing evidence from 17 micro-level large-sample studies and from other unpublished large-scale data to summarize current knowledge on land access, ownership, and control by sex. The fourth section presents new statistics from a variety of nationally representative and large-scale data on gender and land in Africa. Although the statistics derived from these are not strictly comparable, they do provide insights into patterns of gender inequality in land ownership. The final section of the paper provides a more nuanced understanding of the myth and reality of gendered land statistics as well as research and policy recommendations.

Based on the evidence reviewed, it is clear that global or regional statements putting forth a single statistic for women's land ownership are gross oversimplifications. Without suitable data to confidently produce macro-level statistics, policy makers and advocates may be better placed relying on country-specific data that are more relevant to generating information on the nature of underlying inequities and to producing informed recommendations for government and civil society action.

2. Measurement of Sex-Disaggregated Land Indicators

The first challenge in identifying women's land ownership is conceptual, rather than empirical, and requires defining ownership. Frequently, surveys measure *reported ownership* by asking the respondent whether they own the land. This question may be followed by an inquiry into which household members are the owners, allowing for analysis of ownership by men and women. Often the ownership question is embedded in a question about land tenure, asking whether the land is owned, leased, sharecropped, or rented by the household or an individual within the household. While the enumerators of the survey may be given some definition of ownership, at least in practice, it is often left to the respondents to say whether or not they own the specific parcel or plot of land in question.[5]

A second level of ownership is that of *documented ownership*. Households may have some form of documentation indicating that they are the owners of the land, including a certificate indicating registration or a formal title or deed.[6] In areas where land is not formally registered or titled, people may have other forms of documentation, such as a sales invoice or a will. When referring to *documented ownership*, two conceptualizations are commonly used. The first is whether a woman is *reported* to be an owner on a parcel for which the household has some form of documentation. The second is whether a woman's name is on the ownership document as an owner. In many instances, women are reported as joint owners of land when only their husband's name is on the documentation.

Finally, ownership may be conceptualized as *effective ownership*; the ability to make decisions regarding the use and potential sale of the property. In agriculture, decisions regarding use may include decisions about what to plant, what inputs to use,

when and how much to harvest, and how to dispose of the crops; however, these rights are more closely associated with management control, rather than ownership. Ownership implies holding *all* rights within a bundle of rights that typically includes the right to make improvements on, rent out, and decide how to use the land. However, it is the right of alienation, or the right to transfer land to another party, that defines ownership.

Each of these definitions may be useful in a specific context. The extent to which an individual claims to be an owner may affect the choices that he or she makes with regard to the land as well as within their household and community. Both *self-reported* and *documented ownership* may be associated with greater agency and empowerment in a range of domains. In some circumstances, having *documented ownership* may provide greater tenure security. Finally, to understand agricultural production, it may be most important to understand who has the *management control*.

All of the indicators discussed require data on individual owners of land. Simply having data on whether the household owns land will not suffice. When only household-level data are collected, researchers often compare the land ownership patterns of male and female-headed households. However, this approach may underestimate women's land ownership by ignoring the land owned by women in male headed households. Any evidence or statistics included in this review will not rely on indicators at the household level.

While there has been some debate on whether it is in women's best interest to have land titled to them individually in comparison with joint titles with their husband or another household member, relatively few analyses have examined these questions in a rigorous way. What we do know is that the patterns of joint and individual ownership are often complex and differ widely across contexts.

There are numerous ways to present data on the owners of each parcel of land. The first is to categorize the owners of each parcel, such as owned 1) individually by a woman, 2) individually by a man, 3) jointly by a couple, or 4) jointly by people who are not in a couple (for gender analysis, we might want to know whether the joint owners who are not in a couple are all men, all women, or both men and women). If the data include information on value or area of land, it would then be possible to apportion the value or area to the form of ownership. This would provide information such as whether land owned individually by men is larger or of higher value than that owned individually by women or jointly by couples. This is the approach used in the analysis of the LSMS-ISA data in this paper.

The second way to consider individual and joint ownership is by using persons instead of land as the unit of analysis. In this instance, the respondents are asked whether they own any land. The questions may distinguish between individually owned or jointly owned land.[7] Rather than identifying the owner or owners of each parcel, this identifies whether each person owns land. This second approach is used in the analysis of the DHS data in this paper.

Among the definitions of ownership, there are a number of variations in how indicators may be produced based on the data available for analysis. Below, we simply refer to landowners, but the definition of landowner may be a reported or documented owner or a landholder or manager.

In this analysis we utilize five key indicators, which are presented below. A more detailed explanation of each indicator can be found in Appendix A.

(1) Indicator 1 shows the percentage of women/men who are landowners/managers/operators:

$$\frac{\textit{Women landowners}}{\textit{Total number of women}}, \quad \frac{\textit{Men landowners}}{\textit{Total number of men}}$$

(2) The second measure (Indicator 2) is the percentage of landowners who are women:

$$\frac{\textit{Women landowers}}{\textit{Total number of landowners}}$$

(3) A third indicator is the percentage of plots owned/managed/operated by women/men:

$$\frac{\textit{Number of plots owned by women}}{\textit{Total number of plots}},$$

$$\frac{\textit{Number of plots owned by men}}{\textit{Total number of plots}},$$

$$\frac{\textit{Number of plots owned jointly}}{\textit{Total number of plots}}$$

(4) Indicator 4 displays the mean area or value of land that is owned/managed/operated by women, men, or men and women jointly:

Mean size of women's plots; Mean size of men's plots

(5) The final measure (Indicator 5) is the percentage of area or value of land that is owned/managed/operated by women, men, or men and women jointly:

$$\frac{\textit{Land area owned by women}}{\textit{Total land area}},$$

$$\frac{\textit{Land area owned by men}}{\textit{Total land area}},$$

$$\frac{\textit{Land area owned jointly by men and women}}{\textit{Total land area}}$$

3. Existing Evidence from Micro-Studies in Africa

We start by reviewing available micro-level, individual-level statistics on gendered bundles of rights over land in Africa.[8] The review includes data collected after 2002 and found in published studies, technical reports, and gray literature, as well as unpublished data received from researchers. All studies included analyze data that are nationally or sub-nationally representative, with sample sizes near 500 observations. The review also excludes studies where purposive sampling may have created samples that did not accurately reflect individual land ownership, but includes studies that collect data on national land titling programs. In total, we reviewed 17 studies from 8 countries (Ethiopia, Ghana, Malawi, Mozambique, Niger, Rwanda, South Africa, and Uganda). Table 1 presents the results alphabetically by country. The review methodology and results are summarized in Appendix B.

While the representativeness of the samples varies, presenting an obstacle to generalizable conclusions, several trends emerge: 1) Regardless of indicator and country, in the vast majority of cases women are disadvantaged compared with men in regards to *self-reported land ownership, documentation of ownership, operation, management, and decision-making*; 2) There is a wide range in the magnitude of the gender gap, depending on country, region, type of land, definition of landholding, and inclusion of joint ownership, even within the same country; 3) When included, joint ownership is a common occurrence across Africa, comprising a substantial percentage of landholding, however, joint ownership does not necessarily mean that men and women have equal rights over the land; and 4) Less sex-disaggregated information is available on area or value of landholdings, but when it is reported, it points to the same pattern, whereby women have less land and of lower value as compared with men.

This review also confirms a number of gaps in the availability of gender-land statistics. First, information is available on only 8 of the 53 African countries, pointing to large geographical gaps in data coverage.[9] Second, only 2 of the 14 studies reviewed (and both in Uganda) are published in peer-reviewed sources, which points to a gap in the peer-reviewed literature on gendered land statistics. While this may be indicative of a lack of studies that meet journals' publication standards, it may also arise from the dearth of sex-disaggregated data of sufficiently good quality to merit analysis and publication in peer-reviewed outlets. Finally, many of the articles also notably lack a description of or attention to the identity of the survey respondent, a clear definition of land ownership, and the type of land selected for inclusion.

Table 1: Review of Published Large-Scale Micro-Level Estimates on Gendered Land Outcomes in Africa (2002-2013).

Authors (year published)	Country (year data collected)	Sample size	Sampling strategy and characteristics	Type of land surveyed	Indicator *	Further description of indicator	Women	Men	Joint	Other	Data Source(s)
Ragasa et al. (2012) ■■	Ethiopia (2011)	7,530 households, 31,450 plots	Regionally-representative of 4 major regions (Tigray, Amhara, Oromia, Southern Nations Nationalities and Peoples')	Agricultural	3	Plots managed[1]	23	54	23	NR	Central Statistical Agency of Ethiopia Survey
Holden & Tefera (2008) ■■	Ethiopia (2007)	608 households	NR	Any land [2]	1	Name on certificate	0.8	9.6	47 [3]	NR	Norwegian University of Life Sciences
					1	Involved in investment and production decisions	38 – before and after land reform	NR	NR	NR	
					1	Involved in decisions on use of income from crop production	33 – before and after land reform	NR	NR	NR	
Deininger et al. (2007) ■■	Ethiopia (2006)	2,300 households	Nationwide household survey, stratified by agroc-ecological zone and region, across 115 villages administered separately to one male and one female respondent per household, typically the head and spouse	Any land [2]	2 [4]	Certificates held	11	36	52	NR	Ethiopian Economic Association/ World Bank
Teklu (2005) ■■	Ethiopia (Amhara) (2004)	721,978 landholdings	Land registration data in 885 of 2,972 Kebeles in Amhara region. Women over 18 and men over 24 entitled to an allocation	Any land [2]	2	Privately registered land held	29	32	39	NR	Amhara Region Natural Resource and Land Administration Bureau
Doss et al. (2012a.) ■■	Ghana (2010)	2,170 households 3,272 individuals	Nationally representative data on individuals and households, age 18 and older	Agricultural	1	Own land	8.0	15	NR	NR	Gender Asset Gap Project
					1	Name on document	1.0	2.0	NR	NR	
					3	Parcels owned	29	64	3.0[5]	4.0	
					2	Landowners	38	NR	NR	NR	
				Non-Agricultural	1	Own land	8.0	17	NR	NR	
					5	Value of land owned	24	NR	NR	NR	

* **Indicators:** 1 – Percentage of women/men who are landowners/managers. 2 – Percentage of landowners/managers who are women/men. 3 – Percentage of plots owned/managed by women/men. 4 – Mean area or value of women's/men's owned/managed land. 5 – Percentage of area or value owned/managed by women/men. ●● Published in peer-reviewed journal. ■■ Working paper or other unpublished manuscript. ◆◆ Data from authors.

Authors (year published)	Country (year data collected)	Sample size	Sampling strategy and characteristics	Type of land surveyed	Indicator *	Further description of indicator	Women	Men	Joint	Other	Data Source(s)
National Statistical Office of Malawi (2010) ■■	Malawi (2006-2007)	25,000 smallholder farming households. Total of 2.5 million holdings, 7.7 million parcels and 7.7 millions plots	NR	Any land	3	Plots operated	34	66	NR	NR	National Census of Agriculture and Livestock
					4	Average size of parcel 6(hectares)	0.38	0.43	NR	NR	
					4	Average size of plot 7 (hectares)	0.27	0.28	NR	NR	
Hagos (2012) ■■/ ◆◆	Mozambique (2008)	5, 968 households 11,164 parcels	Representative of rural zones at provincial and national levels	Any land 2	3	Plots owned	37	59	1.0 8	3.0	Trabalho de Inquerito Agricola survey, collected by Ministry of Agriculture
Republic of Niger, Ministry of Agricultural Development & Ministry of Animal Resources (2008) ■■	Niger (2005-2007)	1,627,294 households 10,108,795 individuals	Nationally representative	Any land	5	Managed, out of land managed collectively by household	2.7	71	NR	NR	Republic of Niger, General Census of Agriculture and Livestock
					5	Managed, out of land managed individually by household	4.1	22	NR	NR	
					4	Average area, out of land managed collectively by household (hectares)	2.3	2.5	NR	NR	
					4	Average area, out of land managed individually by household (hectares)	0.9	1.9	NR	NR	
Santos, Fletschner, & Daconto (2013) ■■	Rwanda (2011)	355 households 867 individuals	Sample of land owning households, stratified according to marital type (legal marriage, customary, cohabitating, polygamous, and widows). Within each category, households were randomly selected. Husband, wife, and additional wife were interviewed	Agricultural	1	Name on title (sole or joint)	92	97	NR	NR	Women's Land Rights Assesment, Rwanda
					4	Average size of single titled plot in hectares	0.22 0.33 9	0.17	0.19	NR	
					4	Average number of plots with name on title (alone or joint)	2.7	3.0	NR	NR	

* **Indicators:** 1 – Percentage of women/men who are landowners/managers. 2 – Percentage of landowners/managers who are women/men. 3 – Percentage of plots owned/managed by women/men. 4 – Mean area or value of women's/men's owned/managed land. 5 – Percentage of area or value owned/managed by women/men. ●● Published in peer-reviewed journal. ■■ Working paper or other unpublished manuscript. ◆◆ Data from authors.

Authors (year published)	Country (year data collected)	Sample size	Sampling strategy and characteristics	Type of land surveyed	Indicator *	Further description of indicator	Women	Men	Joint	Other	Data Source(s)
Ali, Deininger & Goldstein (2011) ■■	Rwanda (2010)	3,554 households 6,330 parcels,	Sample of rural pilot areas that preceded the national rollout of the Land Tenure Regularization project Sample included both treatment and control areas in Ruganda, Rwaza, Gatsata and Mubama Districts and was desiged to yield numbers of households in each pilot cell equivalent to their share in the total population	Any land	1	Own plot (jointly or alone)	87 [10]	NR	NR	NR	World Bank Land Tenure Regularization Survey
					3	Parcels owned	42	NR	NR	NR	
Jacobs et al. (2011) ■■	South Africa (KwaZulu Natal Province) (2009)	800 households 1,600 individuals	Two sites: KwaDube (rural) and Inanda (peri-urban). Two individual respondents, age 18 and up, per household: household head and a randomly chosen woman[11]	Any land	1	Own land (KwaDube) [12]	20 [13]	85 [13]	7 (women) 33 (men)[14]	NR	Gender Land and Assets Survey [16]
					1	Own land (Inanda) [12]	31 [13]	79 [13]	11 (women) 30 (men)[14]	NR	
					1	Name on ownership document [15] (KwaDube)	5.0	32	NR	NR	
					1	Name on ownership document [15] (Inanda)	10	29	NR	NR	
Doss et al. (2012b.) ■■	Uganda (2009)	381 households 770 individuals	One district chosen in each of three regions of the country (Kapchorwa, Kibale, Luwero). In each district four villages were chosen and households were randomly sampled. Only rural communities sampled.	Agricultural	3 [17]	Parcels owned	18	26	52	4.0	Pathways to Asset Ownership: Land Tenure and Beyond Project sample survey, through USAID Assets and Market Collaborative Research Support Program
					3	Documented parcels held	19	73	7.0	1.0	
					1	Own land	14	20	NR	NR	
					1	Name on document	10	13	NR	NR	
					2	Landowners	49	NR	NR	NR	
					5	Value of land owned	48	NR	NR	NR	
Kes, Jacobs, & Namy (2011) ■■	Uganda	539 households 674 individuals	Representative of mailo land tenure system. Two individuals per household interviewed: household head (male or female) and randomly selected woman non-household head [11]	Any land	1	Own land	33 [13]	88 [13]	20 (women)53 (men)[14]	NR	Gender Land and Assets Survey [1]
					1	Name on document	13 [15]	48	NR	NR	

*** Indicators:** 1 – Percentage of women/men who are landowners/managers. 2 – Percentage of landowners/managers who are women/men. 3 – Percentage of plots owned/managed by women/men. 4 – Mean area or value of women's/men's owned/managed land. 5 – Percentage of area or value owned/managed by women/men. ●● Published in peer-reviewed journal. ■■ Working paper or other unpublished manuscript. ◆◆ Data from authors.

Authors (year published)	Country (year data collected)	Sample size	Sampling strategy and characteristics	Type of land surveyed	Indicator *	Further description of indicator	Women	Men	Joint	Other	Data Source(s)
Uganda Bureau of Statistics (2010) ■■	Uganda (2008-2009)	3.6 million householdsrepresenting 19.3 million individuals [19]	Surveyed small and medium-size agricultural households across all 80 districts of the country.	Agricultural	1	Crop plot managers	43	57	NR	NR	Uganda Census of Agriculture
Peterman et al. (2011) ●●	Uganda (2003)	851 households 3,625 plots	Representative of households in 8 districts.	Agricultural	3	Plots owned	19	53	NR	26	Natural Resource Management data
Deininger & Castagnini (2006) ●●	Uganda (2001)	430 households (126 peri-urban, 304 rural)	5 districts, representing Uganda's main regions. Half the sample drawn from households affected by land conflicts in the past year, while the other half randomly selected.	Agricultural and livestock use	1	Own land	10	47	21	22 [20]	Economic Policy and Research Council/ World Bank survey
Sebina-Zziwa et al. (2003) ■■/ ◆◆	Uganda (1980-2002)	80,000 land records	Estimated 65% of all lands in Uganda	Mailo (freehold) and leasehold	2	Titles held	16	63	3.0 [21]	18 [22]	Ministry of Lands

* **Indicators:** 1 – Percentage of women/men who are landowners/managers. 2 – Percentage of landowners/managers who are women/men. 3 – Percentage of plots owned/managed by women/men. 4 – Mean area or value of women's/men's owned/managed land. 5 – Percentage of area or value owned/managed by women/men. ●● Published in peer-reviewed journal. ■■ Working paper or other unpublished manuscript. ◆◆ Data from authors.

Notes: NR means "Not Reported." "Women" refers to sole female ownership, unless otherwise noted through a footnote. "Men" refers to sole male ownership, unless otherwise noted through a footnote. "Joint" refers to joint ownership between any two or more people, unless further details are provided in a footnote. "Other" ownership refers to any individual or group of people not already mentioned for that given entry, unless further details are provided in a footnote. All percentages are rounded to two significant digits. All percentages are self-reported unless otherwise noted. In addition to those reported here, we reviewed a number of additional studies which did not meet one or several of the qualifying criteria: Studies that collected data before 2002 were excluded, as were studies that did not include data on individual-level land ownership (for example, those including only data disaggregated by sex of household head.

1 Both headship and plot decision-making (proxied by the response to the question: "Who in the household has the right to decide what to grow on this parcel?") were used to determine plot manager.

2 No information is given on whether agricultural land/all land is surveyed, so we make the assumption that all land is included.

3 This figure is a combination of the following two options: (1) husband, wife, and children, and (2) wife and children.

4 Figures reported by the female respondent.

5 This figure refers to joint couple.

6 Parcel refers to "a piece of land that has been allocated to any member of the household, whether used for farming or not. It includes grazing land, woodlot, orchard, and the land where the household has built its dwelling unit."

7 Plot refers to "part of a parcel that contains a different crop or crop mixture or is operated by a different person in the same household."

8 This figure refers to family ownership.

9 First figure refers to all women. Second figure excludes widows.

10 Refers to female head/spouse.

11 In the South African sites, the sample was primarily male and female household heads, female partners of male heads, and daughters of heads of either sex, with fewer mothers, in-laws and sisters. For the Uganda study, in many cases female-headed households did not have another eligible woman to be the randomly chosen female respondent. In Uganda, the sample was primarily male household heads, their partners, and female household heads, with very few daughters, mothers, in-laws, or sisters.

12 No combined statistic for both sites is given.

13 This figure accounts for both individual and joint ownership.

14 Women and men report different levels of joint ownership. "Women" refers to percentage of women reporting joint ownership. "Men" refers to percentage of men reporting joint ownership.

15 This refers to any written documentation for land, including titles, rental agreements, receipts, permission to occupy orders, etc.

16 This study also collected measures of decision-making which did not correspond with any of the five indicators. The study included a measure of decision-making ability over each plot of land for women and men in each of the two sites, where 0 = no role, 0.5 = some input but decision made by other, and 1 = primary/joint decision-maker. For women, this measure was 0.23 in KwaDube and 0.20 in Inanda. For men (male heads), this measure was 0.38 in KwaDube and 0.44 in Inanda.

17 These levels are reported by one respondent. The authors note that overall levels change very little if individual respondents' claims of ownership are used instead.

18 This study also collected measures of decision-making which did not correspond with any of the five indicators. The study included a measure of decision-making ability over each plot of land for women and men in the study site, where 0=no role, 0.5=some input but decision made by other, and 1=primary /joint decision-maker. The measure for women (heads of household) was 0.5, for men it was 0.53.

19 This is an estimate of the number of individuals covered by the survey.

20 Includes landlords.

21 This figure refers to married couples.

22 This figure is a combination of the following categories: Joint man and woman (2%), institution (9%), administrator (4%), joint man and man (2%), joint woman and woman (1%).

4. New Evidence from Nationally-Representative Data in Africa

4.1 Food and Agriculture Organization: Gender and Land Rights Database

Among the most commonly cited statistics on gendered land ownership are those that come from the FAO Gender and Land Rights Database,[10] an online database that provides country-level information on gender and land ownership compiled by FAO from a variety of sources,[11] primarily agricultural censuses. The database includes statistics across six categories.[12] Table 2 displays figures drawn from the final category, land related statistics.

Of the 17 countries with available data in Africa, 10 were excluded from the current analysis because the primary data were collected before 2002.[13] It is also important to note that many of the agricultural censuses do not define a landholder as an owner. Instead, according to the FAO, the holder is defined as a *"...person who makes major decisions regarding resource use and exercises management control over the agricultural holding operation. The holder has technical and economic responsibility for the holding and may undertake all responsibilities directly, or delegate responsibilities related to day-to-day work management to a hired manager."*[14] Therefore, the agricultural censuses provide measure of management, rather than ownership. While this may be the most appropriate measure for considerations of agricultural productivity and providing services to farmers, a holder is not the same as an owner. Therefore, this database is not appropriate for making generalizations about the extent of women's landownership.

The absolute number of women landholders and number of total landholders for eight countries with data available from 2002 are used to calculate the

Table 2: Percentage of Landholders Who Are Women, from the FAO Gender and Land Rights Database.

Country/Year	Number of women landholders	Number of total landholders	Percentage of landholders who are women
Botswana (2004)	17,576	50,690	34.7
Cape Verde (2004)	22,461	44,450	50.5
Comoros (2004)	17,094	52,464	32.6
Ethiopia (2001-2002)	2,149,675	11,507,442	18.7
Gambia (2001-2002)	5,731	69,140	8.3
Madagascar (2004-2005)	371,158	2,428,492	15.3
Mali (2004-2005)	24,636	805,194	3.1
Tanzania (2007-2008)	1,575,129	5,838,523	27.0
Total			**23.8**

Source: Data for all countries but Comoros and Tanzania taken from FAO Gender and Land Rights Database. Data for Comoros comes from related FAO World Census of Agriculture documents. Data from Tanzania comes from a more recent agricultural census (2007-2008) than the one included in the database. Percentages are authors' own calculations. Figures are unweighted as sample weights are not provided in the database.

Notes: Only countries with data from 2002 and after are included. In the 2007-2008 Tanzanian census, the question asked is slightly different as compared with other countries, and asks whether female members of the household own or have *customary* right to land.

percentage of women landholders. The data do not allow for joint holding of plots or parcels; therefore, the remaining percentage is assumed to be held by men. The sample sizes for the total number of landholders surveyed ranges from a low of 44,450 in Cape Verde to a high of 11,507,442 in Ethiopia. While the percentage of women landholders ranges substantially from a low of 3.1 percent in Mali to a high of 50.5 percent in Cape Verde, the mean unweighted percentage across the eight countries is approximately 23.8 percent.

4.2 Demographic and Health Surveys

The DHS are cross-country population-level household surveys administered by host country governments with technical assistance from ICF International and other agencies under the MEASURE project.[15] Starting in 2009, select DHS started collecting information on individual land ownership. All DHS land statistics are nationally representative for households, and for women and men in the relevant age groups and include urban households that do not own agricultural land.[16]

Table 3 displays weighted results from the 10 countries that collected any land ownership information at the individual level.[17] The individual level statistics are disaggregated by gender and include whether the individual owns any land (either sole ownership or joint ownership) and whether or not the individual owns any land alone (sole ownership).

At the household level, reported agricultural land ownership ranges from a low of 47 percent in Senegal to a high of 86 percent in Burundi. The mean unweighted percentage of household land ownership across the 10 countries is approximately 71 percent. Across all countries included in the analysis, a higher percentage of men than women own land, both in terms of owning land solely or jointly as well as in terms of only owning land individually.[18] The mean unweighted percentage of female sole or joint ownership is 39 percent and sole ownership is 12 percent. For men, the mean unweighted percentage for both sole and joint ownership is 48 percent and for sole only is 31 percent. In all countries, the percentage of women owning any land (sole and joint) is more than double the percentage of women owning land alone. While the same general pattern holds for men, the difference between the two figures is proportionally smaller as compared with that for women.

For the eight countries for which there are data for both men and women, in five of them, the percentage of men who are landowners is higher than comparable figures for women. Only in Lesotho are the percentages higher for women as compared with men (38 percent for sole or joint ownership for women as compared with 34 percent sole or joint ownership for men). In two countries, Rwanda and Zimbabwe, the figures for men and women are roughly comparable.

Table 3: Landownership by Households, Women and Men from the DHS.

Country (year)	Household		Women			Men		
	Sample size households	Percentage of households owning any agricultural land	Sample size women	Own any land (sole or joint)	Own any land (sole only)	Sample size men	Own any land (sole or joint)	Own any land (sole only)
Burkina Faso (2010)	14,422	79	17,071	32	12	7,304	54	43
Burundi (2010)	8,589	86	9,372	54	11	4,280	64	50
Ethiopia (2011)	16,693	73	16,503	50	12	14,107	54	28
Lesotho (2009)	9,385	53	7,624	38	7	3,317	34	9
Malawi (2010)	24,818	80	15,399	48	23	NA	NA	NA
Rwanda (2010)	12,540	81	13,666	54	13	6,328	55	25
Senegal (2010-11)	7,902	47	15,688	11	5	4,929	28	22
Tanzania (2010)	9,592	77	10,137	30	8	NA	NA	NA
Uganda (2011)	9,029	72	8,667	39	14	2,292	60	46
Zimbabwe (2010-11)	9,756	63	9,171	36	11	7,480	36	22
Total	**--**	**71**	**--**	**39**	**12**	**--**	**48**	**31**

Notes: NA stands for not available. All descriptives use sample weights provided in the DHS. In Tanzania, the household ownership data included a "don't know" option. Indicators for most countries had very low percentages of missing values (ranging from 0 to 31 observations). Land indicators for individual ownership in Malawi were only asked to currently married or partnered women, resulting in missing information for 7,575 women.

4.3 Living Standard Measurement Surveys: Integrated Surveys on Agriculture

The LSMS-ISA is a joint US$19 million effort led by the World Bank and funded by the Bill and Melinda Gates Foundation to provide high quality nationally-representative data over time on agriculture and living conditions in seven countries in Africa. Household and agricultural surveys collect detailed information on gender-specific ownership, decision-making, and labor contributions to household cultivation efforts, allowing more nuanced, descriptive, and complex analyses of gender. The LSMS-ISA also collect land area, value, and detailed titling indicators, allowing for estimates beyond simple indicators of ownership. The data are publicly available.[19]

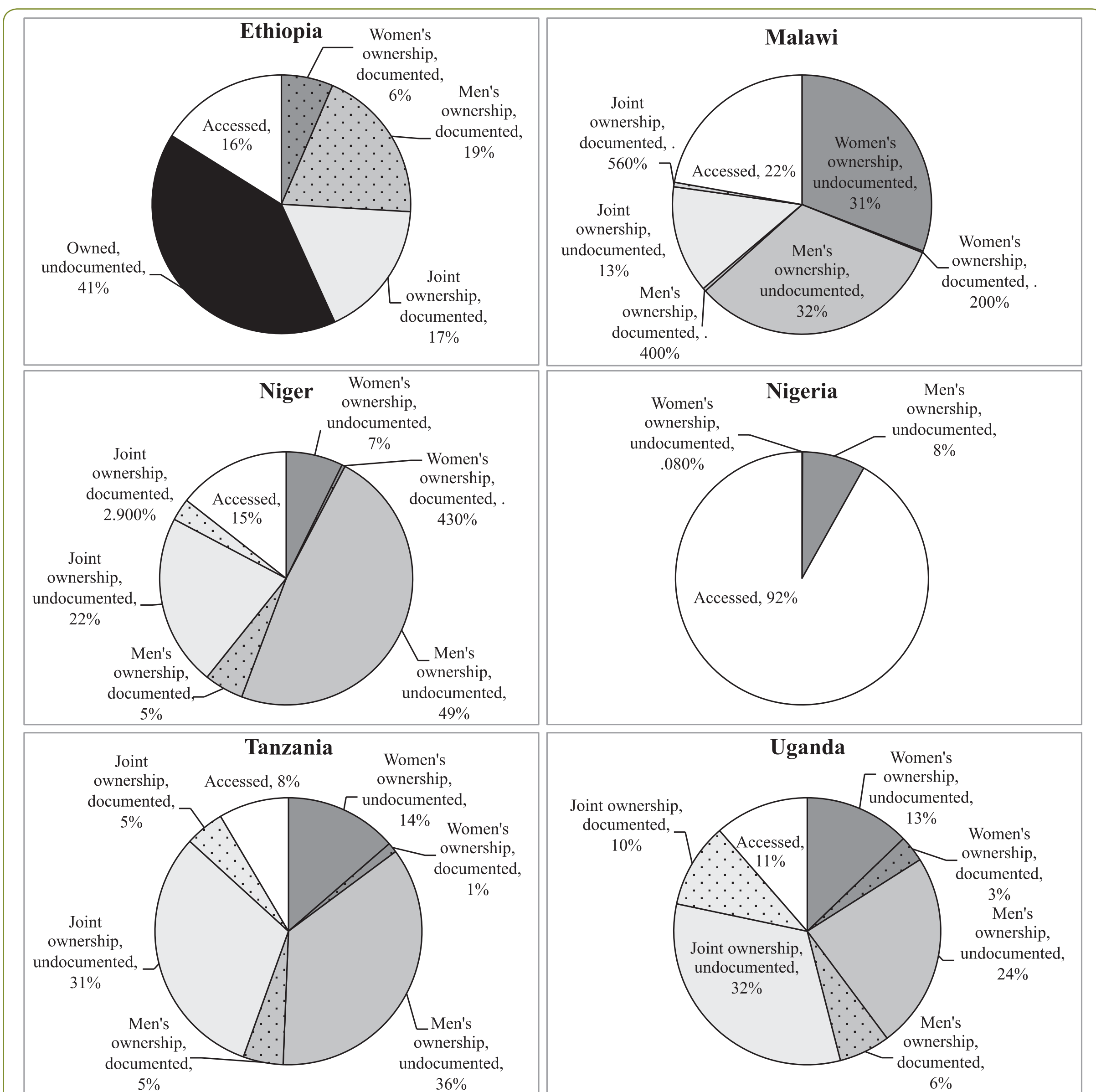
In the current analysis, we include data from six countries: Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda.[20] Details on differences in land definitions, questionnaire structure, land documentation indicators, ownership assignment, treatment of outliers, and calculation of area measures for all LSMS-ISA countries are included in Appendix C.

Figure 1 presents the plot-level results for land *ownership based on area measurements* for each country. The pie charts present, by sex, the proportion of land that is owned or accessed, out of the total land area surveyed for the LSMS-ISA. Figure 2 presents the plot-level results for land *ownership based on value measurements* for each country, except Ethiopia. Tables 4 and 5 present the plot-level results for land ownership by LSMS-ISA country for area and value measures, respectively. These statistics differ from those in the pie charts, which use all of the land of a given type as the denominator.

Despite significant differences across countries and types of ownership, this analysis reveals a single overarching trend: In almost every country for which data is available, men's sole ownership of land, regardless of whether or not it is documented and undocumented land or exclusively documented land, is higher than women's sole ownership of land, by proportion, area, and value. The singular exception is Malawi, where the value of land held solely by men and women is equal. Although this gender gap exists across all countries, the degree

varies significantly. For example, in Nigeria, men own, on average, 4.4 times as much documented and undocumented land area as do women, while in Malawi this ratio is 1.2:1. In Uganda and Tanzania, men own approximately 1.7 times as much documented land area on average as do women, compared with lows of 1.1:1 in Ethiopia. The gap also varies depending on how land is measured and how ownership is defined. Men in Nigeria hold as much as 10 times the proportion of value of documented and undocumented land than that held by women. Although the absolute average value of owned land is higher for men than women across all countries analyzed, the average value of land that is owned *jointly* in Malawi, Niger, and Uganda is higher than the average value of land held *solely* by either *women* or *men* in these countries. There is a substantial difference in the proportion of value of documented land between men and women in Niger (25:1).

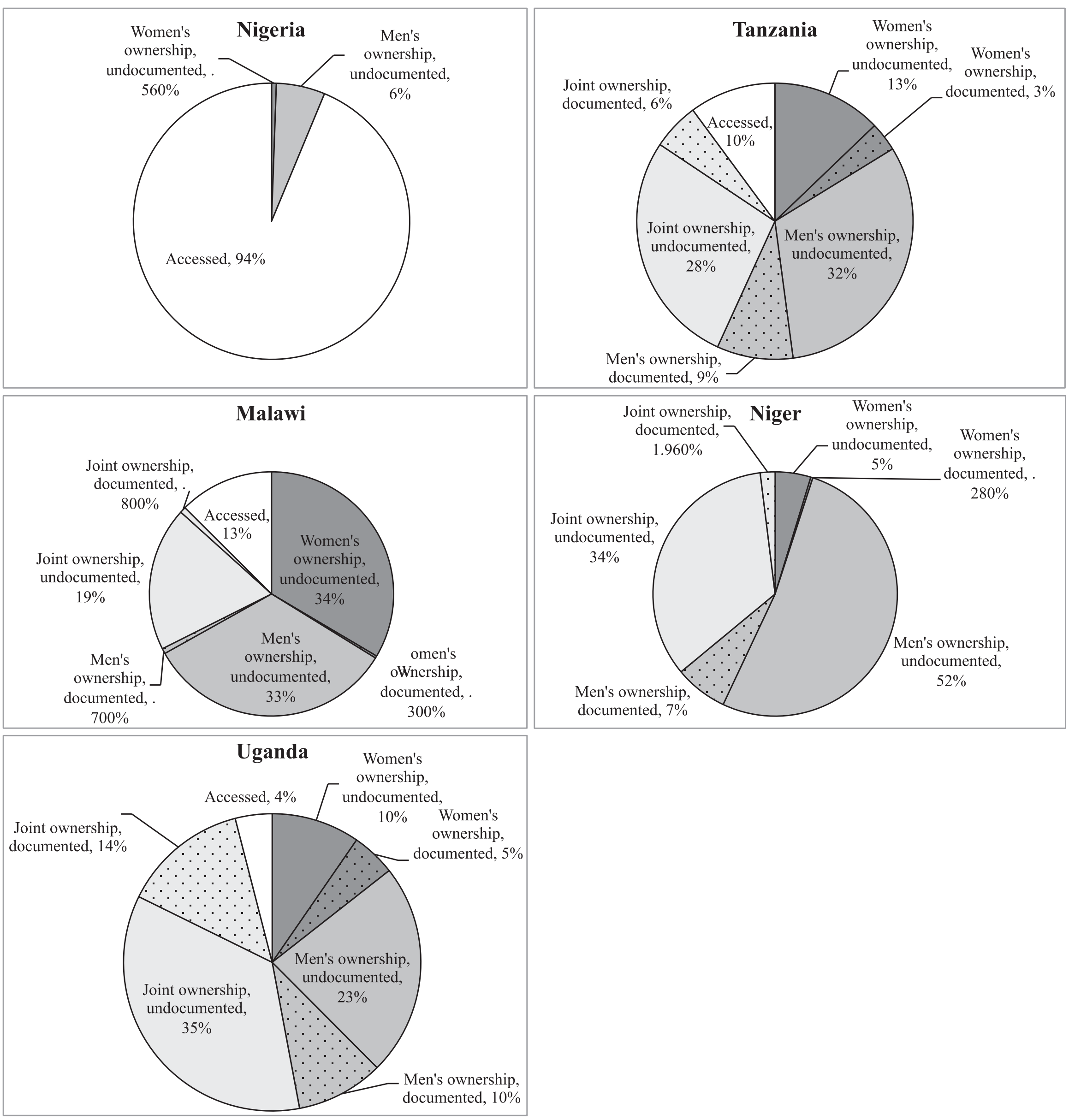
Figure 1: Pie Charts Representing, by Sex, the Area of Accessed or Owned Land as a Proportion of the Total Area of All Household Land.



Notes: Data come from LSMS-ISA Ethiopia (2011-12), Malawi (2010-2011), Niger (2011), Nigeria (2010), Tanzania (2010-2011) and Uganda (2009-2010). All statistics utilize weighting provided in the ISA. All area measures are in acres. Proportion area figures represented are rounded based on Table 4 and thus do not consistently sum to 100 percent. In the case of Ethiopia, plots with undocumented ownership do not have associated sex-disaggregated ownership information.

In terms of the *management* of all *owned* and *accessed land*, men solely manage between three and nearly seven times as high a proportion of land as do women in Malawi and Nigeria, respectively. These differences are magnified when considering the proportions of sole management of owned land only (e.g. a 49:1 ratio in Nigeria). Men also solely *manage* a larger *absolute average area* of *owned* and *accessed land* as compared with sole management by women in both countries. However, in Uganda, data on *management of the output of owned land* show that women solely manage a higher proportion of the output from owned land than do men (24 percent by women, 21 percent by men). For *management of output of either owned* or *accessed land*, the number of plots managed by women is higher than the number managed by men, but women's plots have a lower *absolute average area*. Further details on the results of this analysis can be found in Appendix D.

Figure 2: Pie Charts Representing, by Sex, the Value of Accessed or Owned Land as a Proportion of the Total Value of All Household Land.



Notes: Data come from LSMS-ISA Malawi (2010-2011), Niger (2011), Nigeria (2010), Tanzania (2010-2011) and Uganda (2009-2010). All statistics utilize weighting provided in the ISA. All value measures are in local currency. Proportion area figures represented are rounded based on Table 5 and thus do not consistently sum to 100 percent. In the case of Ethiopia no associated value information was collected.

Table 4: Land Ownership/Access Area Measures from LSMS-ISA Data.

Country and type of land	Total number of parcels					Average area			Proportion Held		
	Total (sample size)	Women	Men	Joint	Total area	Women	Men	Joint	Women	Men	Joint
Ethiopia (2011-2012)											
Documented ownership	3,443	585	1,572	1,286	3,457	0.92	1.01	1.11	0.15	0.45	0.40
Malawi (2010-2011)											
Ownership	15,593	6,646	6,052	2,895	14,009	0.83	0.98	0.91	0.40	0.42	0.18
Documented ownership	208	43	72	93	213	0.90	1.09	1.11	0.17	0.35	0.47
Management (owned + accessed)	19,977	5,194	14,783	N/A	17,990	0.84	0.93	N/A	0.24	0.76	N/A
Management (owned)	15,586	4,123	11,463	N/A	14,003	0.84	0.93	N/A	0.25	0.75	N/A
Management (accessed)	4,391	1,071	3,320	N/A	3,987	0.85	0.93	N/A	0.23	0.77	N/A
Niger (2011)											
Ownership	5,302	685	3,012	1,605	18,974	2.29	3.84	3.52	0.09	0.62	0.29
Documented ownership	450	29	298	122	1,860	3.14	4.12	5.41	0.05	0.60	0.34
Nigeria (2010)											
Ownership	375	28	347	N/A	864	0.56	2.44	N/A	0.01	0.99	N/A
Management (owned + accessed)	5,780	1,052	4,728	N/A	9,757	1	1.78	N/A	0.13	0.87	N/A
Management (owned)	386	42	344	N/A	874	0.63	2.43	N/A	0.02	0.98	N/A
Management (accessed)	5,394	1,010	4,384	N/A	8,883	1.01	1.72	N/A	0.14	0.86	N/A
Tanzania (2010-2011)											
Ownership	5,103	1,110	2,146	1,847	12,864	1.83	2.67	2.57	0.16	0.44	0.39
Documented ownership	553	108	250	195	1,502	1.47	2.49	3.17	0.11	0.45	0.44
Uganda (2009-2010)											
Ownership	4,138	858	1,298	1,982	8,949	1.71	2.27	1.99	0.18	0.34	0.48
Documented ownership	837	157	230	450	1,995	1.94	3.37	2.11	0.16	0.32	0.52
Management or control of output (owned)	4,076	1191	726	2,159	8,728	1.62	2.58	2.02	0.24	0.21	0.55
Use rights (accessed)	1,457	457	361	639	1,147	0.60	0.91	0.70	0.25	0.30	0.45
Management or control of output (accessed)	1,454	562	248	644	1,148	0.63	0.84	0.75	0.32	0.21	0.47

Notes: [1] All statistics utilize weighting provided in the ISA. [2] All area measures are in acres. [3] Proportion areas are rounded to two decimal points; therefore total proportion area does not always appear to sum to 100%.

Table 5: Land Ownership/Access Value Measures from LSMS-ISA Data.

	Total number of parcels					Average value			Proportion Held		
Country and type of land	Total (sample size)	Women	Men	Joint	Total value	Women	Men	Joint	Women	Men	Joint
Malawi (2010-2011)											
Ownership	15,650	6,683	6,062	2,905	662,973	39	44	53	0.39	0.39	0.23
Documented ownership	212	40	80	92	11,732	49	61	56	0.17	0.40	0.43
Management (owned and accessed)	17,987	4,770	13,217	N/A	758,311	37	45	N/A	0.23	0.77	N/A
Management (owned)	15,643	4,152	11,491	N/A	662,620	38	45	N/A	0.23	0.77	N/A
Management (accessed)	2,344	618	1,726	N/A	95,691	32	40	N/A	0.23	0.77	N/A
Niger (2011)											
Ownership	3,816	506	2,162	1,148	1,368,347	132	300	392	0.05	0.59	0.36
Documented ownership	303	24	230	49	127,490	153	290	262	0.03	0.75	0.21
Nigeria (2010)											
Ownership	378	29	349	N/A	108,354	267	297	N/A	0.09	0.91	N/A
Management (owned and accessed)	5,644	1,039	4,605	N/A	1,729,151	278	317	N/A	0.17	0.83	N/A
Management (owned)	382	43	339	N/A	107,099	347	286	N/A	0.14	0.86	N/A
Management (accessed)	5,262	996	4,266	N/A	1,622,052	275	320	N/A	0.18	0.82	N/A
Tanzania (2010-2011)											
Ownership	5,082	1,101	2,149	1,832	6,377,203	1,013	1,327	1,267	0.18	0.45	0.37
Documented ownership	543	104	250	189	1,266,465	2,018	2,288	1,752	0.19	0.50	0.31
Uganda (2009-2010)											
Ownership	3914	778	1,274	1,862	17,800,000	3,034	4,487	4,554	0.15	0.34	0.51
Documented ownership	805	147	225	433	5,197,525	4,537	7,231	5,445	0.17	0.34	0.49
Management or control of output (owned)	3854	1,090	715	2,049	17,400,000	2,893	4,926	4,679	0.21	0.21	0.58
Use rights (accessed)	612	118	189	305	738,243	1,118	1,064	1,297	0.17	0.29	0.54
Management or control of output (accessed)	612	172	131	309	741,443	1,135	1,171	1,227	0.24	0.22	0.54

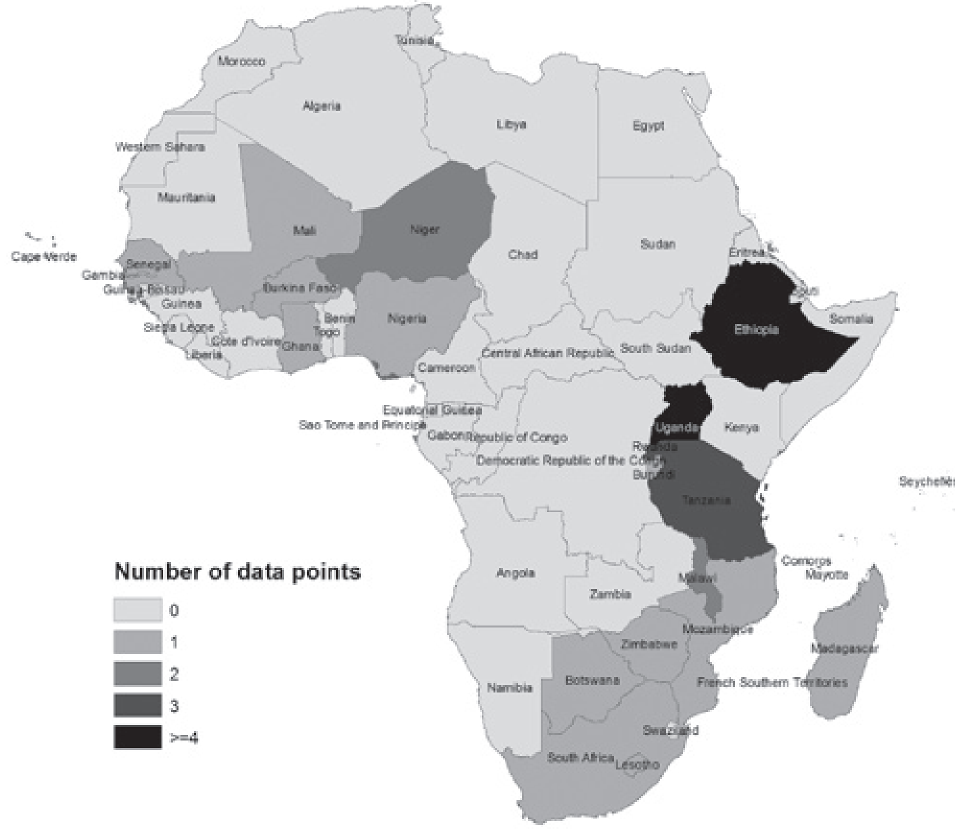
Notes: [1] All statistics utilize weighting provided in the ISA. [2] Local currencies are reported as follows: 1000s of Malawian Kwacha (MWK); 1000s of CFA Francs (FCFA) for Niger; 1000s of Nigerian Naira (NGN); 1000s of Tanzanian Shillings (TZS); 1000s of Ugandan Shillings (USH). No value measures available for Ethiopia. Further methodological details are provided in Appendix C. [3] Proportion areas are rounded to two decimal points; therefore total proportion area does not always appear to sum to 100%.

5. Summary and Recommendations

We began this effort by asking the question: Can we produce a reliable data-driven statistic on land ownership for women in Africa? The answer turns out to be more complex than simply yes or no. There exist virtually no recent, comparable, nationally representative data across African countries that contain information on women's land ownership and control or management. Therefore, in a world of imperfect and scarce data, we undertook a review of existing estimates as well as analysis of large-scale comparable data using the FAO Gender and Land Rights Database, DHS, and LSMS-ISA. This exploration reveals that many gaps remain, both in terms of country coverage (See Figure 3) as well as quality of measurements available.[21]

It is clear that statements such as *"less than 2 percent of the world's land is owned by women"* or that women own *"an average of 15 percent of agricultural landholdings in Africa"* are gross oversimplifications and are not substantiated by any of the available data. Yet, across countries, the pattern that women own less

Figure 3: Geographical Representation of Data Points for Gender-Land Analysis Included in This Study.



land than men, regardless of how we conceptualize ownership, is remarkably consistent. Further, in many cases, the gender gaps are quite large.

The various analyses presented in this paper provide new insights into the gendered patterns of land ownership. Our best estimates from a review of 17 large scale micro-studies indicate that women are disadvantaged relative to men in nearly all measures of land ownership and bundles of rights; however, the gender gap varies widely. These statistics are typically more equitable for management indicators, or for land with use or access rights only, while they are less equitable for indicators based on reported or documented ownership. An eight-country analysis from the FAO Gender and Land Rights database shows that women account for an average of 24 percent of agricultural landholders (though this ranges from 3.1 percent in Mali to 50.5 percent in Cape Verde). Data from ten DHS surveys show that 39 percent of women own land individually and 12 percent of women own land jointly, in contrast to 48 and 31 percent of men, respectively. Analysis of LSMS-ISA from six countries shows that of the total land area owned or accessed by households, women own a high of 31 percent in Malawi and a low of close to 0 percent in Nigeria. Comparatively, men solely own on average 4.4 times as much absolute land area in comparison with women in Nigeria, and between 1.1 to 1.7 times as much land as women solely own in the other countries.

These findings as well as the analysis process point to the following conclusions and recommendations for improving research and policy on women's land ownership in Africa:

First, for any analyses of the gendered patterns of land ownership, it is critical to clearly define both the definitions of ownership and the indicators that are being used. Without this, comparisons cannot be made across studies, making it impossible to discern overall patterns. In our experience, the variations in methodology, even within the same group of surveys, made producing comparable estimates from existing research and data sets a challenge. Thus, standardizing definitions and methodology is important when collecting primary data and differences in methodology should be made explicit when replicating or comparing studies.

Second, any assessment of gender inequality depends on the comparison group. If considering the percentage of women who own land, this must be compared with the percentage of men who own land. When considering the percentage of land that is owned by women, it is critical to identify how jointly owned land is treated. Assessment of inequality differs depending on whether women's land ownership is being compared with men's ownership only or with other joint ownership.

Third, which measures are collected and how they are defined affects both the evidence and the policies on gendered land ownership. This is particularly true for documentation of ownership. While it would be ideal to develop a standardized definition of "titled" or "documented" land, the varied legality or security of land in different contexts requires use of definitions and data which most closely resemble the country situation. Understanding both the central tendencies and outliers in women's land ownership can tell us more about where programs may be most beneficially targeted as well as promising approaches to address large inequalities between women and men in land ownership.

Finally, the methods of collecting individual-level land data must be standardized. Surveys should routinely ask who within the household owns the land and allow for the inclusion of multiple names. This will facilitate analysis of both individual and joint ownership. Researchers should also systematically test whether the identity of the respondent in these types of surveys significantly affects the validity and consistency of individual responses within the household (e.g. Fisher et al. 2010).

While the evidence base on impact evaluations of land and property rights interventions has increased in recent years, evidence on the gender-differentiated impacts of land property rights interventions that is based on longitudinal data or moves beyond simple associations is still scarce. Several recent reviews have attempted to summarize levels, linkages, and programmatic options for strengthening women's land rights (Rodgers & Menon 2013). While these overviews contribute to our understanding of promising approaches, they fall short of including the methodological rigor to identify causality in studies being reviewed. Moreover, it is questionable whether much of the older literature from the early 1990s is still relevant given the evolution of land tenure systems owing to economic growth, structural transformation, and property rights interventions. Because policies and programs to redress inequalities in land ownership are typically designed and implemented at the country level, global and regional statistics on gender inequalities in land ownership, despite being attractive as an advocacy tool, will not provide the information required to design appropriate policy interventions. Rigorous, well-defined, and contextually relevant measurement of gender disparities in ownership and control of land, implemented in population-representative surveys that are embedded within countries' statistical systems, will be essential to future efforts to reduce gender gaps in land.

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Endnotes

1 The "2 percent" (or "1 percent") figure has been widely reproduced, and most commonly traces citations back to FAO. There are variations on how this figure is presented, including "less than," "only" or "more than" 2 percent. See for example, Action Aid (page 5: http://www.landcoalition.org/publications/her-mile-women%E2%80%99s-rights-and-access-land [accessed 8/28/2013]), Oxfam (http://www.oxfam.org/en/node/2037 [accessed 8/28/2013]), Bread for the World (http://www.bread.org/what-we-do/resources/fact-sheets/empowering-women-in-agriculture.pdf [accessed 8/28/2013]).

2 Citations of land ownership from Africa are more varied as compared to global citations. See for example, UN Women (http://www.unwomen.org/en/news/stories/2012/12/cop18-landmark-decision-adopted [accessed 8/28/2013]), Oxfam New Zealand (http://www.oxfam.org.nz/what-we-do/issues/gender-equality/women-in-the-developing-world [accessed 8/28/2013]), IFAD (http://www.ifad.org/pub/factsheet/women/women_e.pdf [accessed 8/28/2013]).

3 Taken from the Bill and Melinda Gates Foundation: http://www.gatesfoundation.org/infographics/pages/women-in-agriculture-info.aspx [accessed 8/28/2013].

4 Taken from the FAO: http://www.fao.org/economic/es-policybriefs/multimedia0/female-land-ownership/en/ [accessed 8/28/2013].

5 Another dimension is the concern of who within the household is doing the reporting. In many surveys, one respondent is asked about who owns each parcel of land. This may result in different answers than asking each person individually about whether she or he owns land.

6 Although often used interchangeably, the terms "title" and "deed" are not equivalent. A title shows the rights to which a person is entitled, while a deed is a legal instrument which is referred to when conferring these rights. Simply put, the title only shows the ownership, while the deed is the formal, legal document that can transfer property ownership.

7 Again, it may be that each individual is asked about their own ownership or that one person is asked about the ownership of everyone in the household.

8 We started by reviewing original research on gender and land, followed by papers that cite these studies. We then conducted online searches using keywords for gender and land in Africa (Google scholar, peer-reviewed journals, and websites of universities and research institutes). We also conducted "snowball" citation techniques and sent emails to researchers in the field working on gender and land within various institutions. We do not consider research which stratifies ownership by sex of household head, as these are not representative of individuals.

9 The figure of 53 countries includes the island nations of Cape Verde, São Tomé and Príncipe, Madagascar, the Comoros, the Seychelles, and Mauritius. The figure fluctuates depending on whether nations such as Somaliland or Western Sahara are included.

10 For more information, see: http://www.fao.org/gender/landrights/home/en/.

11 Botswana data comes from Botswana Agricultural Census 2004. Cape Verde data comes from FAO World Census of Agriculture 1994. Ethiopia data comes from FAO World Census of Agriculture 2001-2002. Gambia data comes from Department of Planning (DOP), Department of State for Agriculture (DOSA) Report of the Agricultural Census of The Gambia 2001-2002. Madagascar data comes from FAOStat 'Principaux résultats du Recensement agricole 2004-2005'. Mali data comes from 'Recensement Agricole 2004-2005'. Data from Comoros is not included in the FAO database, but instead comes from related FAO World Census of Agriculture documents. For more information, see: http://www.fao.org/economic/ess/ess-wca/wca90-country0/en/.

12 Including national legal frameworks, international treaties and conventions, customary law, land tenure and related institutions, civil society organizations, and selected land related statistics.

13 In total, 10 countries were excluded because they were collected before 2002 [Algeria (2001), Burkina Faso (1993), Cote d'Ivoire (2001), Democratic Republic of Congo (1990), Lesotho (1999-2000), Malawi (1993), Mozambique (1999-2000), Senegal (1998-1999), Uganda (1991), Zambia (2000)].

14 FAO, 2007, 3.36.

15 Over the last 25 years, DHS have collected more than 300 surveys in over 90 countries and represent a primary source of statistics on population, health, and nutrition, among others, from developing countries. For more information, see: http://www.measuredhs.com.

16 Agricultural land ownership is collected at the household level, with the question "Does any member of this household own agricultural land?" At the individual level, information on individual ownership of any type of land is collected from each eligible woman (every woman age 15 to 49) and each eligible man (every man age 15 to 49/54/59, depending on the country) in the sample households. At the individual level, typically men and women are asked separately "Do you own any land either alone or jointly with someone else?" and responses of no ownership, sole ownership, joint ownership, or both sole and joint ownership are allowed.

17 Of data collected after 2002, three countries did not collect any land statistics at the household level or at the individual level: Chad (2004), Guinea (2005), and Mozambique (2003). Fifteen countries did not collect any land statistics at the individual level: Benin (2006), Congo [Brazzaville] (2005), Congo [DRC] (2007), Ghana (2008), Kenya (2008-2009), Liberia (2007), Madagascar (2008-2009), Mali (2006), Namibia (2006-2007), Niger (2006), Nigeria (2008), Sao Tome and Principe (2008-2009), Sierra Leone (2008), Swaziland (2006-2007), and Zambia (2007). Three countries were not available in the public domain or restricted access at the time of drafting this analysis: Cape Verde (2005), Eritrea (2002) and South Africa (2003). Finally, two of the 11 countries included in the table do not include questions on individual male land ownership: Malawi (2010) and Tanzania (2010).

18 One exception is Zimbabwe, where levels of ownership are equal for men and women (36 percent) when sole and joint land ownership is considered. However, when only sole ownership is considered, the pattern holds; nearly double the percentage of men own land as compared to women (22 percent versus 11 percent).

19 Further information on sampling, data collection instruments and ongoing research outputs can be found on the LSMS-ISA webpage: http://go.worldbank.org/OQQUQY3P70.

20 At the time of analysis, data from Mali was not available.

21 For example, if we map our data points from the statistical analysis as well as the review of micro-studies (assigning one data point for each country per study), we observe that there are large geographic areas in Northern and Central Africa with virtually no estimates. In addition, of the 19 countries represented, only 6 have two or more data points for triangulation.

APN 3

Measuring Welfare in Developing Countries in Practice: Beyond Income and Besides Consumption

Organizer and chair: Luc Christiaensen, The World Bank

The Global Strategy for Improving Agricultural and Rural Statistics identifies as one of its priorities the need for improving the measurement of well-being beyond income. While collecting income data has its analytical advantages, concerns are often raised about its feasibility and suitability under conditions of high informality of the labor market. In fact, as also recognized in the Wye City Group Handbook "Statistics on Rural Development and Agricultural Household Income", measuring consumption to gauge living standards and poverty, instead of income, may be preferable, especially in developing countries.

Measuring welfare through consumption, however, is not without problems either. Moreover, the complexity of collecting full consumption data often makes it incompatible with many survey undertakings. In many project contexts and in small-survey settings, collecting full consumption data is simply not an option: thus, the need for validating alternative, cost-effective methods for the measurement of welfare. Furthermore, the low frequency in the availability of consumption data makes it imperative for development practitioners to device better methods to monitor welfare overtime.

Asset-based indexes and consumption prediction models are sometimes being used to proxy for full consumption expenditures. However, they remain poorly validated, casting doubt about their credibility and external validity.

This session will assemble the most recent and technically sound theoretical and empirical studies in the measurement of welfare through proxies, in lieu of direct measures of consumption expenditure. Different techniques to select welfare proxies and derive weights to combine them into one index (either anchored in consumption or not) will be explored and their performance in predicting consumption across different segments of the distribution will be examined in different settings.

The session will include three 20-minute presentations of relevant studies by leading experts in the field, followed by a 30-minute round table discussion.

Papers:

- Rodolfo Hoffmann, Régis Oliveira (Brazil), "The Evolution of Income Distribution in Brazil: different characteristics of the agricultural sector"
- Edoardo Pizzoli, Chiara Piccini, Giuseppe Sacco et al. (Italy), "Spatial Estimation of Households' Income and Well-Being: applying geostatistics to microdata"
- Anoubissi Jean De Dieu (Cameroon), "Measuring Countries Welfare"
- Isis Gaddis (Tanzania), Stephan Klasen (Germany), "Mapping Multidimensional and Monetary Poverty: the case of Uganda"
- Thomas Pave Sohnesen, Luc Christiaensen, Gero Carletto (USA), "Tracking Poverty via Reduced Consumption Aggregates"

The Evolution of Income Distribution in Brazil: different characteristics of the agricultural sector*

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Abstract

The paper analyzes the characteristics and the evolution of income distribution in the Brazilian agricultural sector considering two dimensions: the per capita household income and the income of occupied persons. The main data source is the National Household Sample Survey (PNAD). In order to fulfill this purpose, the per capita household income was divided into nine components (for Brazil and considering only the agricultural households) to evaluate their contributions to the decrease in inequality. In the second part, the paper analyzes the characteristics of occupied persons and the determining factors of their income, always comparing the agricultural and non-agricultural sectors. The estimated effects were analyzed over the period 1992-2009, adjusting one earnings equation for each year. In both cases (per capita household income and earnings of occupied persons), the agricultural sector showed markedly different behavior compared to the non-agricultural sector. Regarding the per capita household income, although from 2003 onwards the reduction rate of inequality among agricultural households is similar to the one observed in Brazil as a whole, the determinants associated with this reduction are clearly different in the agricultural sector. Concerning the income of occupied persons, the reduction in inequality is less intense and more irregular in the agricultural sector. The different factors that determine the income of occupied persons also presented distinct behaviors for the agricultural and non-agricultural sectors.

Keywords: per capita household income; occupied persons; agricultural; Brazil.

1. Introduction

In the recent period, the Brazilian economy showed important social changes. Even though it is still one of the most unequal economies of the world, an important decrease in inequality and extreme poverty is observed from 2001 on. Barros, Foguel and Ulyssea (2006 and 2007) present several studies that highlight this fact and show which are the main causes and determinants of this recent decline in poverty and inequality.

Among the determinants, the increase in transfers (pensions[1] and cash transfers programs such as *Bolsa Família*) as a share of household income showed a significant contribution to the decrease in inequality. Besides transfers, changes in the labor market were also important, such as the increase in the mean income of occupied persons, the reduction of the income differentials associated with different levels of schooling, the decrease in inequality between geographical regions, the expansion of the formal sector in the labor market, the systematic growth of the real minimum wage etc.

Considering the recent decline in inequality in Brazil, the paper analyzes more accurately its determinants, comparing the agricultural and non-agricultural sectors. The agricultural sector is very heterogeneous, with strong differences between geographic locations and particular characteristics of the production process. Additionally, the changes in this sector occur more slowly, as illustrated by the fact that the level of schooling of agriculture workers is still far below the national average.

Thus, the paper analyzes the evolution of the income distribution in the agricultural sector in two dimensions: the evolution of the composition of the household income and occupied persons earnings, comparing the agricultural sector with Brazil's total economy or with the non-agricultural sector. As the income from work (earnings) is still the main share of household income, it will be examined in more detail.

Due to the lack of studies discussing the income distribution specifically for the agricultural sector, the paper will not focus in any specific relation, providing general information for households and occupied persons in this sector.

The paper is organized as follows: the next section shows the recent changes in the household income distribution; the third section analyses the evolution of earnings, schooling and other characteristics of occupied persons in the agricultural and the non-agricultural sectors; in the fourth section earnings equations are adjusted for each year (in the period 1992-2009), in order to analyze the evolution of the effects of several factors on earnings; the corresponding methodology is described in each

section; a short fifth section shows the changes in inequality between regions and between Federal Units; the last section presents the conclusions.

2. Changes in the per capita household income distribution

The paper uses data from the National Household Sample Survey (PNAD) to analyze the evolution of the per capita household income distribution in Brazil in the last decades. In this section, the analysis is limited to the period 1995-2009, considering that extremely high inflation rates, which make it difficult to analyze the evolution of real mean income, do not occur from 1995 on, and that the 2009 PNAD is the last one available.

The per capita household income is defined as the ratio between the household income (that is, the sum of all incomes received from all sources by the persons in the household) and the number of persons in the household, excluding boarders, domestic employees and their relatives living in the employers' house.

All the monetary values are expressed in Reais (R$ - Brazilian currency) of September-October 2009. All the values prior to the 2009 PNAD were updated using the geometric mean of the National Index of Prices (INPC) in September and October in each year.

It is known that in such a survey the respondent tends to understate his income[2] (the data is collected through a self-declaration questionnaire). The degree of understatement varies according to the type of income: it is smaller for formal payments (paid by the government) and for regular payments, and larger for informal and or irregular receipts.

The rural areas of the states of Rondônia, Acre, Amazonas, Roraima, Pará and Amapá (the former Northern region) were excluded from the sample, as they were not covered by PNAD before 2004. Thus, in this paper "Brazil" shall be understood as "Brazil, excluding the rural area of the former Northern region".

Table 1 shows the evolution of the main characteristics of the per capita household income distribution in Brazil from 1995 to 2009. Table 2 shows the same indicators, considering only households in which the reference person's main activity is in the agricultural[3] sector (agricultural households).

Table 1: Per capita household income distribution in Brazil(1), from 1995 to 2009: average, median and inequality measures.

Year	Average(2)	Median(2)	Inequality measures				% of income appropriated by			
			Gini (G)	Mehran (M)	Piesch (P)	Theil (T)	Poorest 50%	Richest 10%	Richest 5%	Richest 1%
1995	520.9	254.5	0.599	0.730	0.533	0.727	12.5	47.7	34.0	13.7
1996	530.0	260.3	0.600	0.735	0.533	0.726	12.2	47.3	33.6	13.4
1997	529.1	260.4	0.600	0.734	0.533	0.731	12.2	47.5	33.8	13.6
1998	534.8	268.4	0.598	0.730	0.532	0.728	12.4	47.6	34.0	13.8
1999	504.5	257.7	0.592	0.724	0.526	0.706	12.8	47.1	33.4	13.1
2001	511.8	258.4	0.594	0.726	0.528	0.720	12.7	47.2	33.8	13.8
2002	512.3	262.5	0.587	0.718	0.522	0.705	13.1	46.8	33.5	13.4
2003	482.1	254.8	0.581	0.713	0.515	0.680	13.3	46.0	32.7	13.0
2004	498.1	269.3	0.569	0.700	0.503	0.656	14.0	45.0	31.9	12.8
2005	528.5	289.1	0.566	0.697	0.501	0.651	14.2	45.0	32.0	12.9
2006	577.9	321.4	0.560	0.690	0.495	0.635	14.6	44.5	31.6	12.6
2007	592.4	336.9	0.552	0.684	0.486	0.614	14.9	43.6	30.8	12.3
2008	620.7	365.1	0.543	0.674	0.477	0.594	15.5	42.8	30.2	12.0
2009	637.7	380.0	0.539	0.670	0.473	0.589	15.7	42.5	30.0	12.0
Δ% 95-01	–1.7	1.5	–0.8	–0.5	–0.9	–1.0	1.6	–1.0	–0.6	0.7
Δ% 01-09	24.6	47.1	–9.3	–7.7	–10.4	–18.2	23.6	–10.0	–11.2	–13.0

Source: National Household Sample Survey (PNAD).

(1) Excluding the rural area of the former Northern region.

(2) In Reais (Brazilian Currency - R$) of September-October 2009.

It should be noted that the "agricultural households" subsample excludes not only the households in which the reference person's main occupation is non-agricultural, but also the households in which the reference person is not occupied.

There is a huge difference between the per capita household income of the households classified as "agricultural" in comparison with all households. In 2009, the average per capita household income of Brazil was 91% higher than the average of the agricultural households. Moreover, half of the agricultural households showed a per capita household income under R$204.0 per month (i.e., less than one half of the minimum wage - R$465.0 in September-October 2009). The comparison between the average and the median of per capita household income shows that despite the reduction in inequality, the distribution is still strongly asymmetric.

According to all the indicators, there is a tendency to reduce inequality, especially from 2001 on. The same can be observed, in Table 2, considering only the agricultural households.

According to Tables 1 and 2, the average (and the median) per capita household income growth rate is much higher for agricultural households in both subperiods (1995-2001 and 2001-2009). Meanwhile the decrease in inequality for agricultural households was below the observed for Brazil, except according the Theil's T index, which is more sensitive to changes in the upper tail of the distribution. Despite the decline in inequality in both cases, the income share appropriated by the poorest 50% increased less in the case of the agricultural households in the period 1995-2001 and also in the period 2001-2009. Thus, the decrease in inequality among the agricultural households occurred mainly through changes within the higher tail of the distribution or among the richest 50%.

Figure 1 illustrates the evolution of the average per capita household income and the Gini index for total Brazil and considering only agricultural households. It should be noted that from 1995 to 2003 the overall average decreases but the average of the agricultural households increases. This movement is certainly related to the modernization and increase of productivity in Brazilian agriculture.

Figure 1 shows the well-known process of systematic reduction in inequality of the distribution

Table 2: Per capita household income distribution in Brazil(1), from 1995 to 2009, considering only agricultural households: average, median and inequality measures.

Year	Average[(2)]	Median[(2)]	Inequality measures				% of income appropriated by			
			Gini (*G*)	Mehran (*M*)	Piesch (*P*)	Theil (*T*)	Poorest 50%	Richest 10%	Richest 5%	Richest 1%
1995	224.4	118.8	0.582	0.702	0.522	0.779	14.1	47.9	36.5	17.4
1996	224.6	115.1	0.590	0.713	0.529	0.811	13.5	48.1	36.6	18.0
1997	222.5	114.7	0.588	0.709	0.527	0.789	13.7	48.2	36.4	17.3
1998	221.3	119.3	0.571	0.693	0.510	0.742	14.4	46.5	34.9	16.9
1999	216.6	118.7	0.558	0.682	0.496	0.676	15.1	45.2	33.5	15.1
2001	231.4	122.9	0.577	0.701	0.515	0.744	14.0	46.6	35.0	16.7
2002	239.9	129.7	0.567	0.689	0.506	0.737	14.7	46.0	34.5	17.0
2003	240.5	129.8	0.569	0.693	0.507	0.729	14.4	45.8	34.1	16.7
2004	251.9	139.4	0.559	0.684	0.497	0.696	14.9	45.0	33.2	15.7
2005	266.1	148.0	0.559	0.682	0.497	0.718	15.1	45.1	33.7	16.5
2006	296.1	170.5	0.551	0.679	0.488	0.677	15.2	43.8	32.4	15.7
2007	301.8	174.4	0.541	0.675	0.475	0.602	15.4	42.1	30.0	12.8
2008	330.3	195.4	0.540	0.670	0.476	0.646	15.7	42.5	31.2	14.9
2009	333.6	204.0	0.526	0.661	0.459	0.579	16.0	40.4	28.8	13.0
Δ% 95-01	3.1	3.5	−0.9	−0.1	−1.3	−4.5	−0.7	−2.7	−4.1	−4.0
Δ% 01-09	44.2	66.0	−8.8	−5.7	−10.9	−22.2	14.3	−13.3	−17.7	−22.2

Source: National Household Sample Survey (PNAD).

(1) Excluding the rural area of the former Northern region.

(2) In Reais (Brazilian Currency - R$) of September-October of 2009.

of the per capita household income in Brazil from 2001 on, with a decrease of the Gini index from 0.594 to 0.539. Considering the period 1995-2009, the reduction in the Gini index is slightly higher, because its value is 0.599 in 1995. For the agricultural households, the changes in the Gini index are more irregular (partly due to the smaller sample) and, additionally, the reduction in inequality only becomes systematic from 2003 on. It can be noted that from this year on, in Figure 1 the lines representing the changes in the Gini index of both distributions fall almost in parallel. However, as will be seen below, the factors associated with this reduction are not the same.

To analyze the factors associated with the changes in the Gini index, a method of decomposition of this index briefly described below will be used. If the per capita household income of the i-th person (x_i) has k components (x_{hi}, with $h = 1,...,k$), so that

$$x_i = \sum_{h=1}^{k} x_{ho} \text{ for every } i \quad (1)$$

it can be deduced that the Gini index is equal to a weighted average of the concentration ratios of each component:

$$G = \sum_{h=1}^{k} \varphi_h C_h \quad (2)$$

with φ_h indicating the share of the h-th component in total income and C_h indicating the respective concentration ratio.

Being μ the average of per capita household income and μ_h the average of x_{hi} for the n persons of the population, the Gini index can be defined as

$$G = \frac{2}{n\mu}\operatorname{cov}(i, x_i) \quad (3)$$

and the concentration ratios are

$$C_h = \frac{2}{n\mu_h}\operatorname{cov}(i, x_{hi}) \quad (4)$$

Using subscripts 1 and 2 to indicate the values of φ_h, C_h and G in two different periods and defining

$$\varphi_h^* = \frac{1}{2}(\varphi_{1h} + \varphi_{2h}), \quad (5)$$

$$C_h^* = \frac{1}{2}(C_{1h} + C_{2h}) \quad (6)$$

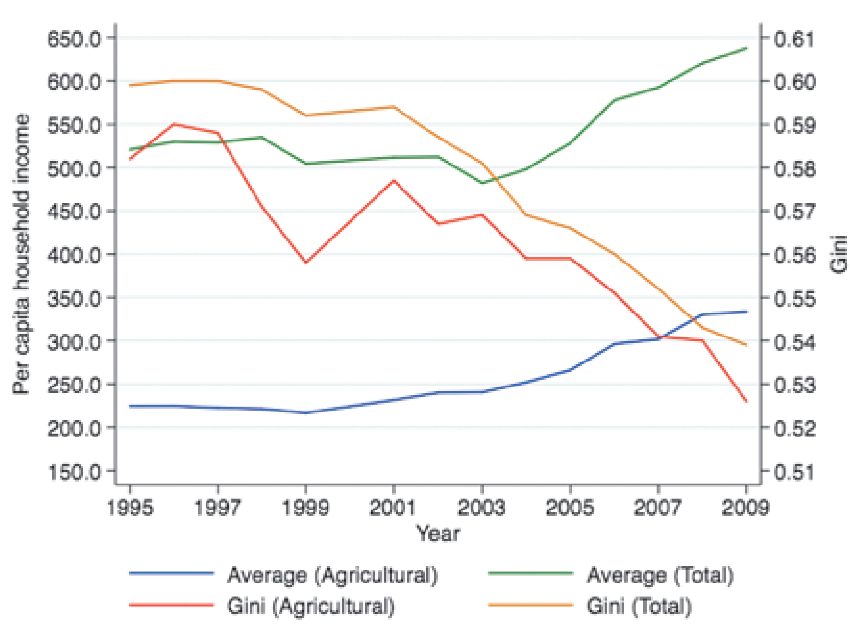
and

$$G^* = \frac{1}{2}(G_1 + G_2), \quad (7)$$

the change in the Gini index ($\Delta G = G_2 - G_1$) can be decomposed as follows:

$$\Delta G = \sum_{h=1}^{k}(C_h^* - G^*)\Delta\varphi_h + \sum_{h=1}^{k}\varphi_h^*\Delta C_h \quad (8)$$

Figure 1: Average and Gini index of per capita household income, Brazil and only agricultural households, from 1995 to 2009.



In right-hand side of expression (8), the first term is the sum of the composition-effects, associated with changes in φ_h, and the second term is the sum of the concentration-effects, due to changes in C_h[4].

The contribution of the h-th income component to the change in the Gini index is given by

$$(C_h^* - G^*)\Delta\varphi_h + \varphi_h^*\Delta C_h \qquad (9)$$

Thus it is possible to analyze the contributions of the different components of the per capita household income to the change in the Gini index in a given time period.

Here the per capita household income will be divided into nine components[5], described as follows:

CSM: earnings of civil servants and military personnel
EMP: earnings of other employees
SLF: earnings of self-employed workers
YER: earnings of employers
PE1: official pensions paid by the official social security (INSS[6]) or by government overall
PE2: other pensions
DON: donations received from other households
IBF: interest, shares, government transfers (such as those from the *Bolsa Família* program) and other incomes.

Table 3 shows the shares (φ_h) of these nine components of the per capita household income in 1998 and 2009, the correspondent concentration ratios (C_h) and the decomposition of the observed reduction in the Gini index (of the per capita household income) in Brazil in this period.

Over 50% of the decrease in the Gini index is associated with changes in earnings of the private sector employees and more than 20% is due to changes in the IBF component. The small share of this last component almost doubled (an increase of 94%) and the respective concentration rate declined strongly (from 0.764 to −0.105). This can be explained by the large expansion of government transfers, especially the *Bolsa Família*[7] program.

Official pensions (PE1) contributed substantially to the decrease in inequality from 1998 to 2009 as well. It can be verified that this effect is associated with the growth in the real value of the minimum wage (MW). The PE1 income was split into two ranges, creating a subcomponent with pensions near or below the MW (below the rounded integer value closest to 1.095 times the MW), and it was verified that the share of these poorer pensions in per capita household income increased from 3.37% in 1998 to 6.08% in 2009, and at the same time its concentration ratio increased from 0.028 to 0.163. The overall effect of this clearly progressive subcomponent explains 10.9% of ΔG = -0.059.

The other PE1 subcomponent is regressive C_h = 0.756 in 2009) and contributed to increase the inequality (total effect equal to −2.6% of ΔG).

Table 4 shows the same information as Table 3 but considering a more recent period: 2003-2009. The major contributions to reduce inequality are still associated with the components EMP and IBF. Note the stronger effect of PE1 and also the negative effect (a contribution to inequality increase) of military and civil servants' wages[8].

As shown in Figure 1, in the period from 2003 to 2009 the Gini index of the per capita household income distribution in Brazil and the corresponding Gini index considering only agricultural households

Table 3: Decomposition of the change in the Gini index of the per capita household income distribution in Brazil between 1998 and 2009.

Component	Share (φ_h)%		Concentration Ratio (C_h)		Effects, in % of ΔG = −0.059		
	1998	2009	1998	2009	Composition	Concentration	Total
1. CSM	9.90	11.30	0.734	0.746	−4.1	−2.1	−6.2
2. EMP	39.61	40.86	0.510	0.435	2.0	50.6	52.6
3. SLF	17.57	13.37	0.509	0.473	−5.5	9.4	3.9
4. YER	12.25	10.65	0.862	0.836	7.6	4.9	12.5
5. PE1	15.47	18.81	0.595	0.564	−0.6	8.9	8.3
6. PE2	1.24	1.32	0.641	0.493	0.0	3.2	3.2
7. DON	0.89	0.44	0.413	0.391	−0.7	0.2	−0.5
8. RNT	2.40	1.56	0.803	0.774	3.1	1.0	4.1
9. IBF	0.87	1.69	0.764	−0.105	3.3	18.7	22.1
Total	100.0	100.0	0.598	0.539	5.2	94.8	100.0

fell almost in parallel, showing a very similar evolution. However, the components of these reductions of the Gini index are quite different, as can be seen by comparing Tables 4 and 5.

Many differences are simply due to the fact that the agricultural households are relatively poor, as shown by the lines of the average per capita household income in Figure 1. Thus, the IBF component (which includes income from the *Bolsa Família* program) is much more important in the case of agricultural households and its contribution to the decline of the Gini index between 2003 and 2009 exceeds 46% (Table 5).

The contribution of the EMP component, 51.1% according to Table 4, falls to only 9.9% in Table 5 when considering only the agricultural households. Partially, this is due to the fact that the minimum wage, which functions in general as a "lighthouse" for the lower wages[9], has no such effect for the informal[10] employees in the Brazilian agricultural sector, as shown in Oliveira (2010) and Oliveira and Hoffmann (2013).

Table 4: Decomposition of the change in the Gini index of the per capita household income distribution in Brazil between 2003 and 2009.

Component	Share (φ_h)%		Concentration Ratio (C_h)		Effects, in % of $\Delta G = -0.042$		
	2003	2009	2003	2009	Composition	Concentration	Total
1. CSM	10.03	11.30	0.734	0.746	–5.4	–3.1	–8.5
2. EMP	39.15	40.86	0.484	0.435	4.1	47.0	51.1
3. SLF	15.83	13.37	0.504	0.473	–4.2	10.7	6.5
4.YER	11.66	10.65	0.860	0.836	7.0	6.3	13.2
5. PE1	18.48	18.81	0.594	0.564	0.1	13.1	12.9
6. PE2	1.35	1.32	0.570	0.493	0.0	2.5	2.4
7. DON	0.71	0.44	0.403	0.391	–1.0	0.2	–0.9
8. RNT	1.74	1.56	0.801	0.774	1.0	1.1	2.0
9. IBF	1.05	1.69	0.337	–0.105	6.8	14.5	21.2
Total	100.0	100.0	0.581	0.539	8.0	92.0	100.0

Table 5: Decomposition of the change in the Gini index of the per capita household income distribution for agricultural households, in Brazil, between 2003 and 2009.

Component	Share (φ_h)%		Concentration Ratio (C_h)		Effects, in % of $\Delta G = -0.043$		
	2003	2009	2003	2009	Composition	Concentration	Total
1. CSM	2.58	3.04	0.727	0.671	–1.6	3.7	2.1
2. EMP	27.52	31.53	0.361	0.372	17.0	–7.1	9.9
3. SLF	26.78	23.39	0.508	0.538	–2.0	–17.9	–19.9
4. YER	18.84	13.29	0.935	0.920	49.3	5.8	55.1
5. PE1	19.98	21.71	0.608	0.589	–2.1	9.4	7.4
6. PE2	0.43	0.64	0.537	0.501	0.1	0.4	0.6
7. DON	0.45	0.29	0.297	0.232	–1.1	0.6	–0.5
8. RNT	1.29	1.42	0.877	0.878	–1.0	0.0	–1.0
9. IBF	2.12	4.69	0.105	–0.073	32.0	14.3	46.3
Total	100.0	100.0	0.569	0.526	90.8	9.2	100.0

Table 5 indicates that the YER component (earnings of employers) contributed to more than 50% of the decrease in the Gini index between 2003 and 2009. This is essentially a composition effect due to the substantial reduction of the participation (from 18.8% to 13.3%) of a strongly regressive component of the per capita household income. An important part of this reduction may be associated with changes in the legal structure of production units, which have allowed transforming employers' earnings into executive salaries (which also helps to explain the growth of the concentration ratio of the EMP component).

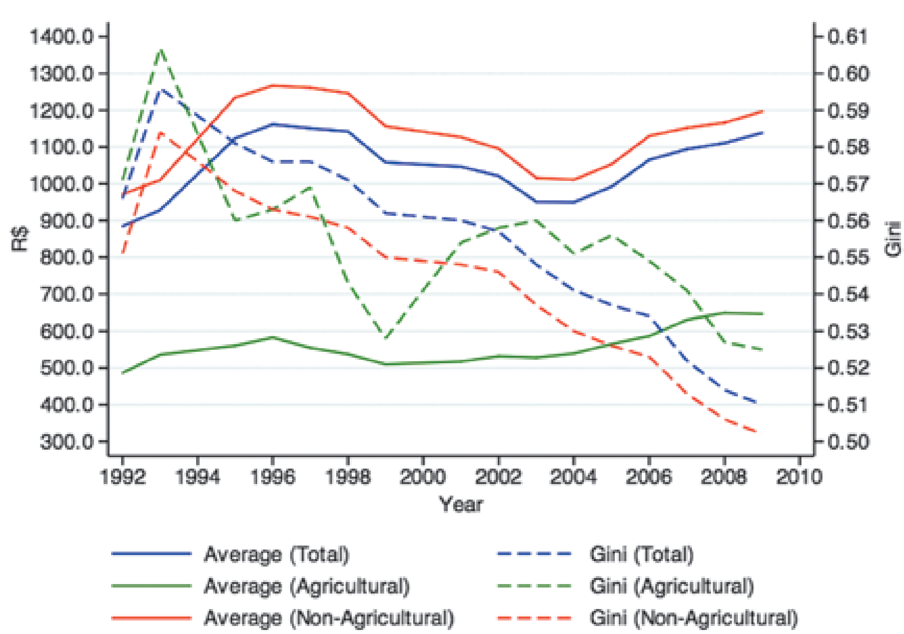
3. Occupied persons earnings

The distinction between agricultural and non-agricultural sectors becomes clearer when considering only occupied persons. Thus, this section analyses the distribution of earnings (including all jobs of each occupied person and excluding unpaid workers). In the data files used, only persons that are 10 or more years old are classified as occupied or not. As it is intended to use subsequently the same sample to estimate earnings equations, in this section the observations that do not contain information about any of the variables included in those equations are excluded.

Therefore, are excluded from the sample persons with no declaration of age, schooling, earnings, color, working hours per week or those classified as "worker in production for own consumption", "worker in construction for own use" or "unpaid workers". Equally excluded are the persons whose color is declared as "indigenous" (due to the very small number in the sample) and those whose working hours (in all jobs) are either less than 15 or above 98 hours per week.

It is important to bear in mind that the "labor income" (or earnings), as defined in the survey, includes the salary of employees but in the case of employers and self-employed it includes "monthly withdrawals" from their businesses. Obviously, in the case of a farmer, for instance, the "earnings" can include profits and land rent. Thus, these earnings should not be confused with wages or with the classic-Marxist concept of labor income. It would be better to call it "income from activity" performed by the person, but it was preferred to keep the

Figure 2: Average and Gini index of the earnings distribution in Brazil, from 1992 to 2009: total, agricultural and non-agricultural sectors.



terminology already established by the Brazilian Census Bureau (IBGE).

In the 2009 PNAD it is found that, for the data previously delimited, about 21% of occupied persons were self-employed and almost 5% were employers. Thus, less than 3/4 of the occupied persons are employees. In the agricultural sector more than 41% of occupied persons with positive earnings were self-employed.

Figure 2 shows the evolution of the average and of the Gini index of the earnings distribution, considering all occupied persons in Brazil, in the agricultural sector and in the non-agricultural sector. It can be noted that for the total economy and for the non-agricultural sector the average decreases from 1996 to 2004 and then rises systematically until 2009. In Figure 1 the decline in the average per capita household income from 1996 to 2004 is less intense and the growth from 2004 on is stronger due to the systematic reduction of the number of members per household, which falls from 3.87 in 1995 to 3.25 in 2009.

Both the average earnings and the Gini index have very similar trajectories for Brazil and for the non-agricultural sector, but the trajectories are different for the agricultural sector (Figure 2). In the 1999-2004 period the average falls in the non-agricultural sector but increases in the agricultural sector, a fact related to the end of the exchange-rate anchor in 1999 (with a devaluation of Brazilian currency), promoting exports of agricultural products.

The Gini index for the total and for the non-agricultural sector decreased systematically from 1993 to 2009, but the behavior of the Gini index is more irregular in the agricultural sector, with a less intense declining trend.

Figure 3 shows that the occupied persons' mean age tends to grow and is always higher in the agricultural sector. The data presented are consistent with the well-known trend of the population's aging. The younger generations in the agricultural sector look for non-agricultural occupations, expecting better wages and living conditions. Thus, the average age of occupied persons in agriculture is greater than the average of Brazil and of the non-agricultural sector.

Figure 3: Growth of the mean age of occupied persons with positive earnings in Brazil, from 1992 to 2009: total, agricultural and non-agricultural sectors.

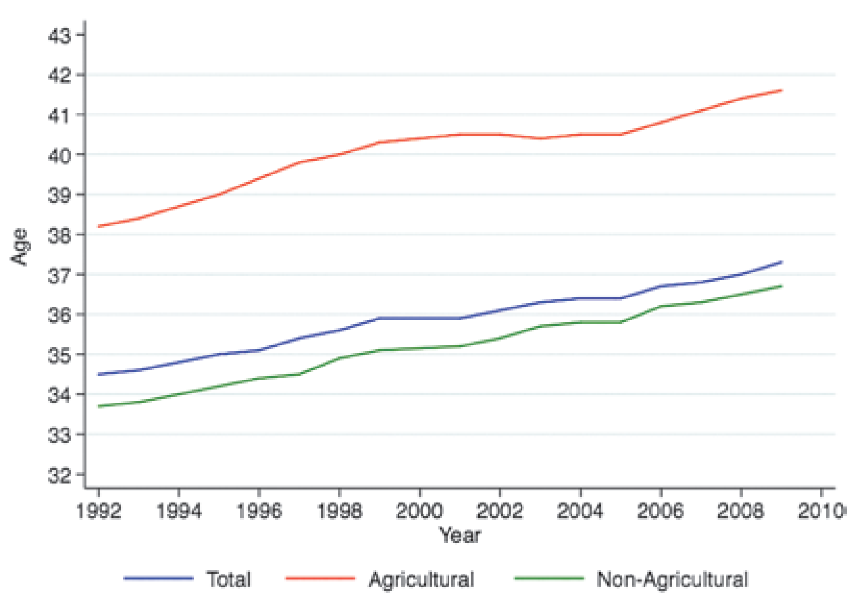


Figure 4 shows that the average of weekly working hours tends to decrease and is always higher in the agricultural sector. The line for the number of hours worked in the agricultural sector is steeper, indicating a sharper decline rate. These results are consistent with IPEA (2009), showing a reduction in the average hours of work in Brazil. The study also shows that the agricultural sector stands out, with a drop of 26.3% in the average number of hours of work between 1988 and 2007[11].

In Figure 5 and Table 6 it is observed that mean schooling is much higher in the non-agricultural sector than in the agricultural sector (9.3 and 4.1 years, respectively, in 2009). In both cases there is a systematic growth[12], but not with the same intensity. The ratio between the average schooling of non-agricultural and agricultural occupied persons falls from 2.9 in 1992-1995 to 2.3 in 2008-2009.

Besides the average schooling, Table 6 shows the value of the mean absolute difference, which

Figure 4: Evolution of the average weekly working hours of occupied persons with positive earnings in Brazil, from 1992 to 2009: total, agricultural and non-agricultural sectors.

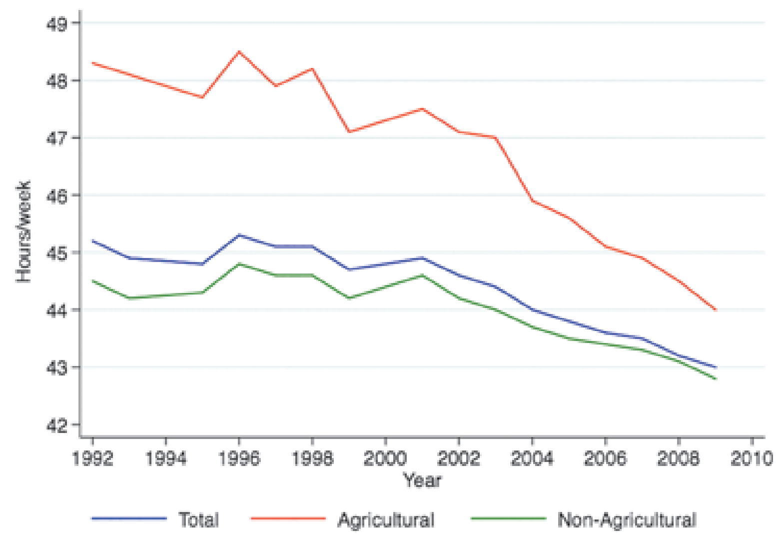
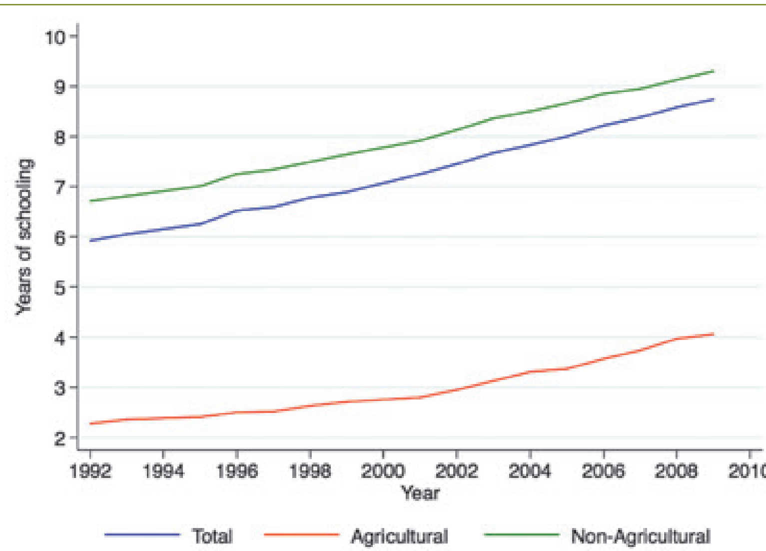


Figure 5: Growth of average schooling of occupied persons with positive earnings in Brazil, from 1992 to 2009: total, agricultural and non-agricultural sectors.



is a measure of the dispersion of the distribution (such as the standard deviation, σ). It is important to distinguish the concepts of dispersion and inequality of a distribution. Note that there are inequality measures, such as the Gini index G and the coefficient of variation C, which are measures of relative dispersion, since

$$G = \frac{\Delta}{2\mu} \text{ and } C = \frac{\sigma}{\mu} \tag{10}$$

with μ indicating the mean of the distribution.

In Figure 6 it is observed that the inequality of the distribution of occupied persons' schooling shows a declining trend both in the agricultural sector and in the non-agricultural sector. However, Figure 7 shows that the dispersion of schooling tends to increase in the agricultural sector and in the non-agricultural sector it tends to decrease from 1998 on.

Figure 6: The decreasing trend of the Gini index of occupied persons' schooling distribution in Brazil, from 1992 to 2009: total, agricultural sector and non-agricultural sectors.

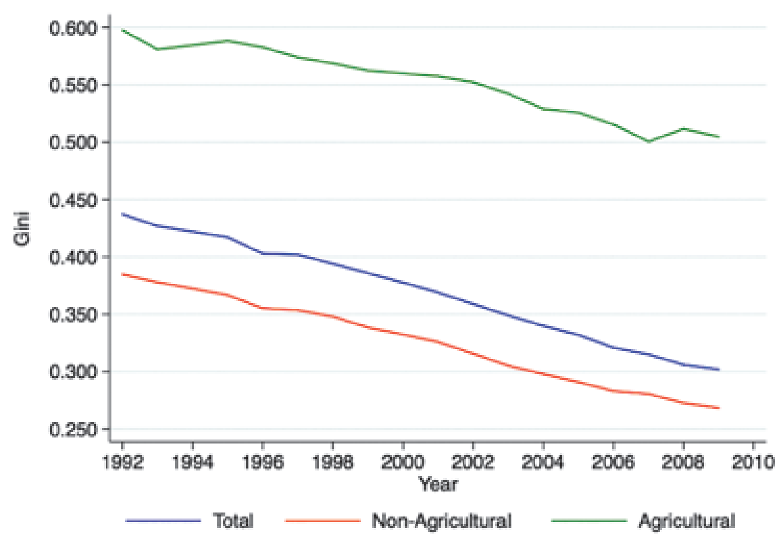


Figure 7: Variation of the mean absolute difference of occupied persons' schooling in Brazil, from 1992 to 2009: total, agricultural sector and non-agricultural sectors.

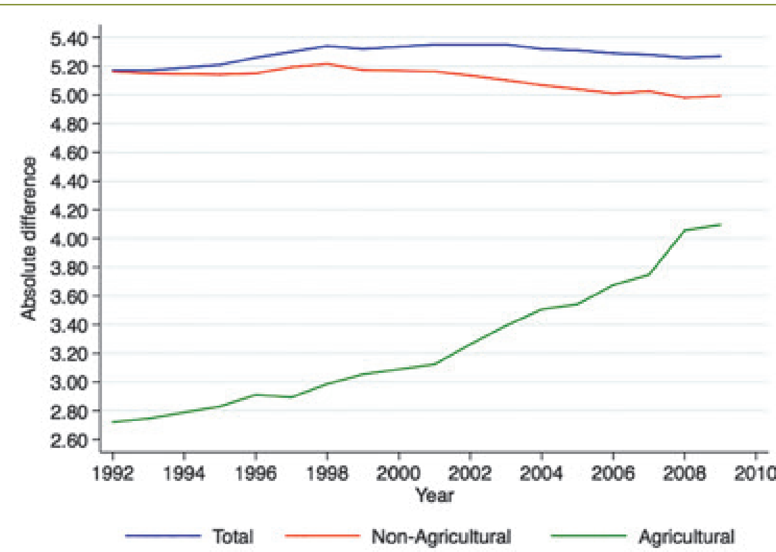


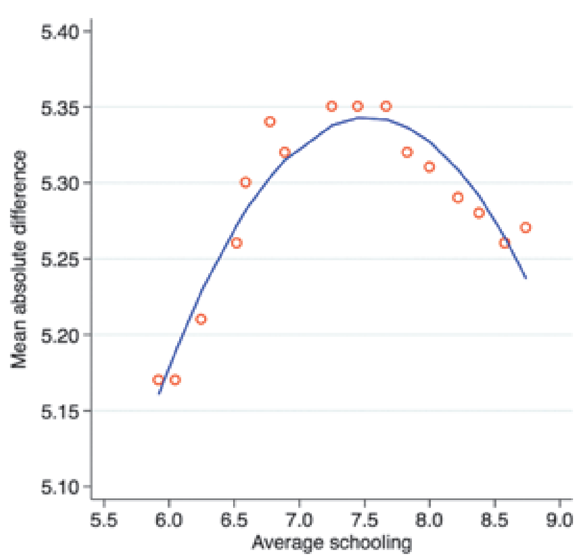
Figure 8 presents the relation between the mean absolute difference (Δ) and the mean schooling in Brazil, based on the values of the two first columns of Table 6. The shape of the curve is almost the same if, instead of Δ, the standard deviation of schooling is used, as done by Barros, Franco and Mendonça (2007) and Lorel (2008). This empirically observed relation resembles the famous and controversial Kuznets' Curve relating inequality and average of the income distribution.

This relation between the mean and the dispersion of schooling will be used subsequently to help explaining the different evolution of the earnings inequality among persons occupied in the agricultural sector[13].

Table 6: Average and mean absolute difference (Δ) of the distribution of schooling among occupied persons in Brazil, from 1992 to 2009: total, agricultural and non-agricultural sectors.

Year	Total		Agricultural sector		Non-agricultural sector	
	Average	Δ	Average	Δ	Average	Δ
1992	5.92	5.17	2.28	2.72	6.71	5.16
1993	6.05	5.17	2.36	2.75	6.81	5.15
1995	6.25	5.21	2.41	2.83	7.01	5.14
1996	6.52	5.26	2.50	2.91	7.25	5.15
1997	6.59	5.30	2.52	2.89	7.34	5.19
1998	6.78	5.34	2.63	2.99	7.49	5.22
1999	6.89	5.32	2.71	3.05	7.64	5.17
2001	7.25	5.35	2.80	3.12	7.92	5.16
2002	7.45	5.35	2.95	3.26	8.13	5.13
2003	7.67	5.35	3.13	3.39	8.36	5.10
2004	7.83	5.32	3.31	3.51	8.50	5.07
2005	8.00	5.31	3.37	3.54	8.66	5.04
2006	8.22	5.29	3.57	3.68	8.85	5.01
2007	8.38	5.28	3.74	3.75	8.95	5.03
2008	8.58	5.26	3.97	4.06	9.13	4.98
2009	8.74	5.27	4.06	4.10	9.30	4.99

Figure 8: Relation between the mean absolute difference and the average of schooling of occupied persons in Brazil, from 1992 to 2009.



The curve illustrated in Figure 8 reaches a maximum when the average schooling roughly equals 7.5 years. As the average schooling in the non-agricultural sector is already above this value and as in the agricultural sector this average is well below, the trend of the schooling dispersion is radically different in the two sectors.

Figures 7 and 9 show that in the period 1992-2009, as the average schooling increases, the mean absolute difference (Δ) of schooling tends to increase in the agricultural sector but tends to decrease in the non-agricultural sector. This has important implications for the evolution of the inequality of the earnings distribution in both sectors.

Figure 9: Relationship between the mean absolute difference and the average schooling for agricultural and non-agricultural sectors from 1992 to 2009.

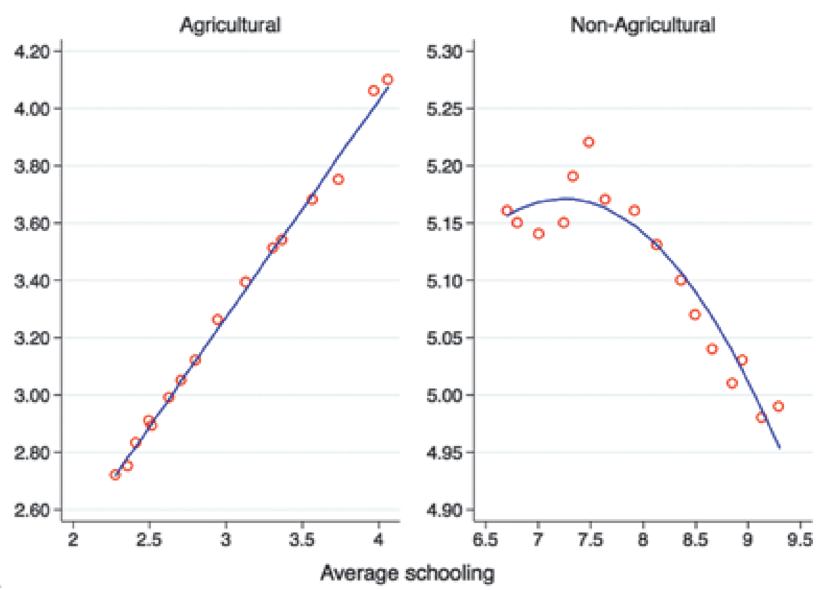


Figure 10: Evolution of the real minimum wage and of three quantiles (the first decile, the first quartile and the median) of occupied persons earnings' distribution in Brazil, from 1992 to 2009.

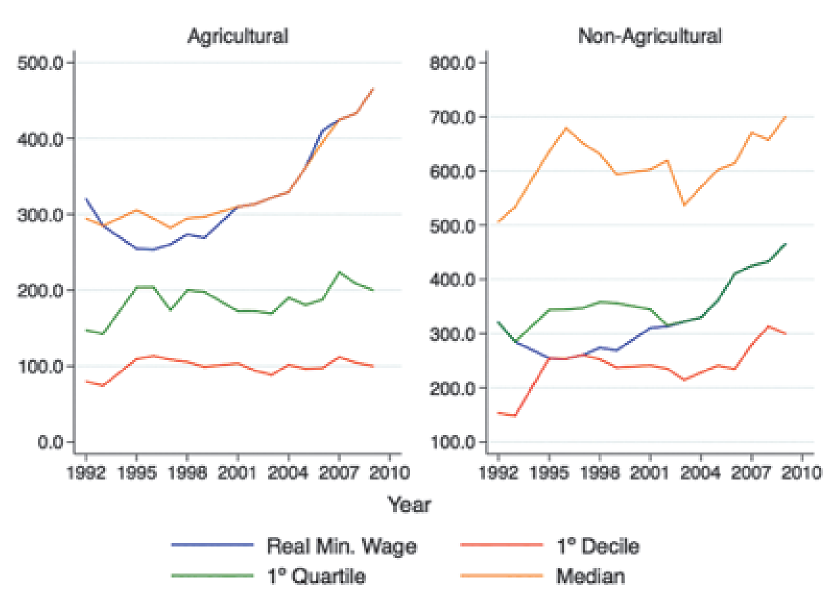


Figure 10 highlights the evolution of the values of three quantiles of the earnings distribution in the agricultural and the non-agricultural sectors: the first decile, the first quartile and the median (which is also the second quartile or the fifth decile). Since the earnings are much lower in the agricultural sector, different scales were used on the ordinate axis. In the two graphs that compose Figure 10, a fourth line (in blue) representing the evolution of the real value of the minimum wage (MW) was included. In the agricultural sector, from 2001 to 2009, the MW is generally equal to the median. In the non-agricultural sector, on the other hand, the MW coincides with the first quartile from 2002 to 2009 and with the first decile in 1995, 1996 and 1997[14].

Figure 11 shows the evolution of four inequality measures of the earnings distribution in the two sectors: the Gini index, Theil's *L* and *T* indices and the proportion of total earni00ngs received by the richest tenth.

In Figure 2 it was possible to observe that, from 1992 to 2001, the Gini index in the agricultural sector is at times higher and at other times lower than the non-agricultural sector's index. As the inequality decreases systematically in the non-agricultural sector, from 2002 on the Gini index in the agricultural sector is systematically higher than in the non-agricultural sector. Figure 11 shows a very similar picture of the values of Theil's *L* index in the two sectors. As the Theil's *T* index is more sensitive to changes in the upper tail of the distribution, the fact that this index is always higher in the agricultural sector indicates that this sector is characterized by income concentration in its upper tail. Note that the proportion of the total income appropriated by the richest tenth is also systematically higher in the agricultural sector than in the non-agricultural sector.

Figure 12 contrasts the participation in the total earnings of the richest one hundredth (1+) and the poorest half (50−). Note that the origin of the ordinate axis is not the same for the two graphs. The proportion of the total income appropriated by the richest 1% is always much greater in the agricultural sector.

In the non-agricultural sector, in 2003, the share of the richest 1% was even greater than the share of the poorest 50% (both around 14%). From this year on, the share of the poorest 50% increases systematically, reaching almost 19% in 2009, when the share of the richest 1% was 12%.

In the agricultural sector the share of the poorest 50% also showed an increasing trend, but less intense and much more irregular. From 2001 to 2006, the share of the richest 1% was higher than the share of the poorest 50% in total agricultural earnings.

Figure 11: Inequality measures of the occupied persons earnings' distribution in Brazil, from 1992 to 2009.

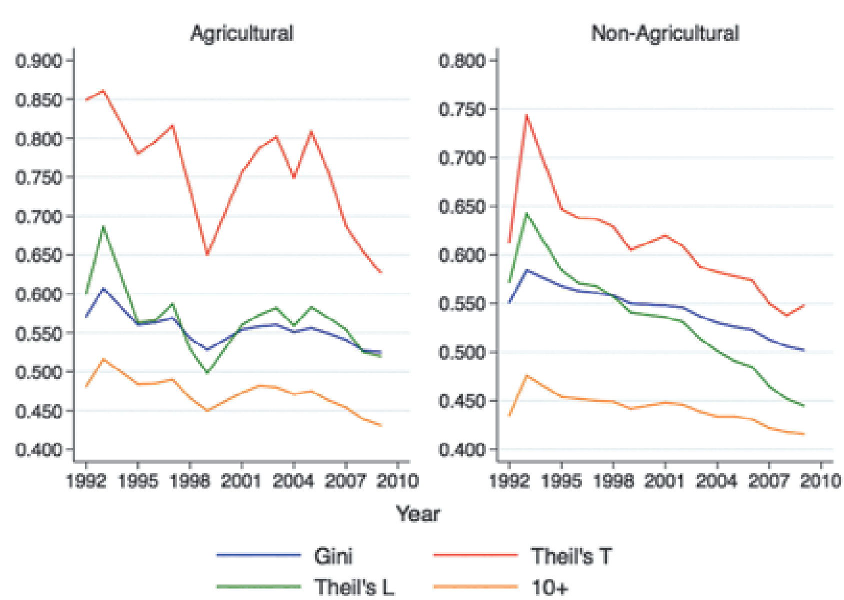
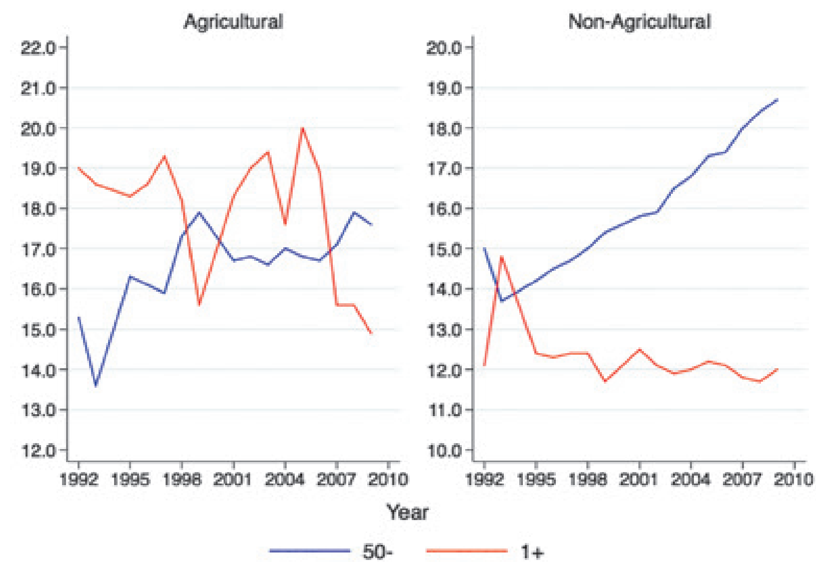


Figure 12: Percentage of the total income appropriated by the richest 1% and the poorest 50% in the occupied persons earnings' distribution in Brazil, from 1992 to 2009.



4. Evolution of the effects estimated fitting earnings equations for each year

The estimation of earnings equations is a well-established methodology to analyze how different factors (age, education, gender, etc.) affect earnings. Using the data described in the previous section and the Weighted Least Squares method (WLS), earnings equations were fitted for each year from 1992 to 2009 in order to analyze how the effect of the factors varied over this period.

The general regression model is given by:

$$\ln Y_j = W_j = \alpha + \sum_i \beta_i X_{ij} + u_j \tag{11}$$

The dependent variable W_j is the natural logarithm of monthly earnings from all jobs per occupied person (given the restrictions described at the beginning of the previous section), α and β_i are model parameters, X_{ij} indicates the explanatory variables (characteristics of the persons and their occupations) and u_j represents a random error with the usual statistical properties.

The explanatory variables are described in the following list.

a) A binary variable with value 1 for females and value 0 for males.

b) The age of the person, measured in decades, and the square of such number of decades. Age is measured in decades only to avoid extremely small coefficients. Denominating as c_1 and c_2 the estimates of the coefficients for age and for the square of age, respectively, the estimate of the age in which earnings reach their maximum value is $-10c_1/(2c_2)$ years.

c) Schooling of the person (E), varying from 0 to 17. Values 0 to 14 correspond to the level of schooling achieved by the person, and the value 17 is attributed to persons with 15 or more years of schooling. As rates of return for schooling show a very substantial change around 10 years of schooling, a binary variable Z was created, with $Z = 0$ for $E \leq 10$ and $Z = 1$ for $E > 10$. Thus, the model for the earnings equation includes terms $\beta_1 E$ and $\beta_2 Z(E-10)$, corresponding to a polygonal with vertex at $E = 10$, declivity β_1 for $E \leq 10$ and declivity $\beta_1 + \beta_2$ for $E > 10$. Being b_1 and b_2 the estimates of β_1 and β_2, the estimate of the rate of return for schooling is $100[\exp(b_1)-1]$ for $E \leq 10$ and is $100[\exp(b_1+b_2)-1]$ for $E > 10$.

d) The logarithm of weekly working hours in all jobs. The coefficient of this variable is the income elasticity of earnings in relation to the number of hours worked per week.

e) Five binary variables to distinguish six regions of the country: North; Northeast (adopted as the reference category); the grouping of the tree states of Minas Gerais, Espírito Santo and Rio de Janeiro; São Paulo state; South; and Midwest.

f) A binary variable equal to 1 when the person is a resident in rural areas and equal to 0 when the person resides in urban areas[15].

g) Three binary variables to distinguish between four categories of skin color, according to what the respondent declared in the survey: white (category adopted as reference), black, Asian, and mulatto or mixed.

h) Finally, three binary variables to distinguish four occupational positions: employees with a labor contract (taken as reference), employees without a labor contract, self-employed and employers.

In the earnings equations, if Y is the value of earnings and X is a continuous explanatory variable, and if the value of the all other terms of the equation is indicated by Θ, it is possible to write

$$\ln Y = \beta X + \Theta \qquad (12)$$

Keeping the value of all other explanatory variables, it follows that

$$\frac{dY}{Y} = \beta dX \text{ or, approximately, } \frac{\Delta Y}{Y} = \beta \Delta X \qquad (13)$$

The first term of this equation represents the relative variations in earnings, which corresponds to the concept of inequality in the distribution of earnings. Thus, it can be verified that the inequality tends to increase with the absolute value of the coefficient β and with the variations (dispersion) of X.

It is important to keep in mind that, in the earnings equation, it is the *dispersion* of schooling (measured by standard deviation or by the mean absolute difference), and not its *inequality*, that is directly associated with the earnings' inequality.

If b is the estimated coefficient of a binary variable, the *effect* of this variable is defined as the percentage variation in the earnings value when the binary variable changes from zero to one, as follows:

$$100[\exp(b) - 1] \qquad (14)$$

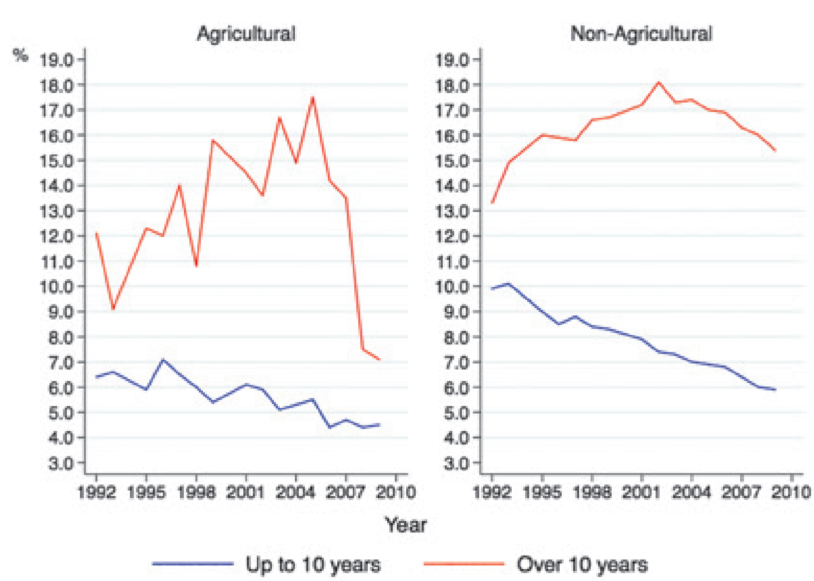
In the case of a continuous variable the same equation provides the percentage increase in the expected earnings due to a unitary increase in the explanatory variable.

Figures 13 to 18 show the evolution of the effects of the selected explanatory variables from 1992 to 2009.

The graph for the non-agricultural sector in Figure 13 shows that the rate of return to schooling up to 10 years shows a clear downward trend and the rate of return to schooling that is above the threshold of 10 years increased until 2002 and then started to decrease.

It was observed, in Table 6, that the dispersion of schooling in the non-agricultural sector (measured by the mean absolute difference) tends to decrease from 1998 on. Thus, from 2002 on, schooling is contributing to reduce inequality in the earnings' distribution in the non-agricultural sector, due to its lower dispersion and also to the reduction in the rate of return to schooling for those with relatively high schooling (over 10 years).

Figure 13: Rate of return up to 10 years of schooling and over 10 years of schooling for occupied persons in Brazil, from 1992 to 2009.



In the agricultural sector a similar trend can be observed regarding the rate of return to schooling for persons with more than 10 years of formal education, although the peak of this rate occurred in 2005 and not 2002, as observed for the non-agricultural sector. Regarding the dispersion of schooling, however, the phenomenon is totally different because, as was seen earlier, the dispersion of schooling in the agricultural sector is increasing and contributes to increase the inequality of the earnings' distribution.

Figure 14 shows the evolution of the effect of being black, mulatto or female, a white male taken as the reference category. It can be seen that the absolute effect of being female is diminishing in both sectors, and it is always greater in the non-agricultural sector. The effects of being black or mulatto are quite similar and unfortunately there is no trend of reduction.

It is simplistic to interpret the effect of being black or mulatto as resulting from discrimination alone since, as shown by Figure 15, the effect of being Asian is positive, and it would be strange to consider that there is "discrimination" in favor of the Asians. It is worth noting that the value of the effect of being Asian shows a downward trend in both sectors.

Figure 14: Effect of being female, black or mulatto on occupied persons' earnings in Brazil, from 1992 to 2009.

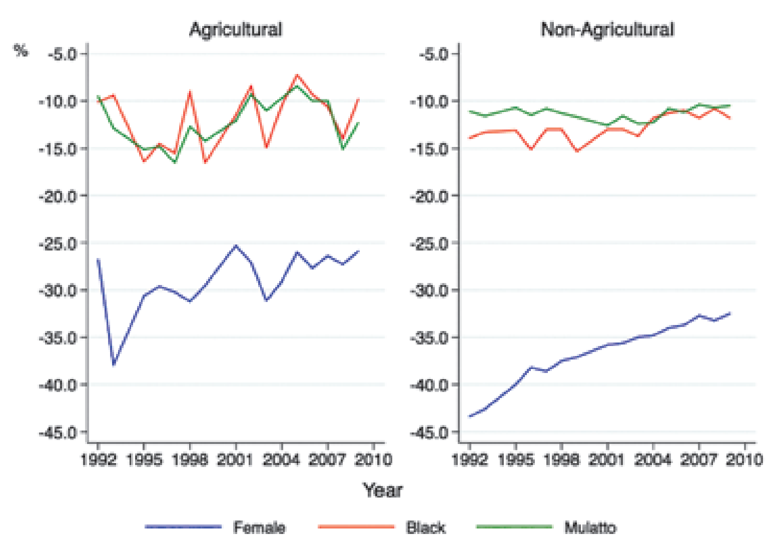
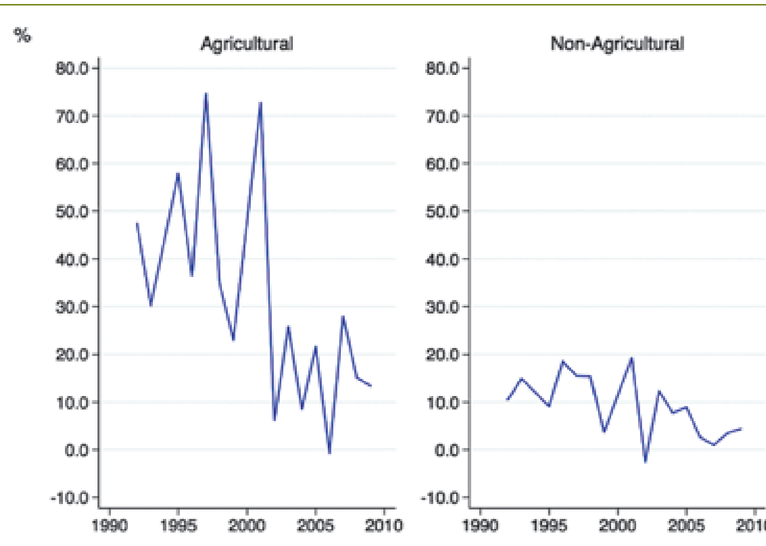


Figure 15: Effect of being Asian on occupied persons' earnings in Brazil, from 1992 to 2009.



As the poorest region of the country was taken as the reference category (Northeast), the effects associated to the other regions are always positive, as shown in Figure 16. In the graph for the non-agricultural sector, it is observed that the effect associated to São Paulo (SP), which was initially well above the other regions, tends to decrease, contributing to reduce interregional inequality. The same does not occur in the agricultural sector.

Figure 17 shows the evolution of the effects of being self-employed or employee without labor contract compared to the reference category (employee with labor contract). These effects are always more negative in the agricultural sector. It should be noted that from 1996 on the effect of not having a labor contract tends to be increasingly negative in the agricultural sector. Certainly, this is related to the growth of the real value of the minimum wage in the period and also to the fact that this growth benefits more the employees with a labor contract (see Oliveira and Hoffmann, in press). In the non-agricultural sector, the evolution of the effect of not having a labor contract is quite different.

Figure 16: Effect associated to the regions (Northeast taken as reference) on occupied persons' earnings in Brazil, from 1992 to 2009.

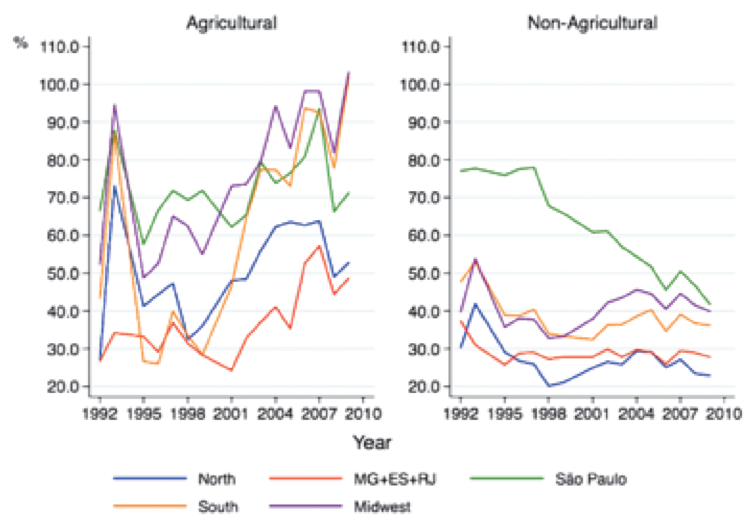
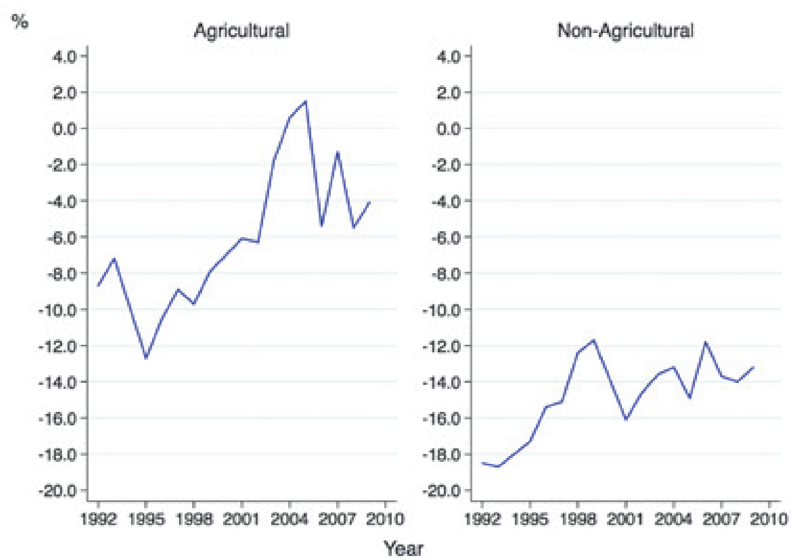


Figure 17: Effect of not having a labor contract or of being self-employed (in comparison with an employee with a labor contract) on occupied persons' earnings in Brazil, from 1992 to 2009.

Figure 18 shows that the effect of having residence in rural areas is stronger in the non-agricultural sector, but in both cases its absolute value shows a decreasing trend, indicating some convergence between rural and urban areas (still with great disadvantage for rural areas).

Figure 18: Effect of rural residence on occupied persons' earnings in Brazil, from 1992 to 2009.



5. Earnings' inequality among six regions or among the 27 Brazilian federation units

Figure 19 shows the evolution of the components of the Theil's indexes (T and L) related to the earnings inequality between six regions or between the 27 Brazilian Federation Units (FUs). The different behavior of the inter-regional inequality in the two sectors is evident, and only in the non-agricultural sector a clear reduction of the inter-regional inequality after 1997 can be observed.

Figure 19: Theil's L and T indexes of earnings of occupied persons' inequality between six regions or between 27 Federation Units in Brazil, from 1992 to 2009.

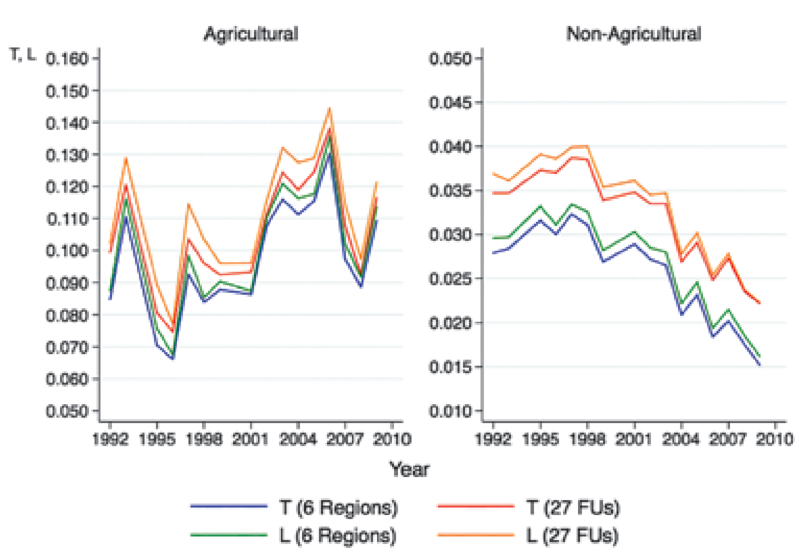
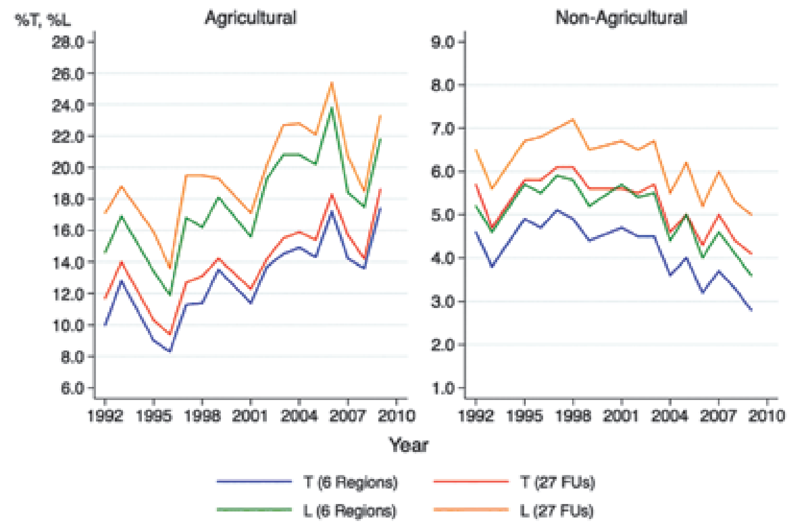


Figure 20: Percentages of the Theil's T and L indexes of occupied persons' earnings distribution related to the inequality between six regions or between 27 Federation Units in Brazil, from 1992 to 2009.



6. Conclusions

The data from the national households sample survey (PNAD) show that the agricultural sector presents a differentiated behavior considering changes in the income distribution in Brazil. Regarding the per capita household income, although from 2003 on the reduction rate of inequality among agricultural households is similar to the one observed in Brazil as a whole, the determinants associated with this reduction are clearly different in the agricultural sector. Considering all households, between 2003 and 2009 about 21% of the reduction in the Gini index of per capita household income distribution can be attributed to the IBF component, which includes government transfers such as the *Bolsa Família* (besides interests, dividends and other incomes). In the case of agricultural households this percentage reaches 46%.

Another important result is that, in the case of the agricultural sector, the contribution of the share of employees' earnings (EMP) in reducing inequality is substantially lower compared to Brazil (10% versus 51% between 2003 and 2009).

Concerning the income of occupied persons, the reduction in inequality is less intense and more irregular in the agricultural sector compared to the non-agricultural sector. The different factors that determine the income of occupied persons also presented distinct behaviors for the agricultural and non-agricultural sectors. The evolution of the dispersion of schooling is radically different for the two sectors. In the period 1998-2009, as the average schooling increases, the dispersion tends to grow in the agricultural sector but tends to decrease in the non-agricultural sector.

For the persons occupied in the agricultural sector the real minimum wage is close to the median of earnings (from all jobs). On the other hand, in the non-agricultural sector the minimum wage coincides with the first quartile of the earnings distribution over the period 2002-2009.

Analyzing the evolution of the effects estimated by fitting earnings equations for each year from 1992 to 2009, it was found that the effects of being black or mixed (taking a white person as basis) are very similar in both sectors and show no tendency to decrease. The earnings difference between men and women decreased, especially in the agricultural sector, but women are still in disadvantage.

It was verified that the differences associated with geographic location are still strong, but in the case of the non-agricultural sector there is a convergence trend, with reduction in inequality among six regions or among the 27 Federation Units from 1997 on. This is not observed for the agricultural sector, which even presents an increasing trend of the measures of inequality among the six regions or the 27 Federation Units.

Finally, it is worth mentioning that, from 1996 on, the effect of being employed without a labor contract (taking the employees with labor contract as the reference category) tends to be increasingly negative

in the agricultural sector. This fact is associated with changes in the real minimum wage, which benefit more the employees with a labor contract.

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Endnotes

1 * An updated version of this paper, using data until 2012 is entitled "The evolution of income distribution in Brazil in the agricultural and the non-agricultural sectors" and was published in the World Journal of Agricultural Research 2(5):192-204, 2014. It is noteworthy that overall official pensions are a regressive component of the total household income, and contributed to increase inequality from 2001 to 2007, according to Hoffmann (2009). However, Hoffmann (2010) found that pensions paid by the Official Social Security (INSS in the acronym in Portuguese) for the private sector workers are a progressive component of the household income.

2 See, for example, Hoffmann (1988).

3 Only permanent private households (variable V0201 = 1) were considered. The household is considered "agricultural" if the reference person's main job is in the agricultural sector- variable V4709 = 1 (until the 2001 PNAD) or variable V4809 = 1 (from 2002 on). All estimates were computed using the weights or sample expansion factors available in the data files.

4 This decomposition is presented in Hoffmann (2011).

5 Note that the components of the household income must be exhaustive and mutually exclusive.

6 Portuguese acronym for Instituto Nacional do Seguro Social (the Brazilian Social Security Office).

7 There are many studies showing this relation. They disaggregate the IBF component, separating transfers from other incomes included in this component: Soares et al. (2006), Barros, Carvalho and Franco (2007) and Hoffmann (2007).

8 For a detailed analysis of the influence of the public servants' earnings on the per capita household income distribution in Brazil from 1995 to 2009, see Daré (2011).

9 The "lighthouse effect" was first announced by Souza and Baltar (1979). According to this theory the minimum wage works as a signal for wage bargaining even in the informal sector. For more recent research on minimum wage in Brazil (and Latin America) and this effect, see: Maloney and Mendez (2004), Lemos (2003) and Neumark, Cunningham and Siga (2003).

10 According to Oliveira and Hoffmann (2013), the informal employees represented, in 2009, 64.1% of all agricultural employees.

11 It should be mentioned that the 1988 National Constitution reduced the regular maximum of weekly working hours from 48 to 44 but the effect of this legal change was not immediately felt, especially in the agricultural sector. Moreover, there was an intense process of modernization in the agriculture sector in Brazil throughout the entire country (obviously with regional differences), increasing productivity and reducing the amount of labor demanded. These two facts are related to the decrease in the weekly hours of work in the agricultural sector.

12 Schooling is defined by the most advanced degree achieved by the person, with 0 (zero) meaning "no schooling or less than one year". For the category "15 years or more" (variable V4703 or V4803 of PNAD) was attributed the value 17.

13 Barros, Carvalho, Franco and Mendonça (2010) used the relation between standard deviation and mean schooling to explain the decline in inequality in the distribution of income in Brazil, evaluating the contribution of changes in schooling to reduce the Gini index from 2001 to 2007.

14 For a detailed analysis of the impact of the MW on earnings of agricultural employees, see Oliveira and Hoffmann (2013).

15 It is important to mention the fact that the delimitation of urban areas was updated in the 2000 Census, obeying the laws of each municipality. So, the definition of urban areas remained fixed in the survey (PNAD) from 1992 to 1999, suffering a change in 2000 and remaining fixed again from 2001 to 2009. When interpreting the corresponding coefficient and its evolution it is necessary to take these changes into account.

Spatial Estimation of Households' Income and Well-Being: applying geostatistics to microdata

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Abstract

Improvement in statistical techniques allows nowadays to link microdata produced from different independent surveys. In the present paper we propose a new microeconomic database on farm households obtained using statistical matching techniques. Information on total households' income and well-being gathered by the European survey on living condition (EU-SILC) was attached to the observations included in the Farm Business Survey (FBS/REA) database for Italy.

The new dataset, still representative of agriculture as an industry, also allows a proper statistical representation and socio-economic characterization of farming households as an institutional sector. Indicators on total households' income, from farming and off-farm activities, and a composite well-being indicator were developed. Point data were then interpolated and spatialised using geostatistical methods, in order to obtain estimated maps better describing the spatial distribution of the phenomenon.

The same approach, tested here for one of the Italian regions, could be suitable for any developing country, at different administrative levels, when microdata on farm activities and households' income were available from Censuses, Sample Surveys and/or administrative records.

Keywords: farm households; geostatistics; microdata.

1. Materials and methods

1.1 Statistical matching

A new microeconomic database on farm households in Italy was created using statistical matching techniques (Rassler, 2002; D'Orazio et al., 2006). Information on total households' income and well-being gathered by the EU-SILC survey on living condition for Italy (ISTAT, 2010) was attached to the observations included in the FBS database for Italy (ISTAT, 2011). The new dataset, still representative of agriculture as an industry, also allows a proper statistical representation and socio-economic characterization of farm households as an institutional sector (Rocchi, 2010).

The FBS yearly surveys a sample of agricultural holdings representative of the Italian agriculture. The database includes a detailed set of variables on farm structures (such as cultivated area, livestock number, labour employment) and on costs and revenues from farming. According to this information a good estimate of income from farming can be obtained. Furthermore, a small set of variables on farming household's composition as well as on extra-farm source of income (classes of income by four types of sources) is available.

The EU-SILC is a sample of Italian households designed to gather detailed information on incomes as well as on living condition and well being. The sample is representative of total Italian population but, given the optimization criteria adopted in the design of the survey, farming households are under-represented. The dataset includes variables on occupation, professional position and income sources by type of single household's members; a number of nominal variables expressing well-being of household's members and family living condition are available as well.

Farming households samples in the two surveys samples can be assumed to be homogeneous statistical units, extracted from the same target population. Farming households, by construction, belong to the households population and are a specific typology (socio-professional) group, according to the following definition: "households... that derived any income, however minor, from agriculture or contributed some labour input to agricultural production." ("broad" definition: United Nations, 2011).

For the aim of the analysis a sub-sample of 9606 was considered as the "recipient" database. A set of 14

"matching variables" on households' characteristics, was defined according to available information.

The integrated archive was built by means of statistical matching techniques based on nonparametric imputation methods (hot-deck). More precisely in the realization of the matching between the two files was used the method of nearest-neighbor imputation where the proximity between two records is expressed by an appropriate distance function. The distance function chosen is a mixed distance (Gower distance), in order to take into account the presence of discrete variables between the matching variables.

Different weights can be assigned to the matching variables. Given the aim of the analysis (to create an improved dataset to ground the estimate of the total income of farm households) in the matching procedure the largest weight was assigned to the variable representing the total household income (THI).

1.2 Spatial analysis and mapping

When we talk about spatial data we mean that each data value is associated with a location in space and there is at least an implied connection between the location and the data value. How conditions tend to persist locally, and how it is possible to divide the surface into regions that exhibit substantial internal similarity is known as spatial dependence (de Smith et al. 2011). Spatial dependence is the degree of relationship that exists between two or more spatial variables, such that when one changes, the other(s) also change. This change can either be in the same direction, which is a positive correlation, or in the opposite direction, which is a negative correlation (Cliff and Ord 1981). Spatial dependence leads to the spatial autocorrelation problem in statistics, since this violates standard statistical techniques assumption of independence among observations. The spatial autocorrelation is defined as the variation of a property within a geo-space: characteristics at proximal locations appear to be correlated, either positively or negatively. Spatial autocorrelation is the matter of geostatistics.

Spatial statistics is a term commonly applied to the analysis of discrete objects (e.g. points, areas), and is defined by both its material (spatial datasets) and its methods. Three main topics can be identified in spatial statistics: i) point pattern analysis, corresponding to a location-specific view of the data; ii) lattice or regional analysis, corresponding to zonal models of space; iii) geostatistical modelling, applying to a continuous field view of the underlying dataset (Cressie 1993).

Aiming at representing statistical data on a map, one of the main problems to be solved is to obtain information in unsampled locations from measured data. Spatial prediction models (algorithms) can be classified, according to the amount of statistical analysis included, in deterministic models - where arbitrary or empirical model parameters are used, e.g. Inverse Distance Weighting, Radial Basis Function – and statistical models - the model parameters are estimated in an objective way, following the probability theory, e.g. geostatistics. In general, deterministic prediction models are more primitive than the statistical models and often sub-optimal; however, there are situations where they can perform as good as the statistical models or even better. No estimate of the model error is available for predictions with deterministic models, while the predictions with statistical models are accompanied with the estimate of the prediction error. A drawback in this second case is that the input dataset usually need to satisfy strict statistical assumptions.

Basic geostatistical analysis usually has the following steps: i) calculation of the semivariogram, a function that describes the differences (variance) between samples separated by varying distances, ii) estimation of parameters of the semivariogram model, and iii) estimation of the surface using kriging algorithm, an optimal interpolator that generates best linear unbiased estimate at each location, employing the semivariogram model (Goovaerts 1997; Isaaks and Srivastava 1989). The most commonly used kriging algorithm is the Ordinary Kriging (OK).

A validation of the estimation can be added. Cross validation is a technique used to assess how accurate an interpolation model is. One point is left out and the rest is used to predict a value at that location. The point is then added back into the dataset, and a different one is removed. This is done for all samples in the dataset and provides pairs of predicted and known values that can be compared to assess the model's performance. Results are usually summarized as Mean and Root Mean Squared errors (ME and RMSE).

A normal distribution of the data is usually a prerequisite for the application of geostatistics:

OK may give unacceptable results if the data are severely non-normal. For the theory of geostatistics, see for example Clark (1979), Isaaks and Srivastava (1989), Goovaerts (1997), Houlding (2000).

For computational easiness, ordinary kriging was applied not directly to the single households, but to the centroids of municipalities, assigning to each centroid the average value of the farming households present in the correspondent municipality. Only those municipalities with valid individual values were considered for the estimation: in the final dataset there were 166 usable points.

First, the presence of spatial autocorrelation was verified for the two variables by means of variographic analysis.

Geographic elaborations were performed using the software ESRI ArcGIS 10®.

2. Results and discussion

The frequency distributions of the two variables were determined. While the wellbeing index fairly approaches normality, the total per capita income has a distribution very far from normal. A winsorization, using as threshold the mean value plus two times the standard deviation, was carried out to transform the dataset. Then, the variographic analysis was performed adopting a lag distance of 11,000 m. In Figure 1 the semivariograms for total per capita income (after winsorization) and wellbeing index are reported.

The semivariogram for total per capita income shows the clearest spatial variation structure, while in the other semivariogram a lower degree of spatial autocorrelation is present; thus, the adjusted model is less definite. In both cases the best fit can be found by minimizing the IGF index (Indicative Goodness of Fit; Pannatier, 1996), a standardized measure of the difference between observed values and estimated values based on the Ordinary Least Squares criterion. In Table 1 the parameters of the models adjusted to the experimental semivariograms are reported, together with the correspondent IGF values.

Figure 1: Semivariogram plots with adjusted models for total per capita income (winsorized dataset, a) and wellbeing index (b).

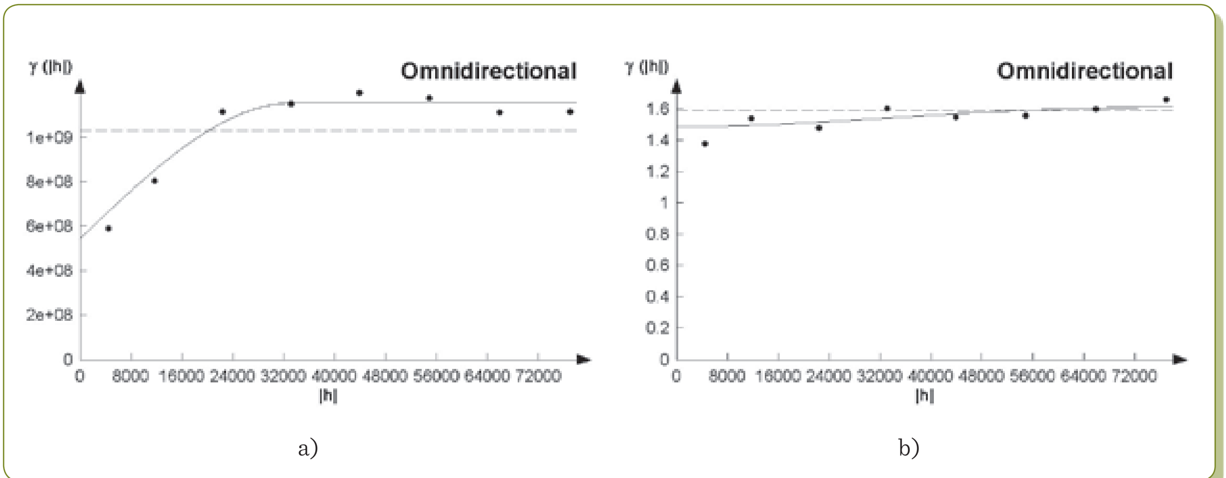


Table 1: Parameters of the adjusted semivariogram models.

	Nugget	Model	Range (m)	Sill	IGF
Total per capita income (winsorized dataset)	5.47×10^8	Spherical	33306	6.13×10^8	0.0035
Wellbeing index	1.49	Gaussian	78000	0.13	0.0015

All these parameters were then used in the OK algorithm for the spatial estimation; the obtained maps are reported in Figure 2.

Figure 2: Estimated maps by OK for total per capita income (winsorized dataset, a) and wellbeing index (b).

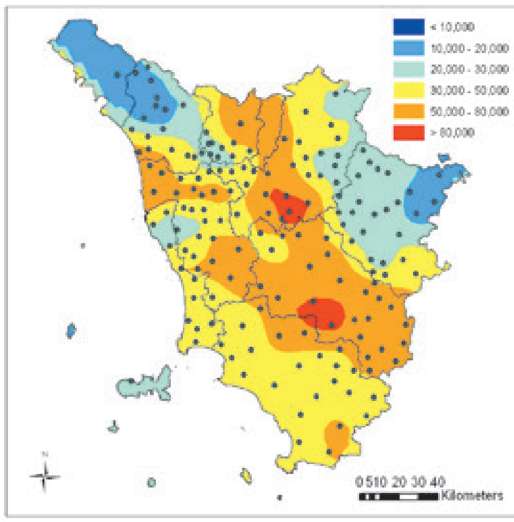
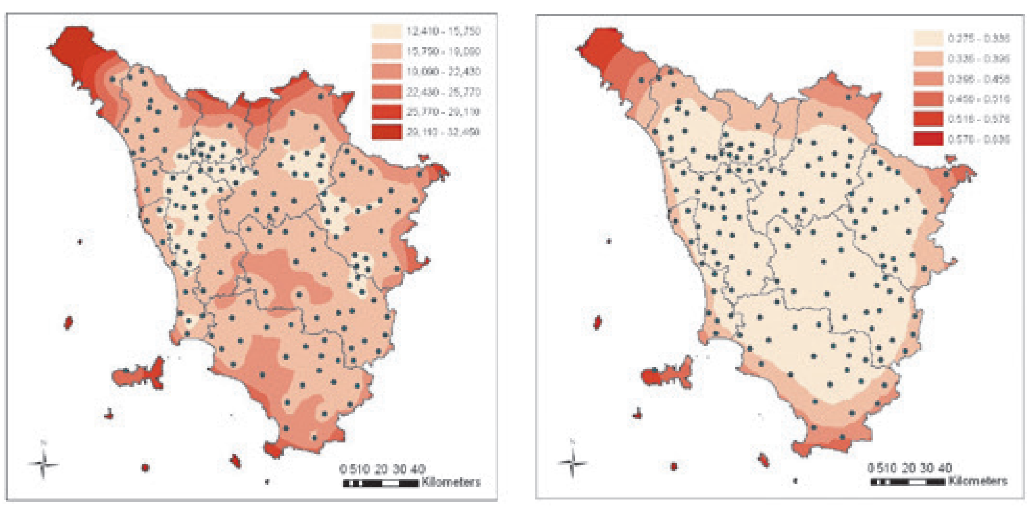


Figure 3: Standard error maps for total per capita income (winsorized dataset, a) and wellbeing index (b).



A cross validation was performed to assess the accuracy of the two interpolation models; the calculated Root Mean Squared Normalized Error (RMSNE) for the two maps were 0.997 and 0.983 respectively, indicating a good map accuracy in both cases. One of the main advantages of OK application is the evaluation of the estimation error. In Figure 3 the standard error maps for the two variables are reported.

It can be easily observed that the higher error is committed where observation points are lacking or absent. In this case, the rather homogeneous distribution of observation points ensures an almost good prediction over all the territory. As expected the standard error tends to increase moving from the centre towards the borders of the region, reflecting the arbitrary selection of the geographical units considered in the analysis (a single administrative region).

The geographical pattern of the observed phenomena (i.e. income level and well-being of farming households in Tuscany) as represented by the estimated model seems coherent with previous analyses on Tuscan agriculture.

Per capita income shows higher level in the central area of the region, mainly in the provinces of Florence and Siena. According to a recent analysis of the last Census data, these areas show an average size of holdings higher than the rest of Tuscany and a larger presence of entrepreneurial farms (Rocchi and Landi, 2013). The most competitive wine regions (Chianti, Brunello di

Montalcino) as well as the nursery seedling district around in the Pistoia province are included in the area with the highest levels of per capita income. Furthermore, a recent analysis of structural change in the period 2000-2010 showed a stronger trend in the exit of farms from agriculture in the north-western area of Tuscany (Landi et al, 2013), associated the lowest level of per capita income of farming households in figure 2.

The spatial distribution of the well-being indicator shows a lower differentiation among different part of the region. The geographic pattern is similar to those of per capita index, despite some interesting differences (for example in the western area between the provinces of Pisa and Livorno). Also in the case of a multidimensional valuation of well-being, the results seem to be cross validated by other, independent analyses. A recent study on well being in the different rural areas of Tuscany, shows a similar geographical differentiation in the level of indicators (Rocchi and Turchetti, 2013). It is interesting noting that the cited paper estimates of well-being indicators were carried out based on the EU-SILC sample for Tuscany and using post-stratification techniques for small, sub-regional areas. The exercise of statistical matching proposed in this paper seems able to yield results coherent with those of the direct survey of well being levels. This evidence confirms the potential interest of the technique for the analysis of well-being of agricultural households.

3. Conclusions

Microdata on farming activities from samples of agricultural holdings often include also relevant information on farming households. This information may be used as a basis for a statistical matching with data from general surveys on households income and well being. In this paper we show the potential interest of such an approach. Data from the largest farm survey in Italy (FBS) were matched with data from the European Survey on Incomes and Living Conditions EUSILC according to a set of common variables. The resulting dataset allowed to analyse income and well-being levels of farming households in Tuscany. A spatial analysis showed that the geographic pattern of "imputed" income and well-being values is coherent with the results of other, independent analysis.

These results suggest possible improvements in the design of surveys on agricultural sector. Despite their focus on production (holding size, production activities, revenues, costs etc.) the "industry-oriented" surveys, such as Census and samples on Farm Structures may gather a few, key set of information on farming households (Rocchi, 2010). These variables may ground a subsequent exercise of statistical matching in order to extend the results also to income and well-being of farming households. A good statistical practice may be a careful definition of the variables to be used as a basis of matching, ensuring their coherence with concepts and definitions adopted in the surveys on households potentially eligible as "donors" in the statistical matching (United Nations, 2011).

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Measuring Countries Welfare

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Abstract

This last decade has seen a great economic performance from Africa countries. The region was among the fastest growing in the world economy. But at the same time, most African countries continue to face challenges of persistent poverty and inequality. This observation seems to contrast with the economic literature evidence, suggesting that the pursuit of economic growth is associated with concomitant improvement in the living standards and welfare of the population. The main purpose of this paper is to measure a country level of welfare. More specifically, we follow the methodology of Jones and Klenow (2011) to construct summary statistic for measure welfare as function of consumption, leisure and probability of surviving. We then apply the methodology on data of second and third Cameroonian household survey conducted en 2002 and 2007 respectively. We found an improvement of welfare between 2002 and 2007.

Keywords: welfare; consumption; leisure.

1. Introduction

The improvement of population's living standard has always been a key objective for policy makers. For this end, it's appeared necessary to know how to act on an individual quality of life and how to measure their welfare. For many years already, sociologists, economists and politicians have used many statistical and economic tools to meet this need. GDP is one of the first statistics used for this purpose. Although it is still used as the key indicator for economic policy, many studies have noted that the GDP as a measure of welfare fails to capture some important factors (e.g. leisure, health, inequality, education, sustainability) that affect the level of life in society. Thus, in order to create an ideal measure of welfare, there has been significant attempt to include a number of these factors in a welfare measure.

Daly and Cobb (1989) constructed the Index of Sustainable Economic Welfare (ISEW) that incorporates personal consumption expenditures and such factors as income distribution, net capital growth, resource depletion, environmental damage.

One of the more popular used welfare metric is the Human Development Index (HDI) Developed by the United Nation Development Program, that summarize into a single number data on income, literacy and life expectancy at birth. HDI face many criticism by economist [Kelly (1991), Noorbakhsh (1996a), Harkness (2004), Ravallion (2009)] mainly because of it lack of theoretical basis and the way to combine the indicator used to produce it. To solve the problems caused by the limitations of the HDI as a measure of well- being of a society, a range of alternative indices have been proposed in the economic literature.

Fleurbaey and Gaulier (2009) propose a measure of living standards for international comparisons. Based on GDP per capita, their measure incorporates corrections for international flows of income, labor, risk of unemployment, healthy life expectancy, household demography and inequalities.

Jones and Klenow (2011) propose a framework for measuring cross-country welfare across the dimensions of consumption, leisure, and inequality. They proceed by computing the consumption equivalent that will make one indifferent to live in a reference country (U.S.) or in host country. They find a strong correlation between their welfare index and GDP per capita.

This paper is organized as follows. Section 2 develops the model used to construct a welfare indicator based on Jones and Klenow (2011). Section 3 reviews the data used to application on the case of Cameroon. Section 4 presents the results and section 5 conclude.

2. Theoretical framework

In this work, we propose a framework to measure a country flow of welfare. The model proposed follow the work of Jones and Klenow (2011) which aggregate data on consumption, leisure, per capita GDP, inequality and morbidity to propose a summary statistic for a nation flow of welfare.

Let c denote the annual consumption of a random individual in a country and l his leisure during the year. We assume the individual utility during the year given by:

$$u(c,l) = u_0 + logc - \frac{\theta}{1+\varepsilon}(1-l)^{\frac{1+\varepsilon}{\varepsilon}} \quad (1)$$

Where u_0 is the utility gain to just being in live, ε the Frisch elasticity and θ the utility weight on leisure.

We assume the country to be composed by individuals belonging to different age groups and that individuals are heterogeneous in their consumption and leisure.

Because individuals have to be alive to perform a year of consumption, and that they face different mortality rate in any age group, the expected utility for random individual in the country is given by:

$$V = \sum_{a\epsilon A} S(a) \sum_{i=1}^{N_a} \varpi_{a,i} \left[u(c_{a,i}, l_{a,i})\right] \quad (2)$$

Where A is the set of age groups, $S(a)$ is the probability to surviving a year for peoples in age group a, N_a the number of individual of age group a, $\varpi_{a,i}$ is the normalize sample weight of individual i of age group a.

The measure propose by Jones and Klenow (2011) is a consumption equivalent measure representing the proportion of consumption in a baseline nation (United States), given its values of leisure, life expectation, inequality, that would deliver the same expected utility as the values in host countries.

In this paper, we assume a country divided into five wealth groups (quintile of wealth). We then define the country welfare as the utility gain by its poorest members. Based on this definition, and follow Jones and Klenow (2011), we define the country flow utility as the proportion of consumption of richest quintile that deliver the same expected utility as the values of poorest quintile given their level of leisure and probability of surviving during a year.

Denote by $V_r(C_r, l_r)$ and $V_p(C_p, l_p)$ the expected utility of rich and poor respectively. The consumption equivalent measure is obtained by solving the following equation:

$$V_r(\lambda) = V_r(\lambda C_r, l_r) = V_p(C_p, l_p) = V_p(1) \quad (3)$$

Using (1) and (2) and using $v(l) = -\frac{\theta\varepsilon}{1+\varepsilon}(1-l)^{\frac{1+\varepsilon}{\varepsilon}}$ we have:

$$V_r(\lambda) = \sum_{a\epsilon A} S_r(a) \sum_{i=1}^{N_{r,a}} \varpi_{r,a,i} \left(u_0 + logC_{r,a,i} + log(\lambda) + v(l_{r,a,i})\right) \quad (4)$$

Using the notation,

$$u_{x,a} = \sum_{i=1}^{N_{x,a}} \varpi_{x,a,i} \left(u_0 + logC_{x,a,i} + v(l_{x,ai})\right) \quad (5)$$

We can write (4) as:

$$V_r(\lambda) = \sum_{a\epsilon A} S_r(a)[u_{r,a} + log(\lambda)] \quad (6)$$

The solution of (3) can then be written as follow:

$$log\lambda = \frac{1}{\sum_{a\epsilon A} S_r(a)} \sum_{a\epsilon A} [S_p(a)u_{p,a} - S_r(a)u_{r,a}] \quad (7)$$

Incorporating (5) in (7) this expression can be decomposing as follow:

$$log\lambda = \frac{1}{\sum_{a\epsilon A} S_r(a)} \sum_{a\epsilon A} \left(S_p(a) - S_r(a)\right) u_0$$

$$+ \frac{1}{\sum_{a\epsilon A} S_r(a)} \sum_{a\epsilon A} \left(S_p(a) \sum_{i=1}^{N_{p,a}} \varpi_{p,a,i} logC_{p,a,i} - S_r(a) \sum_{i=1}^{N_{r,a}} \varpi_{r,a,i}\, logC_{r,a,i}\right)$$

$$+ \frac{1}{\sum_{a\epsilon A} S_r(a)} \sum_{a\epsilon A} \left(S_p(a) \sum_{i=1}^{N_{p,a}} \varpi_{p,a,i} v(l_{p,a,i}) - S_r(a) \sum_{i=1}^{N_{r,a}} \varpi_{r,a,i} v(l_{r,a,i})\right)$$

That is:

$$\boldsymbol{Welfare} = \mathbf{\Delta Probability\ of\ surviving} + \mathbf{\Delta Consumption} + \mathbf{\Delta Leisure}$$

Where:

$$\mathbf{\Delta Probability\ of\ surviving} = \frac{1}{\sum_{a\epsilon A} S_r(a)} \sum_{a\epsilon A} \left(S_p(a) - S_r(a)\right) u_0$$

$$\mathbf{\Delta Consumption} = \frac{1}{\sum_{a\epsilon A} S_r(a)} \sum_{a\epsilon A} \left(S_p(a) \sum_{i=1}^{N_{p,a}} \varpi_{p,a,i} logC_{p,a,i} - S_r(a) \sum_{i=1}^{N_{r,a}} \varpi_{r,a,i}\, logC_{r,a,i}\right)$$

$$\mathbf{\Delta Leisure} = \frac{1}{\sum_{a\epsilon A} S_r(a)} \sum_{a\epsilon A} \left(S_p(a) \sum_{i=1}^{N_{p,a}} \varpi_{p,a,i} v(l_{p,a,i}) - S_r(a) \sum_{i=1}^{N_{r,a}} \varpi_{r,a,i} v(l_{r,a,i})\right)$$

3. Data

For our calculations, we need data on income, consumption, leisure, life expectancy and inequality.

For consumption and income, we use data of second and third Cameroonian Household Survey (ECAM II and ECAM III) conducted respectively in 1998, 2002 and 2007 by the National Institute of Statistic (NIS). These dataset provide data on income and consumption in household and individual level.

The household surveys ask about the number of working hours per week and the number of working days per week. We used these variables to measure time spent in leisure during a year as the difference between a time endowment and time spent in employment.

We assume that sleep is neither work nor leisure and that people sleep 8 hours per day. Thus endowment time per day is 16 hours, which gave 16×365=5840 hours per year.

For a giving worker, the time spent in leisure is *5840- annual hours worked*, our measure of leisure *l* is

$$l = 1 - \frac{annual\ hours\ worked\ per\ worker}{5840}$$

Data on life expectancy were taken from dataset of demographic and Health Surveys (DHS), conducted in 2011 by the NIS. During the survey, people were ask about the survival status of their siblings, the current age of those still alive, sibling's age at death and the date of dead of siblings. We used

these variables to compute age specific probability of surviving per year.

The value of intercept in flow utility u_0 was taken in Jones and Klenow (2011). In their work, they choose u_0 so that a 40-year old in the United States in 2000 has a value of remaining life equal to $4 million in 2000 prices. This choice leads to $u_0 = 5.5441$.

We assume the Frisch elasticity of 1. The utility weight of leisure θ is obtained by solving the following equations:

$$\begin{cases} \frac{u'_l}{u'_c} = \omega \\ c = \omega(1 - l) \end{cases}$$

Where ω is the wage

$$\theta = (1 - l)^{-\frac{1+\varepsilon}{\varepsilon}}$$

4. Results

Table 1 presents some summary statistics for 2002 and 2007. The second household survey reported an annual mean consumption per capita of FCFA 289.8 thousand. Poorest fifth had an annual mean consumption of FCFA 83 thousand, when the richest had an average of FCFA738.7 thousand. The consumption quintile ratio in 2002, was 8.9, indicating that in average, consumption of richest individual was more than eight time of that of poorest.

Five year later, in 2007, the annual mean Consumption per capita was FCFA 324.7 thousand. That is higher by about 34 point of the 2002 value. At the same time, the annual mean consumption per capita increase in each quintile groups. But the growth was higher in highest quintile (25.6%) than in the poorest (20.4%).

Many recent studies suggest that longevity has been a quantitatively important component of welfare gain in developed countries (Haacher, 2010). There is general evidence that the poor tend to suffer higher rates of mortality and morbidity. Table 1 indicates that the probability of surviving during a year is slightly higher for rich than for poor. But we found no significant difference between probability of surviving 2002 and 2007.

Data also indicates that there was a decrease in working time between 2002 and 2007. Indeed, in 2007, people spent more than 67% of their time in leisure against about 65% in 2002. The leisure of poor is higher than that of rich; the different between the values of the two groups is about 9% point. This can be explaining by the fact that the poor are more affected by unemployment and are less likely to have a stable job.

Table 2 presents our welfare measure and its components for 2002 and 2007. In 2002, the welfare of poor worth 62.7% of that of the rich, this was 3.2 point less than the value of 2007. In 2002, higher time of leisure of poor increase their welfare by 1.1% compare to that of rich, when their lower consumption share and probability of surviving reduces it respectively by 18 and 29 percentage point. The improvement of welfare in 2007 is due to a slowly decrease of consumption difference and the increase of leisure difference by 4 %.

Table 1: Summary Statistics, 2002, 2007.

Year	Wealth quintile	Mean Consumption per capita	Quintile share ratio (Q5/Q1)	Probability of surviving	Average Leisure
2002		289.8	8.9	0.955	0.649
	Poorest (Q1)	83.0		0.938	0.684
	Richest (Q5)	738.7		0.982	0.592
2007		324.7	7.5	0.955	0.672
	Poorest	104.3	-	0.929	0.693
	Richest	779.1	-	0.983	0.604

Table 2: Welfare measure and Decomposition components.

Year	Welfare	ΔConsumption	ΔProbability of surviving	ΔLeisure
2002	62.7	-0.185	-0.294	0.011
2007	65.9	-0.178	-0.294	0.054

5. Conclusion

This paper summarizes a measure of national welfare and the empirical application on Cameroon. Welfare is considered here as the factor by which the consumption of the richest quintile must be adjusted so that the value of the latter is equal to that of the poorest quintile of the country. The theoretical model expresses welfare in the country as a function of the level difference of leisure, consumption and probability of survival of individuals between two quintiles. Using data from the second and third Cameroonian household survey, conducted in 2002 and 2007. The results of calculations showed an improvement of welfare of poor compared to that of rich's. This improvement was mainly due to the increase of poor time of leisure in 2007 compared to that of rich.

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Mapping Multidimensional and Monetary Poverty: the case of Uganda

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Abstract

Measures of multidimensional poverty have become increasingly popular amongst researchers and policymakers, complementing traditional money-metric poverty estimates. In particular the Multidimensional Poverty Index (MPI) has become a widely used measure of acute poverty, featured prominently in the 2010 Human Development Report (UNDP 2010), and is being utilized by several countries in Latin America and Asia to monitor national poverty trends and the effectiveness of policies on the ground.

Yet many tools developed to assess money-metric poverty cannot be mechanically transferred to the concept of multidimensional poverty, but require methodological adjustments. This paper focuses on small-area estimates of poverty, often called poverty maps, which are used widely to design and implement geographically-targeted interventions, such as community development funds or transfer programs. We make three important contributions. First, we extend the idea of poverty mapping to the concept of multidimensional poverty. Second, we compare small area estimates of monetary and multidimensional poverty for the case of Uganda. Third, we assess the micro-relationship between the individual indicators of the composite MPI and consumption per adult. This shows how well the different components of the MPI correlate with consumption-based poverty, and yields important information for future refinements of that index.

We argue that there are substantial advantages to MPI mapping compared to traditional monetary poverty mapping. This is because many censuses in developing countries capture a sufficiently large number of MPI indicators to compute a 'reduced' variant of the MPI directly from the census. In contrast, there are hardly any census data that collect income or consumption information, which implies that monetary poverty maps have to rely on more complex imputation methods. Multidimensional poverty maps hence also do not suffer from prediction errors and can be disaggregated to any desired geographic level. Second, using data from Uganda, we show that county-level estimates of monetary and multidimensional poverty are strongly correlated, which suggests that the decision between MPI and monetary poverty maps may not lead to radical changes in geographic targeting (though differences can be substantial for specific regions). Finally we show that most of the components of the MPI are empirically strongly related to consumption, but some MPI indicators (adult education, sanitation and bicycle ownership) merit attention as they correlate poorly with money-metric poverty.

Keywords: poverty measurement; multidimensional poverty; poverty mapping.

Endnote

Full paper has not been submitted.

Tracking Poverty via Reduced Consumption Aggregates

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Abstract

Reducing poverty is central to development and might be even more central with the renewed commitment and focus on poverty reduction by the international community. Currently poverty is usually measured every four to five years, which is hardly ideal, but can this be done more frequently at a reasonable cost? This paper evaluates the reliability of poverty head counts based on reduced consumption aggregates compared to the full consumption aggregate. Using six country evaluations we find that reduced consumption aggregates with recalculated poverty lines can reproduce poverty numbers from full consumption aggregates, but also find that not all reduced aggregates do a good job. Those capturing a larger share of the full aggregate and fulfilling theoretical assumptions do better, though there are notable country variations. We further find that both poverty trend and level can be sensitive to the chosen inclusion or exclusion of consumption components in the consumption aggregate.

1. Introduction

The setting of new and more ambitious targets for poverty reduction is generating renewed interest in tracking poverty. If we are to achieve the ambitious target of less than 3 percent poverty by 2030 greater effort in assessing and tracking poverty would be needed to properly allocate resources and poverty reducing efforts[1].

Poverty – particular in the poorest of the poor countries – is arguably best measured through household consumption surveys. These surveys are complex and costly to undertake and are therefore usually only done every three to five years. Having a measure of poverty every three to five years is a low frequency, particular for goals to be reached within 15 years. Hence, we would like to track poverty at a higher frequency and without incurring the high cost and complexity of standard household consumption surveys. One option is to utilize a reduced consumption aggregate as suggested in Lanjouw and Lanjouw (2001). They write:

"Our results points to the possibility of monitoring poverty using abbreviated low cost survey...abbreviated consumption definition combined with aggregation consistent approach to setting the poverty line, yield the same head count rate as with the most comprehensive consumption dentition."

Though a strong statement, the claim is not validated by empirical data. This note takes the approach into practice and evaluates the empirical validity by testing it in six different country contexts where we have both complete and comparable expenditures over time.

If successful the approach could be used not only to measure national poverty over time, but also to directly evaluate projects impact on poverty.

Tracking poverty is not an easy feat, even using full scale consumption measures. See for instance Christiensen et al (2011) that outline main challenges in tracking poverty, including: a) having regular consumption measures (only 18 out of 48 countries in Sub-Saharan Africa (SSA) included in the World Bank's PovcalNet database possess more than one national household consumption survey since 1995). b) Construction of comparable survey-based consumption measures (see Deaton and Zaidi 2001 for guidelines and challenges). Numerous studies show how consumption measures (and hence poverty) is sensitive to even subtle changes in survey design and implementation (see Beegle et al. (2013) for recent work and overview. And c) trends in poverty also rely on price adjustments to capture real changes in command over goods and services. These are at times of dubious validity, and based on urban prices that might not reflect the country as a whole.

Lanjouw and Lanjouw's (2001) approach is also not the only possible approach that allows tracking poverty without large consumption surveys, though it might be the only proposal that relies exclusively on measured consumption, and not on estimation of some sort. Collecting even partial consumption data, which likely is more complicated and costly then data collection for predictions, could lead to higher accuracy and be more robust in countries with dramatic changes. For estimation approaches see for instance the ELL approach evaluated in Christiaensen et al (2010) and successfully applied in Douidich et al. (2013), and alternative estimations methods as in Tarozzi (2007) and Mathiasseen (2013).

2. Evaluation approach

Lanjouw and Lanjouw (2001) argue that it is possible to take a full consumption aggregate, reduced it by excluding some components, recalculate the poverty line using the "upper bound" method (Ravallion, 1998) and compare the poverty rates from the reduced consumption aggregates over time.

The idea is that if the excluded part of the consumption aggregate is continuously increasing as a share of total consumption, then the share of the population below the recalculated poverty line will remain the same. The authors both argue that the approach holds great promise as a method of tracking poverty at smaller cost, while also caution that it at a minimum relies on empirical regularities captured in these three assumptions:

1. That the reduced aggregate as a share of the full aggregate is non-increasing over the distribution of the full aggregate.
2. That consumption patterns are the same across time for the groups being compared.
3. That there are no measurement errors.

These assumptions are unlikely to hold in general, but the authors show via examples that the approach is empirical relevant as poverty headcounts *within* same year are fairly robust to consumption aggregates and the recalculated poverty lines. They start-out with food consumption only and subsequently add more and more non food consumption groups as education, utilities, and durables. For each new consumption aggregate they recalculate the poverty line and the poverty headcounts. With examples from Ecuador, Brazil and Nepal they show that measured poverty headcount vary with 0 to 4 percentage points within same country and year. The authors use this variation within year to support their argument of reduced consumption aggregate ability to track poverty[2].

Though the robust poverty estimates within same year support the theoretical argument laid out in the article, it does not provide proof of the empirical relevance in tracking poverty over time.

In this paper we will test empirically if the approach *over time* provides equally promising results. We follow a very similar approach with two main differences. In addition to calculating poverty rates for different definitions of the consumption aggregate in year one, we calculate the poverty rate in a second subsequent year using the poverty line establish in year 1. In essence we empirical test if the approach is empirically capable of tracking poverty over time. Further, instead of calculating poverty rates by consecutively adding more and more non food items to the consumption aggregate in an arbitrary chosen order, we calculate poverty rates for all possible combinations of the consumption aggregate. We start with the number of predefined sub components of the consumption aggregate (these subcomponents are defined by the statistical agencies that calculated the total consumption aggregate), in some cases this follows the CIOCOP definitions[3], in other cases not (table 1 in the data section below shows this in detail). We then recalculate the poverty line for all possible combinations of these non-food sub components. We believe this more extensive approach provides better indication of the robustness of the results as we cover much larger variation by calculating between 15 and 1023 poverty rates per country and year, compared to between 4 and 6 per country in Lanjouw and Lanjouw (2001). The larger number of tested cases also allows us to use regression analyses to look for empirical regularities in which type of reduced consumption aggregates that perform better than others.

3. Data

To test empirically if the approach provides consistent poverty estimates we need to have at least two rounds of data with fairly comparable consumption data. We utilize consumption expenditure data from Malawi, Albania, Tanzania, Uganda, and Rwanda – all countries known to have fairly comparable consumption data. We also include Ghana, even though there was a change in how consumption data was collected. Table A1 in the appendix include the full references to the surveys utilized.

We utilize the variation in sub components of the consumption aggregate as identified by the national statistical agencies for Albania, Malawi, Rwanda and Tanzania. For Uganda and Ghana we utilize the consumption sub-aggregates generated as parts of the World Banks SHIP dataset. The SHIP data set is a forthcoming dataset that treat survey data consistently for a large number of African countries[4]. Table 1 shows the subcomponents and the years of data utilized by country. The last row shows the number of different consumption aggregates evaluated[5].

To evaluate over time we need to either deflate the poverty line or the consumption data, and for this we use CPI conversion factors. For the data from national statistics offices we utilize their CPI

Table 1: Sub components of consumption aggregate by country.

Country	Albania	Malawi	Rwanda	Tanzania[1]	Uganda	Ghana
Years	**2002 2005**	**2005 2011**	**2001 2006**	**2009 2011**	**2006 2010**	**1999 2006**
Food[2]	x	x	x	x	x	x
Education	x	x	x	x	x	x
Health		x		x	x	x
Clothing and footwear		x			x	x
Alcohol and Tobacco		x		x	x	x
Housing and utilities[3]	x	x	x	x	x	x
Transport		x		x	x	x
Communications		x		x	x	x
Recreation		x		x	x	x
Furnishing and		x		x	x	x
Other non food	x	x	x	x	x	x
Durables	x		x			
Number of consumption aggregates combinations	15	1023	15	511	1023	1023

Notes: The full name and references to the survey can be found in table A1. 1) This data set is a household panel data set. 2) Food includes food eaten away from the household, and in Rwanda and Albania it includes alcohol and tobacco. 3)In Rwanda and Malawi imputed value of housing is included, while this is not included in Tanzania.

conversion factors, and for the data from SHIP we utilize the CPI conversion factors from the World Bank PovCal database already included. We start with the national food poverty line and dynamically generate the full poverty line following the upper bound approach (Ravallion 1998). To increase comparability across countries we utilize the same definition of consumption and same method to calculate the non-food component of the poverty line, and poverty numbers might therefore not match national poverty numbers. For instance we utilize per capita and do not adjust for adult equivalent scales[6].

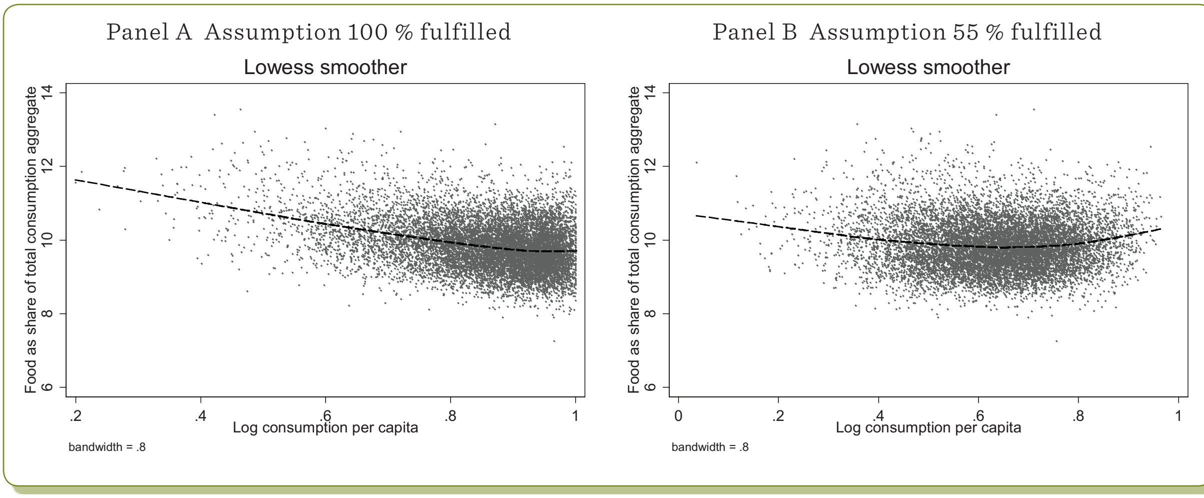
Are the assumptions for the approach fulfilled?

As mentioned above, we generally need to assume that: 1) That the relationship between two definitions of consumption follows a regularity with the reduced aggregate as a share of the full aggregate being non-increasing over the full aggregate, and 2) That consumption patterns are the same across time for the groups being compared.

Below we crudely assess if these two assumptions are fulfilled. To assess assumption one (the reduced consumption aggregate is non-increasing over the full aggregate) we utilize non-parametric lowess curves. In these regressions we relate the reduced consumption aggregate as a share of the full, over the distribution of the full aggregate. If the assumption generally holds we should observe a falling share over the distribution. Panel A in Figure 1 is an example of a reduced aggregate that generally fulfill the assumption using this approximation[7]. To assess the degree to which the assumption if fulfilled we calculate the proportion of the lowess curve that is non-increasing over the distribution. Using this approximation panel A is an example of reduced consumption aggregate that fulfills the assumption over the entire distribution and there have a value of 100. Panel B on the other hand only fulfill the assumption over roughly half of the distribution and have a value of 55, as in 55 percent of the distribution the assumption is fulfilled.

To generally assess if assumption two is fulfilled, we compare changes in consumption patterns over time. We compare the reduced consumption aggregate as a share of total consumption over time. Large changes over time indicate that the relative consumption pattern have changed over time, which would jeopardize comparability of the reduced consumption aggregate over time. For instance, a

Figure 1: Degrees of reduced aggregate being-non-increasing as share of total.



reduced consumption aggregate might in year 1 be 75 percent of total consumption, but only 64 percent in year 2. Such a difference would indicate that consumption patterns have changed over time[8].

Table 2 shows the distributions of these two approximations of our assumptions. It shows that in all country cases we have reduced consumption aggregates that violate our assumptions. On average there are notable shifts in the consumption aggregates in Malawi and Rwanda. The large average in Malawi is likely driven by a 4 percentage point higher food consumption and six percentage point lower utility expenditure in the second year (appendix table A2 shows the average expenditure distribution in all years and countries). More on the utilities in Malawi below. However, the table also shows that in all countries we do have reduced consumption aggregates that do not change substantially. 40 percent of the aggregates change less than 1 percentage point over time, and 67 percent change less than 2 percentage points over time.

The non-increasing assumption holds for most consumption aggregates, on average consumption aggregates are non-increasing in between 70 and 90 percent of the distribution. Further, 60 percent of all the aggregates are non-increasing in more than 90 percent of the distribution, and 50 percent is non-increasing in 95 percent of the distribution. Hence, the two assumptions do not generally hold, but do hold for a number of reduced consumption aggregates.

Consumption aggregates and trend in poverty

As table 1 shows, each country use a differently defined consumption aggregate. Variations occur from variations in questionnaire design, which is known to impact measured level of poverty, but also from inclusion and exclusion of entire sections or types of expenditure. For instance, in Rwanda use value of durable goods is included while in Malawi, Tanzania and Uganda it's not. We illustrate what this means for trend in poverty by showing the trend in poverty based on all our definitions of the

Table 2: Fulfillment of assumptions.

		Albania	Ghana	Malawi	Rwanda	Tanzania	Uganda
Change in consumption aggregates over time	Mean	2.3	1.9	3.1	3.9	1.0	1.0
	min	0.0	0.0	0.0	0.0	0.0	0.0
	max	5.0	6.4	7.2	8.3	2.3	3.2
Proportion of consumption aggregate being non-increasing	Mean	70	90	73	81	91	79
	min	9	23	5	59	25	1
	max	100	100	100	100	100	100

consumption aggregate. These are the poverty trends we would have observed based on full consumption aggregates if we had defined the consumption aggregate as the reduced version.

Figure 2 shows the variation in change in poverty over time. Each data point shows what the change in poverty would have been have we used any of these consumption aggregates to track poverty. Figure 2 clearly shows that the definition of the consumption aggregate has implications for trend in poverty. At the aggregate level we see large variation in poverty headcounts, increases of 2 to 4 percentage point in Tanzania, decreases of 2 to 7 percentage point in Albania, variation from an increase of 3 to a decrease of 6 percentage points in Malawi, and similar a variation from an increase of 5 to an decrease of 5 percentage points in Rwanda. These are large variations in trend in poverty – and all these estimates would have been considered consistent results as the method is applied to two sets of fully comparable consumption aggregates. The only difference is inclusion or exclusion of certain subcomponents. Hence, based on how we designed the survey and the consumption aggregate we would observe a trend in poverty that change direction from a fall in poverty to an increase in poverty, and vary as much a 10 percentage point, which is beyond the confidence intervals of surveys.

In Rwanda for instance a consumption aggregate consisting of food and housing and utilities which capture 79 percent of the complete consumption aggregate used shows a 4.4 percentage point increase between 2001 and 2006. An alternative consumption aggregate consisting of food and Other non food (which in this case includes vacation, non-food, and use value of durables goods), capturing 84 percent of the consumption aggregate used, shows a 4.4 percentage decline in poverty. Hence aggregates that in monetary terms are very similar leads to a 9 percentage point variation in trend in poverty.

The two large "groupings" observed in Figure 2 for Malawi is driven by the inclusion or exclusion of housing and utilities. This nonfood subcomponent is on average across all household in the two years 51 percent of total non food consumption and therefore weight heavily in the aggregate. Within this component 59 percent is the value of housing it-self. Its' inclusion or exclusion leads to a 5 percentage point difference in poverty trend, which is particular interesting as the value of housing is estimated for 88 percent of households, based on the 12 percent that report actual or estimated rental cost in 2010. Such estimations are not uncontroversial as they often, including in Malawi, rely on a small rental markets and strong assumptions.

Figure 2: Different consumption aggregates and change poverty headcounts, Year 2-Year 1.

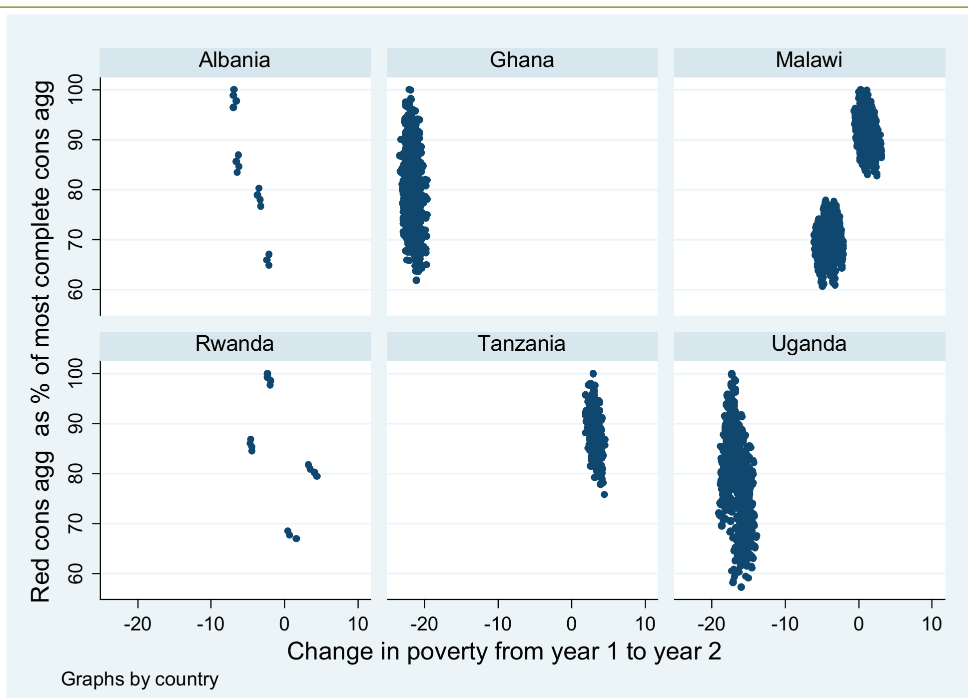
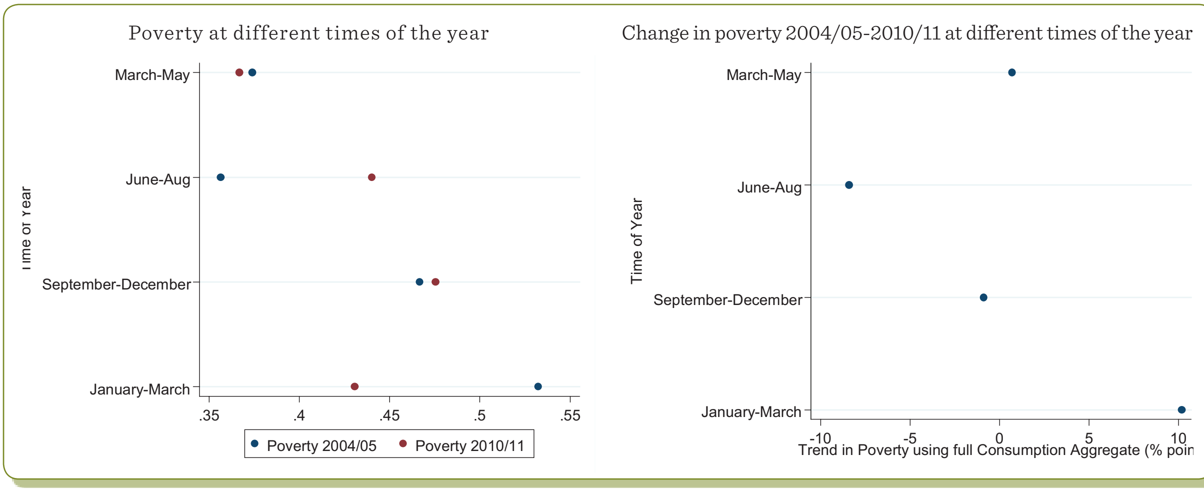


Figure 3: change in Poverty by quarter of the year, Malawi 2004/05-2010/11.



Trend in poverty by quarter

One way to cut cost and complexity of a survey would be to implement it over say a quarter of year instead of a full year. To illustrate this approach we also show how trends in poverty move across a year.

Data from Malawi indicate that the trend in poverty also depends on what time of the year we measure poverty[9]. Measured in March to May 2004/05-2010/11, and September to December 2005/05-2010/11 there is no substantial change in poverty. However, measured in June-August or in January-March we observed a fall or increase in poverty of about ten percentage point, respectively. Hence, our measured trend in poverty not only depends how the consumption measure is defined, but also on the time of the year we measure. The variation in trend in poverty originates in a falling level of poverty in 2004/05, while u-shape dominates in 2010/11.

4. Results

Consumption aggregates and poverty within same year

As a first step we basically replicate the approach taken in Lanjouw and Lanjouw (2001) and generate poverty headcounts for each combination of consumption aggregate and poverty line. The results illustrated in Table 3 largely confirm the empirical observations found previously; reducing the consumption aggregate and recalculating the poverty line leads to very similar headcounts as a full consumption aggregate. We clearly observe that most poverty estimates are within the range of the 95 percent confidence interval of the full aggregate and that most estimates are close. On average estimates are within a half and one percentage away from the estimates based on the full consumption aggregate. Estimations in Uganda and Rwanda are more volatile and a number of aggregates produce estimations outside the 95 percent confidence interval of the full aggregate.

Consumption aggregates and poverty over time

Secondly, we evaluate the poverty headcount estimates in year 2 utilizing the poverty lines from year 1 and the CPI corrected consumption aggregates for year 2. Table 4 shows how close poverty estimates in year 2 are to the poverty estimates from the full consumption aggregate in year 2. Unlike Table 3 based on poverty estimates in year 1, we observe a large number poverty

Table 3: Accuracy of poverty head counts based on reduced consumption aggregates in year 1.

	Absolute difference in headcount estimates between full and reduced consumption aggregate (percentage point)					Percentage of estimates outside 95 CI of full consumption aggregate	Observations
	Average	Min	25th percentile	75th percentile	max		
Albania	1.0	0.2	0.6	1.5	2.0	0%	15
Ghana	0.5	0.0	0.2	0.7	1.8	0%	1023
Malawi	0.4	0.0	0.1	0.5	1.9	0.5%	1023
Rwanda	0.9	0.0	0.2	1.3	3.3	35.2%	15
Tanzania	0.4	0.0	0.2	0.6	1.6	0.2%	511
Uganda	2.0	0.0	0.6	3.0	6.9	21.3%	1023

Table 4: Accuracy of poverty head counts based on reduced consumption aggregates in year 2.

	Absolute difference in headcount estimates between full and reduced consumption aggregate (percentage point)					Percentage of estimates outside 95 CI of full consumption aggregate	Observations
	Average	Min	25th percentile	75th percentile	max		
Albania	1.5	0.3	0.5	2.8	3.0	46.7%	15
Ghana	1.0	0.0	0.5	1.5	3.3	22.5%	1023
Malawi	2.6	0.0	0.9	4.1	6.8	61.7%	1023
Rwanda	3.4	0.0	0.8	5.7	7.4	50.7%	15
Tanzania	0.8	0.0	0.4	1.2	3.0	29.7%	511
Uganda	1.7	0.0	0.7	2.5	5.3	20.4%	1023

headcounts that are far from the headcount using the full consumption aggregate. In all countries at least 22 percent, and in one country 62 percent, of the estimates are significantly different than the full aggregate. On average we observe difference from around one percentage point to 3.4 percentage points.

However, a fair number of poverty headcount estimates are somewhat close to the observed level from the full consumption aggregate. Can we untangle which consumption aggregates are capable of tracking poverty from those that are not? To investigate this we run a regression analysis of how well a consumption aggregate track the full aggregate and characteristics of the sub aggregate. We do this by regressing the absolute difference in headcount between the full aggregate and the reduced aggregate on characteristics of the reduced aggregate.

We first assess if our assumption approximations are significantly related to the accuracy of the reduced aggregates. The approximations clearly capture key aspects of the reduced aggregates ability to track poverty consistent with the full aggregate. A relative change in consumption pattern of one percentage point translates into a loss of accuracy in poverty head count of 0.6 percentage point. Hence, a substantial loss of accuracy due to changes in consumption pattern (Table 5 columns 1 and 2). We should keep in mind that consumption aggregates in this data is likely to change more than we would normally observe as in most cases we have five years between the surveys, which would is more you would use if implemented. The share of the distribution that is non-increasing is also significantly related to accuracy of the reduced consumption aggregate. A 10 percentage point increase in the proportion being non-increasing is associated with 0.1 percentage point improvement the reduced aggregates accuracy (Table 5 columns 1 and 2).

Through selection of particular reduced consumption aggregates we can improve the tracking of poverty. Table 5 column three shows that how much of the full aggregate that is included in the reduced aggregate is significantly related to accuracy of the reduced aggregate. Ten percentage points more of the aggregate covered is associated with poverty head counts 0.5 percentage point closer to the full aggregate. In column four we exclude the change in consumption pattern overtime as this would not be a variable we have control over.

Obviously any inclusion of expenditure type increase the share covered, while columns three and four indicate that above that impact education, health, clothing, alcohol and furniture expenditures are associated with less accuracy, while recreational and communication expenditures are associated with higher accuracy.

Both the country dummies, but in particular the country level regressions in column five though eight in Table 5, indicate that the relationship between types of expenditure and accuracy is country specific. The importance of our assumptions remains significant in all countries though the coefficients do vary between them. The relationship to expenditure types are in many cases country specific and we observe that many results in columns three and four are driven by single country results. None of the expenditure types have a significant and same sign coefficient in all countries. This illustrates that beyond fulfilling the assumptions and the share of the consumption aggregate covered, country specific expenditures matter for the accuracy.

Appendix tables 3 and 4 looks into if certain expenditure types are associated with the fulfillment of the assumptions. This is particular relevant for the assumption of change consumption patterns over time, as we can observe this a priori in year one. The tables show that also here country specific occur, though health expenditures are consistently related to larger changes in consumption patterns over time. Transportation, communication and recreation expenditures are associated with aggregates being increasing, and not fulfilling the non-increasing assumption.

Table 5: OLS of absolute difference between headcount measures from full and reduced consumption aggregates.

	(1) Cross country	(2) Cross country	(3) Cross country	(4) Cross country	(5) Ghana	(6) Malawi	(7) Tanzania	(8) Uganda
Share of aggregate non-increasing in total consumption	-0.01***	-0.01***	-0.00**	-0.01***	-0.00***	-0.01***	0.01***	0.01***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Change in reduced aggregate over time	0.62***	0.58***	0.48***		0.12***	0.64***	0.45**	0.48***
	(0.008)	(0.009)	(0.009)		(0.007)	(0.013)	(0.182)	(0.026)
Share of total consumption			-0.05***	-0.08***	-0.01	-0.04***	-0.06***	-0.01***
			(0.002)	(0.003)	(0.006)	(0.011)	(0.013)	(0.005)
Dummies for expenditure type included.								
Education			0.14***	0.25***	-0.09***	0.02	0.18	0.24***
			(0.022)	(0.029)	(0.022)	(0.031)	(0.111)	(0.050)
Health			0.06***	0.22***	0.25***	0.05	-0.09	-0.12***
			(0.021)	(0.029)	(0.026)	(0.032)	(0.072)	(0.041)
Clothing			0.28***	0.53***	0.33***	0.06	0.00	0.10***
			(0.027)	(0.036)	(0.062)	(0.052)	(0.000)	(0.039)
Alcohol			0.16***	0.27***	-0.02	0.19***	0.38***	0.04
			(0.021)	(0.028)	(0.028)	(0.039)	(0.057)	(0.033)
Utilities			0.05*	-0.03	-0.68***	0.57**	0.39***	-0.14
			(0.030)	(0.042)	(0.030)	(0.244)	(0.148)	(0.089)
Transport			0.05*	0.06*	-0.29***	0.01	0.34**	-0.09**
			(0.025)	(0.034)	(0.025)	(0.051)	(0.134)	(0.042)
Communications			-0.07***	-0.04	-0.16***	0.05	-0.03	-0.19***
			(0.020)	(0.028)	(0.017)	(0.030)	(0.105)	(0.036)
Recreational			-0.04**	-0.08***	-0.37***	-0.03	0.01	0.01
			(0.020)	(0.027)	(0.019)	(0.030)	(0.040)	(0.032)
Furniture			0.04*	0.19***	-0.32***	0.05	0.09*	0.01
			(0.022)	(0.029)	(0.045)	(0.044)	(0.048)	(0.034)
Country dummies								
Ghana		0.01	0.54***	1.03***				
		(0.036)	(0.043)	(0.058)				
Malawi		-0.45***	-0.30***	0.25***				
		(0.031)	(0.029)	(0.037)				
Tanzania		0.41***	0.74***	1.80***				
		(0.034)	(0.033)	(0.037)				
Constant	1.15***	1.02***	4.10***	7.32***	2.29***	4.56***	3.71***	1.08***
	(0.053)	(0.048)	(0.141)	(0.176)	(0.450)	(0.661)	(0.929)	(0.370)
Observations	3,580	3,580	3,580	3,580	1,023	1,023	511	1,023
R-squared	0.71	0.76	0.81	0.64	0.82	0.93	0.33	0.40

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. Cluster effects for countries are included.

From an empirical point of view the method only have merit if you can reduce the number of consumption items considerable, otherwise there would be only limited savings. We look into this with an example using the Uganda data maximizing the share of the total aggregate covered. To capture 50 percent of total expenditure you need only 15 items, while you need 44 questions to capture 80 percent of total expenditure. Table 6 shows head counts in both years using these 15 and 44 consumption items. To utilize such a reduced aggregate we redefine the food poverty line and still apply the "upper bound" method for calculating the full poverty line. We recalculate the food poverty line to replicate poverty head count based on the food poverty line observed in the first year. With the full aggregate we observe a poverty rate based only on food consumption of 38.2 percent in 2005. We rescale the food poverty line, so that we observe the same poverty rate in the reduced consumption aggregates (column 2 in Table 6). Based on this food poverty line, we generate the full poverty line using the reduced aggregate and calculate poverty numbers in both 2005 and 2010.

Table 6 shows that using 80 percent of total consumption, based on 44 questions (26 food, 18 non-food), we are able to track poverty remarkable well. The full aggregate shows a reduction in poverty from 34.9 to 19.3, while the reduced aggregate to 80 percent shows a reduction from 34.3 to 19.2. The aggregate reduced to only 50 percent or 15 questions on the other hand, does not track poverty well. Here we observe a head count of 65.2 percent in the first year, based on the reduced aggregate, so even within year, we observe a large variation.

Table 6: Poverty headcounts based on full and reduced aggregate.

	Poverty (food poverty line)		Poverty (total poverty line)	
Consumption aggregate\Year	2005	2010	2005	2010
Full aggregate	38.2%	24.5%	34.9%	19.3%
Reduced aggregate 80 % of total (44 questions)	38.2%	24.7%	34.3%	19.2%
Reduced aggregate 50% of total (15 questions)	38.1%	23.8%	65.2%	44.1%

5. Conclusions

As in Lanjouw and Lanjouw (2001) we confirm that reducing the consumption aggregate and adjusting the poverty line accordingly using the "upper bound "method, poverty headcount estimates within same year are in most cases remarkably consistent. Empirically evaluating the proposition that this regularity can be used to track poverty over time by using reduced consumption aggregates, however, shows that this does not always work well, as the reduced aggregates leads to substantially different headcount estimates in subsequent years. However, numerous reduced consumption aggregates do track poverty well. Reduced aggregates that make up a larger share of the full consumption aggregate, and that are non-increasing as a share of total consumption do perform better. Further, aggregates that do not have changes in consumption patterns also perform better. The expenditure types that track poverty well show some notable country variation. A single example picking single consumption items as oppose to different types of consumption sub components show that using only 44 consumption items, is sufficient to track poverty.

We further show how trends in poverty are very sensitive to the definition of the consumption aggregate with both change in direction of poverty trend, and variation in level of change of up to 10 percentage point, purely based on how the consumption aggregate has been defined. In certain cases that could mean that the poverty trend observed is depended on potentially arbitrary choices made at both survey design stage and at by statisticians calculating the consumption aggregate. The same sensitiveness in poverty trend to definition of the consumption aggregate is also relevant for the frequent efforts in creating comparable consumption aggregates that usually define consumption aggregates by the lowest common denominator of consumption items measured the same way in all years.

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Appendix

Table A1: Data sources.

Country	Year	Survey
Albania	2002	Living standard measurement survey
	2005	Living standard measurement survey
	2008-09	Household Budget Survey
Rwanda	2000-01	Enquete Intégrale sur les Conditions de Vie des ménages de Rwanda (EICV1)
	2005-06	Enquete Intégrale sur les Conditions de Vie des ménages de Rwanda (EICV2)
	2010-11	Enquete Intégrale sur les Conditions de Vie des ménages de Rwanda (EICV3)
Malawi	2004-05	Malawi 2004-05 Second Integrated Household Survey (IHS2)
	2010-11	Malawi 2010-11 Third Integrated Household Survey (IHS3)
Tanzania	2008-09	Tanzania National Panel Survey (NPS)
	2010-11	Tanzania National Panel Survey (NPS)
Uganda	2005-06	Uganda National Household Survey (UNHS 2005/06)
	2009-10	Uganda National Household Survey (UNHS 2009/10)
Ghana	1991-92	Ghana Living Standard Survey (GLSS3)
	1998-99	Ghana Living Standard Survey (GLSS4)
	2005-06	Ghana Living Standard Survey (GLSS5)

Descriptive statistics

Table A2: Average consumption shares by country and year.

Country	Malawi		Ghana		Uganda		Tanzania[1]	
Years	2005	2011	1999	2006	2006	2010	2009	2011
Food[2]	60.5%	64.0%	61.9%	58.3%	59.0%	59.9%	75.6%	73.6%
Education	0.9%	1.2%	2.0%	2.4%	4.6%	6.0%	2.8%	3.3%
Health	1.3%	1.3%	3.2%	2.0%	4.7%	4.5%	3.8%	3.6%
Clothing and footwear	3.8%	2.5%	9.8%	7.5%	4.4%	3.5%		
Alcohol and Tobacco	2.2%	2.5%	3.0%	2.0%	2.5%	2.1%	2.5%	2.5%
Housing and utilities[3]	22.2%	16.2%	4.2%	6.4%	11.9%	11.4%	3.5%	4.4%
Transport	2.7%	2.7%	3.9%	4.7%	4.1%	3.9%	3.6%	4.1%
Communications	0.2%	2.3%	0.2%	2.2%	1.3%	2.4%	2.5%	3.0%
Recreation	0.5%	0.4%	1.8%	3.3%	0.4%	0.3%	0.0%	0.1%
Furnishing and	3.1%	3.7%	6.7%	7.1%	2.5%	2.2%	2.0%	2.0%
Other non food	2.7%	3.1%	3.3%	4.0%	4.6%	3.6%	3.6%	3.5%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

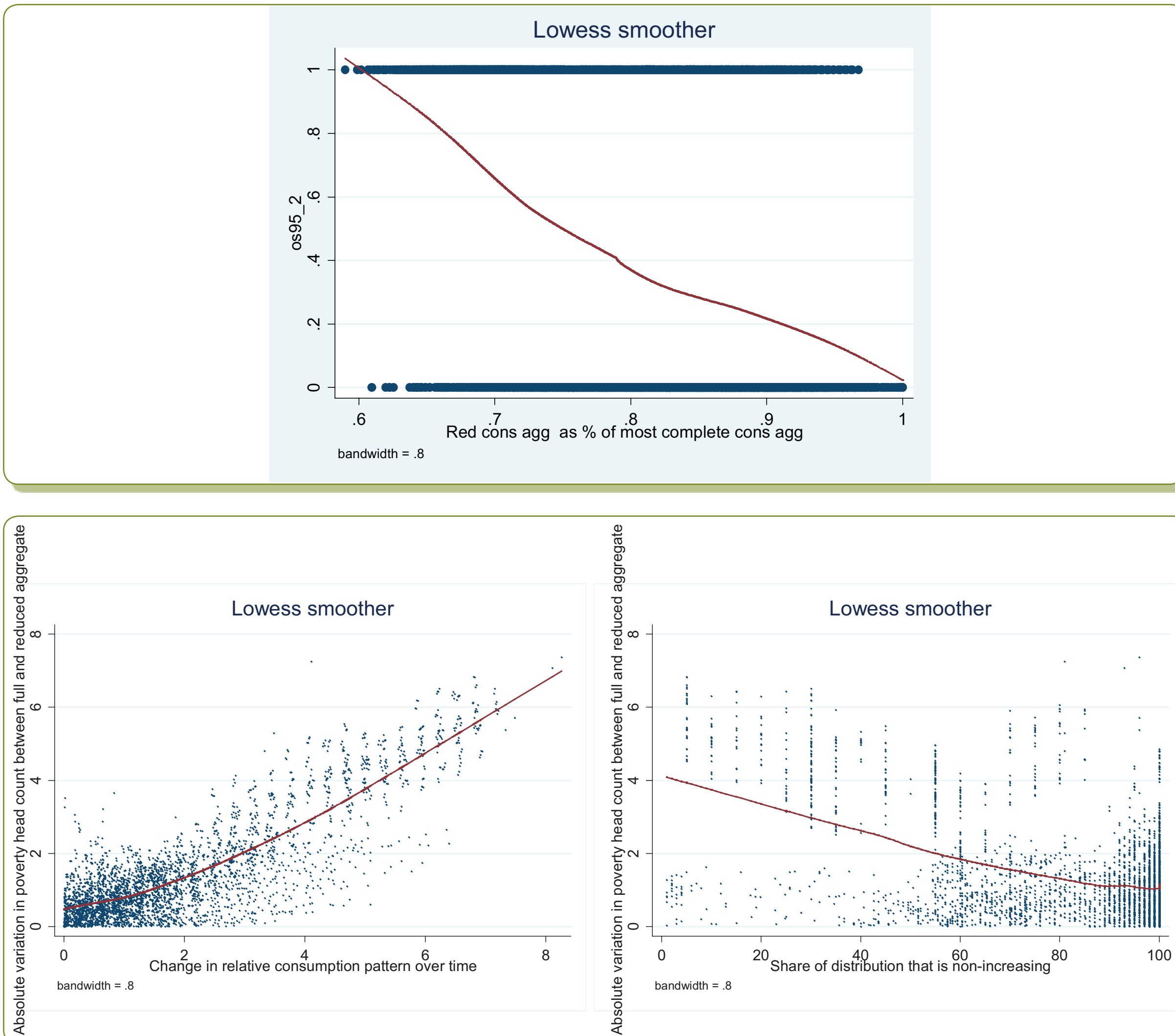
Table A3: OLS regression of Absolute change in reduced aggregate between years.

	(1) Cross country	(2) Cross country	(3) Ghana	(4) Malawi	(5) Tanzania	(6) Uganda
Share of total consumption		-0.08***	-0.02	0.03	0.01***	-0.05***
		(0.004)	(0.024)	(0.027)	(0.003)	(0.006)
Tanzania	0.03	1.08***				
	(0.070)	(0.082)				
Ghana	0.90***	1.10***				
	(0.054)	(0.052)				
Malawi	2.12***	2.27***				
	(0.054)	(0.051)				
Education	0.01	0.28***	-0.04	0.05	-0.52***	0.63***
	(0.041)	(0.040)	(0.099)	(0.076)	(0.015)	(0.054)
Health	0.09**	0.36***	0.36***	-0.03	0.20***	0.15***
	(0.041)	(0.041)	(0.108)	(0.081)	(0.016)	(0.049)
Clothing	0.09**	0.60***	0.95***	-0.34***	0.00	0.01
	(0.044)	(0.048)	(0.251)	(0.124)	(0.000)	(0.047)
Alcohol	0.06	0.26***	0.28***	0.00	-0.00	0.05
	(0.041)	(0.040)	(0.103)	(0.093)	(0.012)	(0.040)
Utilities	-1.16***	-0.22***	-0.34***	-3.78***	-0.72***	0.53***
	(0.041)	(0.058)	(0.124)	(0.594)	(0.014)	(0.080)
Transport	-0.13***	0.17***	-0.05	-0.08	-0.55***	0.16***
	(0.041)	(0.041)	(0.118)	(0.103)	(0.015)	(0.046)
Communications	0.03	0.10**	-0.34***	0.23***	-0.41***	0.48***
	(0.041)	(0.038)	(0.077)	(0.073)	(0.012)	(0.039)
Recreation	-0.10**	-0.04	-0.31***	-0.02	-0.01	0.01
	(0.041)	(0.038)	(0.089)	(0.074)	(0.010)	(0.038)
Furniture	0.03	0.35***	0.16	0.06	0.06***	0.04
	(0.041)	(0.041)	(0.178)	(0.109)	(0.012)	(0.041)
Constant	1.51***	6.65***	3.39**	3.00*	1.01***	4.07***
	(0.073)	(0.251)	(1.520)	(1.650)	(0.231)	(0.380)
Observations	3,580	3,580	1,023	1,023	511	1,023
R-squared	0.43	0.50	0.16	0.66	0.96	0.23

Table A4: OLS regression of share of distribution where reduced aggregate is non-increasing in year 1.

	(1) Cross country	(2) Cross country	(3) Ghana	(4) Malawi	(5) Tanzania	(6) Uganda
Share of total consumption		1.36***	-3.35***	0.37	1.46***	-0.57***
		(0.054)	(0.163)	(0.313)	(0.160)	(0.125)
Tanzania	8.25***	-8.66***				
	(0.969)	(1.116)				
Ghana	10.78***	7.54***				
	(0.750)	(0.703)				
Malawi	-6.47***	-8.89***				
	(0.750)	(0.698)				
Education	-4.74***	-9.17***	6.40***	-2.14**	-0.01	-11.60***
	(0.567)	(0.551)	(0.672)	(0.899)	(0.782)	(1.088)
Health	-1.14**	-5.63***	10.39***	1.41	-5.75***	-2.82***
	(0.567)	(0.552)	(0.739)	(0.952)	(0.841)	(0.989)
Clothing	-6.57***	-14.80***	29.94***	-14.47***	0.00	-0.57
	(0.613)	(0.652)	(1.711)	(1.459)	(0.000)	(0.941)
Alcohol	-1.77***	-4.99***	16.78***	-11.24***	-8.92***	0.98
	(0.567)	(0.538)	(0.702)	(1.098)	(0.653)	(0.807)
Utilities	23.40***	8.23***	13.19***	37.15***	-5.60***	43.82***
	(0.567)	(0.797)	(0.844)	(6.988)	(0.732)	(1.601)
Transport	-16.95***	-21.74***	-0.34	-28.08***	-14.60***	-12.40***
	(0.567)	(0.556)	(0.803)	(1.211)	(0.781)	(0.920)
Communications	-5.28***	-6.34***	-1.30**	-4.57***	-11.57***	-7.38***
	(0.567)	(0.524)	(0.527)	(0.861)	(0.658)	(0.777)
Recreation	-3.69***	-4.70***	-1.10*	-3.87***	-0.47	-1.63**
	(0.567)	(0.524)	(0.604)	(0.871)	(0.541)	(0.764)
Furniture	-0.75	-5.86***	23.39***	-2.76**	-3.02***	-0.58
	(0.567)	(0.560)	(1.211)	(1.288)	(0.630)	(0.818)
Constant	87.89***	4.85	312.3***	56.95***	-13.08	120.10***
	(1.013)	(3.421)	(10.353)	(19.416)	(12.435)	(7.608)
Observations	3,580	3,580	1,023	1,023	511	1,023
R-squared	0.50	0.58	0.59	0.81	0.62	0.77

Figure 4: Lowess regression curve of poverty rate within 95 confidence interval of full aggregate and share of full aggregate covered by reduced aggregate.



Endnotes

1 See Lanjouw et al that evaluates this target is given different assumptions.

2 The authors provide the SEs of poverty head counts for Ecuador, which are clearly within the 95 percent confidence interval. Standard errors are not provided for Brazil and Nepal, so a statistical assessment of the accuracy is not possible.

3 Classification of Individual Consumption According to Purpose (unstats.un.org/unsd/cr/registry/regcst.asp?Cl=5).

4 This does not take variation in questionnaire or sampling design into account. Original data is taken as face value and that handled in a comparable way.

5 The number of possible combination is 2^n – 1, where n is number of subcomponents excluding food which is always included. As example consider three components: clothing, utilities, and health. These can be combined in 2^3-1=7 combinations, being 1)clothing and food, 2) utilities and food, 3) health and food, 4) clothing, utilities and food, 5) clothing, health and food, 6) health, utilities and food, 7) Clothing, utilities, health and food.

6 Even though all countries utilize the upper bound approach to calculate the non-food component of the poverty line there are differences in the details of the calculations. For instance in Albania the non food component of the poverty line based on the percentage of total consumption, while in Malawi its based on the value of non-food for those around the food poverty line. Both calculations built on the same idea of the “upper bound” but the different calculations do lead to minor variations in value of the poverty line.

7 Figure 1 also shows that there is a lot of noise or variation around the curve with many households having a share of devoted to to the reduced consumption aggregate that is not non-increasing. This variation indicates that measures of the degree to which the assumption is fulfilled could vary with choice of approximation method. Even within Lowess curves, the degree of smoothing could impact the approximation.

8 The assumption is about groups that we want to compare overtime, while here we only compare the aggregate at the mean.

9 The sampling is designed so that the data is representative at the national level for quarters of the year.

APN 4

The Challenges of Measuring Labor and Employment in Developing Economies

Organizer and chair: Katheen Beegle, The World Bank

Improving employment outcomes to improve well-being and raise incomes are at the national and global policy discussions. Yet, measuring employment in developing countries faces a number of challenges. Statistics on employment are largely drawn from household surveys, but the quality and content of these surveys varies widely. Within country, definitions across surveys (designed for different objectives) may also vary. Moreover, international definitions (ILO and others) of labor force status, unemployment, and main job may not be applicable to countries characterized by low income, high seasonality, and informal work. Labor income in household surveys is often only partially measured, particularly in agriculture where unit value of labor is often not available for a lack of measures of the aggregate supply of household labor. Job creation measures from enterprise surveys often miss microenterprises, which can dominate in many of the poorest countries, thereby distorting the picture of where job creation lies. And, the lack of annual labor force data in many countries necessitates estimates derived from models/estimates.

The objective of this session is to discuss these challenges and discuss new innovations and methodologies for employment measurement. Preference will be given to papers with some focus on agricultural jobs and rural employment issues.

This technical session will consist of three 15-minute paper presentations, followed by 45-minute panel discussion from leading experts, complemented by interventions from the floor.

Papers:

- Blagica Novkovska (Republic of Macedonia), "Defining and Measuring Non-standard and Informal Employment in Agricultural Sector"
- Joachim De Weerdt, Andreas Kutka (Tanzania), "Urbanisation and Youth Employment in Tanzania"
- Marcia Quintslr (Brazil), "New Resolution Concerning Statistics of Work, Employment and Labour Underutilization and Issues on Work in Agriculture Activities and in Rural Areas "

Defining and Measuring Non-standard and Informal Employment in the Agricultural Sector

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Abstract

Non-standard and informal employment in the agricultural sector in its diverse forms contributes significantly in total employment of less developed countries. This situation is gaining increasing attention within researchers and policy makers. At the same time, statisticians should seriously treat the incidence and persistence, the causes and consequences of non–standard and informal employment and the quality, timeliness and reliability of existing sources of agricultural data.

There are always problems with quantifying total employment in agriculture, definition and measurement of employment relationships in agriculture, especially employment relationships like part-time work, fixed-term contracts, temporary work, seasonal work, and own-account employment. All these forms of work are part of flexible labour markets that at the same time decrease incomes and social security of agricultural workers and highly increase risks of poverty, gender inequality and social exclusion. Implications for low-income workers are mostly recognised for agricultural households.

Analyses of non-standard and informal employment in the agricultural sector using data from available sources are limited by the scarcity of information that can precisely identify non-standard and informal employment in relation to other indicators important for measurement of the development of the agricultural sector.

This paper analyses and evaluates the definitions and measurement of employment in the agricultural sector through analysis of total employment, non-standard employment and informal employment in agriculture in the Republic of Macedonia.

Keywords: informal employment; non-standard employment; agriculture.

1. Introduction

Many analyses of the labour market situation in less developed countries suggest that the rates of non-standard and informal employment would increase in response to the expanding globalisation and economic crises.

There are always problems with quantifying the total employment in agriculture, defining and measuring employment relationships in agriculture, especially employment relationships like part-time work, fixed-term contracts, temporary work, seasonal work and own-account employment. All these forms of work are part of flexible labour markets that at the same time diminish incomes and social security of agricultural workers and highly increase risks of poverty, gender inequality and social exclusion. Implications for low-income workers are mostly recognised for agricultural households.

Analyses of non-standard and informal employment in the agricultural sector using data from available data sources are limited by the scarcity of information that could precisely identify the non-standard and informal employment in relation to other indicators important for measurement of the development of the agricultural sector.

Employment-related indicators are among the most significant measures, especially in the case of less developed countries.

However, it is very important by using available employment indicators to identify the incidence and persistence, and the causes and consequences of non-standard and informal employment in total employment and in agriculture as an important sector of economy. At the same time, these analyses will be the basis for identifying poor and very low-income earners. Most of the working poor in the world work informally or are part of non-standard employment. This situation confirms a strong link that exists between informality and non-standard forms of employment with poverty. According to available statistics, informally and non-standard employed persons lack basic social protection and are very low-income earners. Because of this, the policy of reduction of the poverty of poor employed persons in agriculture needs to be focused on non-standard and informal employment in agriculture. At the same time, statisticians need to be focused on enhancement of the current agricultural surveys in view of better treatment of information on employment in agriculture. This information has to become regularly available.

The main aim of this paper is raising awareness among the statisticians of the limitations in the existing sets of agricultural statistics, which have not been designed to measure non-standard and informal employment in the agricultural sector.

2. Defining and Measuring Non-standard and Informal Employment

Informal employment in its diverse forms is gaining increasing attention within global and national development agendas.

The interest in informal employment was promoted by the 2002 International Labour Conference Resolution and Conclusions on Decent Work and the Informal Economy. The resolution includes conclusions related to the definition and diagnosis of the informal economy, the main characteristics and decent work deficits of informal workers and informal economic units, and a range of actions to address these decent work deficits and to facilitate integration into the mainstream economy.

The term "informal economy" was considered preferable to the traditional "informal sector", because informal workers and economic activities do not belong to one sector of economic activity, but cut across many sectors. The informal economy refers to "*all economic activities that are, in law or practice, not covered or insufficiently covered by formal arrangements*." (H. Huitfeldt & J. Jutting, 2009).

In January 1993, the Fifteenth International Conference of Labour Statisticians (15th ICLS) adopted an international statistical definition of the informal sector that was subsequently included in the revised international System of National Accounts (SNA 1993).

The 15th ICLS defined employment in the informal sector as comprising all jobs in informal sector enterprises, or all persons who, during a given reference period, were employed in at least one informal sector enterprise, irrespective of their status in employment and whether it was their main or a secondary job. Employment in the informal sector refers to all employment in enterprises which are classified as informal according to a common set of criteria. The resolution adopted by the 15th ICLS identified the set of criteria for defining informal enterprises (Hussmanns and du Jeu, 2002): legal organisation of the enterprise, market production and firm size and/or registration.

The 17th ICLS defined informal employment as comprising the total number of informal jobs, whether carried out in formal sector enterprises, informal sector enterprises, or households, during a given reference period (Hussmanns, 2004). The modern society, marked with economic and technological changes in the processes of production of goods and services, creates various forms of non-standard work. Non-standard work as a term is used to describe the work that differs from the regular or standard model of full-time, permanent and direct employment and the differences refer to protection of the workers (M. Ebisui, 2002).

Non-standard workers are facing conditions that make them more insecure and vulnerable; in non-standard jobs the duration of employment is uncertain, the employment can be terminated more easily and without prior notice by the employer, the non-standard workers have lower and irregular wages, lower quality of work, limited occupational safety and health protection, fluctuations in hours of work or volume of work.

There are many variant forms of non-standard work. (G. Schmid, 2010). However, according to the European Labour Force Survey, the definitions for labour force participation and non-standard employment are as follows:

1. Activity rate / or labour force participation rate = (Employed + Unemployed) as percentage of working age population (age 15 to 64);
2. Part-time employment rate = employed in part-time work and in open-ended contracts or in own-account work as percent of working age population; or as a share of total employment;
3. Fixed-term employment rate = employed in fixed-term contracts (including temp-agency work with fixed-term contracts and part-timers in fixed-term contracts) as percent of working age population; or as a share of total employment;
4. Self-employment rate = own-account workers (own-account employed without dependent employees) in full-time as percent of working age population; or as share of total employment; and
5. (Aggregate) Non-standard employment rate = sum of (2, 3 and 4) as percent of working age population; or as share of total employment.

Three categories – **own-account employment, part-time work, and temporary work (fixed term contract)** – comprise non-standard or atypical employment.

3. The Size and Persistence of Non-standard and Informal Employment in the Republic of Macedonia

The current state of the labour market in Macedonia reflects the economic, social and political transformation of the country after gaining independence in 1991, but also the long-term problems in the labour market.

In the period of economic and political transition of the country, a lot of attention has been given to analysis and policy debates about unemployment as a most serious problem. Macedonia has faced double-digit open unemployment since independence. However, labour mobility and the flexibility and security of employed person have not been treated adequately and a complete picture of the labour situation is still lacking. (B. Novkovska, 2008).

Table 1 shows the profile of the labour force in Macedonia: low activity and employment rate, high unemployment rate. Participation of agricultural employment in total employment is 17.3%. In Non-agricultural employment employees participate with 85.9%, while in agricultural employment the participation of employees is only 12.4%. The structure of agricultural employment is dominated by unpaid family workers (44.2%), followed by own-account employed with 41.5% of the total. This profile reveals the particular role of agricultural employment in the economy.

The importance of the agricultural sector (Agriculture, forestry and fishing) is confirmed by data on the participation of this sector with almost 10% in GDP.

Table 1: Profile of the Labour Force, Republic of Macedonia, 2012.

	Male	Female	Total
Total population	**1033138**	**1029156**	**2062294**
Labour force participation	68.7	44.3	56.5
Unemployment rate	31.5	30.3	31.0
Employment, total	393092	257462	650554
Agricultural employment	67360	45262	112623
Non-agricultural employment	325732	212200	537931
Employment rate	47.1	30.8	39.0
Non-agricultural employment by status	**100.0**	**100.0**	**100.0**
Employee	82.4	91.2	85.9
Own-account employed	10.0	4.1	7.7
Employer	6.5	3.7	5.4
Unpaid family worker	1.1	1.0	1.0
Agricultural employment by status	100.0	100.0	100.0
Employee	15.7	7.5	12.4
Own-account -employed	57.8	17.3	41.5
Employer	2.6	0.7	1.8
Unpaid family worker	23.9	74.4	44.2

Source: Labour Force Survey, 2012, author's calculations.

Table 2: Gross domestic product by production method (current prices), total and in agriculture, 2007-2011.

in million denars

Sector	2007	2008	2009	2010	2011	Distribution (%)				
						2007	2008	2009	2010	2011
Total	364 989	411 728	410 734	434 112	459 789	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry and fishing	33 053	41 267	39 825	43 739	43 895	9.1	10.0	9.7	10.1	9.5

Source: SSO

For the purpose of this paper, the focus will be the analysis of non-standard and informal employment in the Republic of Macedonia made on the basis of LFS data as the most quoted and the most reliable labour market data.

The changes in the last five years in employment by status are illustrated in Table 3. Results show that in the last five years the proportion of employees in total employment has increased, while the number of employers and unpaid family workers has decreased. In the years before this period the number of unpaid family workers grew significantly from 7.0 percent in 1996 to 10.9 percent in 2000 and 10.1 percent in 2007. The number of own-account employed has continuously increased over the last 15 years.

At the same time, there have been slightly different changes in the agricultural sector. The number of employees, employers and unpaid family workers decreased, while only the number of own-account employed increased.

These indicative changes in the structure of the labour force were the main reason to measure non-standard and informal employment in agriculture.

The dimensions and the trends of informal and non-standard forms of employment in agriculture were not measured before although there are available LFS data.

For the purpose of the measurement of informal employment two concepts were relevant: the informal sector and informal employment. The informal sector is composed of all informal enterprises.

Informal employment, developed as a broader concept than employment in the informal sector, comprises the total number of informal jobs whether carried out in informal sector enterprises or households, during a given reference period.

Table 4 presents estimates of formal/ informal employment for the Republic of Macedonia for the period 2008-2012. Formal employment participation in total employment increased in this period, and the decline in informal employment was smaller than the growth in formal employment. At the same time, informal employment decreased in both sectors: non-agricultural sector and agricultural sector, but with different intensity. The reduction in informal employment in the agricultural sector was slow.

Measurement of formality of employment by sex shows that in total informal employment work the participation of men is higher, while in informal employment in agriculture the participation of women is much higher than that of men. During the concerned period, an almost monotonous increase is observed in the participation of formal agricultural employment, complemented by a decrease in the participation of informal employment. Such a decrease in the participation of informal employment is much more pronounced for men than for women.

Table 3: Employed population by status in employment in the Republic of Macedonia, 2008 - 2012.

	2008	2009	2010	2011	2012
Total employment	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Employee	71.8	71.9	71.5	71.8	73.2
Employer	4.9	5.2	5.4	5.7	4.8
Own-account employed	12.9	12.7	13.1	13.0	13.6
Unpaid family worker	10.3	10.2	10.1	9.6	8.5
Total agricultural employment	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Employee	13.3	13.6	11.8	12.5	12.4
Employer	2.0	2.6	2.2	3.2	1.8
Own-account employed	37.1	36.0	38.2	37.2	41.5
Unpaid family worker	47.5	47.8	47.8	47.0	44.2

Source: Labour Force Survey, author's calculations.

Table 4: Employment by formality and sex, Republic of Macedonia, 2008-2012.

	2008			2009			2010			2011			2012		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Total employment	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Formal employment	**69.9**	**73.8**	**71.4**	**71.3**	**75.9**	**73.0**	**73.0**	**75.3**	**73.8**	**73.5**	**77.4**	**75.0**	**76.7**	**78.7**	**77.5**
Informal employment	**30.1**	**26.2**	**28.6**	**28.7**	**24.1**	**27.0**	**27.0**	**24.7**	**26.2**	**26.5**	**22.6**	**25.0**	**23.3**	**21.3**	**22.5**
Total non-agricultural employment	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Formal non-agricultural employment	82.4	90.4	85.5	83.4	91.4	86.5	84.8	91.9	87.6	86.1	93.2	88.9	87.7	93.6	90.1
Informal non-agricultural employment	17.6	9.6	14.5	16.6	8.6	13.5	15.2	8.1	12.4	13.9	6.8	11.1	12.3	6.4	9.9
Total agricultural employment	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Formal agricultural employment	18.8	6.1	13.9	18.6	6.1	13.9	21.2	7.2	15.6	18.9	8.9	14.9	23.5	8.9	17.6
Informal agricultural employment (all)	81.2	93.9	86.1	81.4	93.9	86.1	78.8	92.8	84.4	81.1	91.1	85.1	76.5	91.1	82.4

Source: State Statistical Office, LFS, author's calculations.

The reasons for these different trends and intensity of changes could not be easily identified without additional analysis and more detailed data. Calculations of non-standard employment and non-standard employment rates present an option (Table 5).

Calculations of non-standard employment have been made for the period year 2009-2012. Data for the year 2008 are missing because the question about fixed term contracts was deleted from LFS 2008. This situation confirms that for measurement of informality and non-standard employment it is important to have all the elements for calculation.

Calculations of non-standard rates are done as a percent of working age population and as a share of total employment as was find in used literature. However for further analyses of non-standard employment in Republic of Macedonia, non-standard rates as a percent of working age population will be used.

The results presented in Table 5 show that self-employment rates, part-time rates and fixed-term rates are much higher as a share of total employment than as a share of working age population. The reason for this is the high participation of older population in informal and non-standard employment. Self-employment rates and part-time rates are higher for agriculture than for the non-agricultural sector. The situation is opposite with fixed-term employment rates, which are much higher for the non-agricultural sector than for agriculture. These results confirm that most agricultural workers work without contracts.

Table 5: Non-standard employment rates, 2009-2012.

	Year	Self-employment rate in full time as % of working age population[1]	Self-employment rate in full time as share of total employment[1]	Part time employment rate as % of working age population[2]	Part time employment rate as share of total employment[2]
		1	2	3	4
Total	**2009**	**4.3**	**11.1**	**2.1**	**5.6**
Non-agriculture		2.1	5.4	0.8	2.2
Agriculture, hunting and forestry		2.2	5.7	1.3	3.4
Total	**2010**	**4.3**	**11.0**	**2.3**	**5.9**
Non-agriculture		1.9	4.9	1.0	2.5
Agriculture, hunting and forestry		2.3	6.1	1.3	3.5
Total	**2011**	**4.2**	**10.8**	**2.5**	**6.3**
Non-agriculture		2.0	5.1	1.1	2.8
Agriculture, hunting and forestry		2.2	5.7	1.4	3.5
Total	**2012**	**4.4**	**11.3**	**2.5**	**6.4**
Non-agriculture		2.1	5.4	1.2	3.0
Agriculture, hunting and forestry		2.3	5.9	1.3	3.4
		5	6	7	8
Total	**2009**	**1.8**	**4.6**	**8.2**	**21.2**
Non-agriculture		1.7	4.4	4.6	12.0
Agriculture, hunting and forestry		0.1	0.2	3.6	9.3
Total	**2010**	**2.3**	**6.1**	**8.9**	**23.0**
Non-agriculture		2.3	5.9	5.1	13.3
Agriculture, hunting and forestry		0.1	0.1	3.7	9.7
Total	**2011**	**2.2**	**5.7**	**8.9**	**22.9**
Non-agriculture		2.1	5.5	5.2	13.4
Agriculture, hunting and forestry		0.1	0.3	3.7	9.5
Total	**2012**	**2.9**	**7.5**	**9.8**	**25.2**
Non-agriculture		2.8	7.3	6.1	15.6
Agriculture, hunting and forestry		0.1	0.2	3.7	9.5

Source: State Statistical Office, LFS, author's calculations.

1) Self-employment rate = own-account workers (own-account employed without dependent employees) in full-time as percent of working age population; or as share of total employment.

2) Part-time employment rate = employed in part-time work and in open-ended contracts or in own-account work as percent of working age population.

3) Fixed-term employment rate = employed in fixed-term contracts (including temp-agency work with fixed-term contracts and part-timers in fixed-term contracts) as percent of working age population; or as a share of total employment.

4) (Aggregate) Non-standard employment rate = sum of self-employment rate, part-time employment rate and fixed-time employment rate as percent of working age population; or as share of total employment.

Table 6 presents non-standard employment rates calculated as % of working age population and non-standard employment rate as a share of total employment. The results show an increase in both rates in the period 2009-2012 (Figures 1 and 2). Non-standard employment rates are higher for men than for women, these differences being bigger when comparing corresponding non-standard employment rates by sex as a share of total employment.

Table 6: Non-standard employment rates[5], 2009-2012.

Base	Non-standard employment rate as % of working age population			Non-standard employment rate as a share of total employment		
	Total	Men	Women	Total	Men	Women
	2009			**2009**		
Total	**8.2**	**11.7**	**4.6**	**21.2**	**24.7**	**15.6**
Non-agriculture	4.6	6.3	2.9	12.0	13.3	9.9
Agriculture, hunting and forestry	3.6	5.4	1.7	9.3	11.4	5.7
	2010			**2010**		
Total	**8.9**	**12.7**	**5.1**	**23.0**	**26.7**	**17.0**
Non-agriculture	5.1	7.1	3.2	13.3	15.0	10.7
Agriculture, hunting and forestry	3.7	5.6	1.9	9.7	11.8	6.3
	2011			**2011**		
Total	**8.9**	**12.4**	**5.4**	**22.9**	**26.4**	**17.4**
Non-agriculture	5.2	6.9	3.6	13.4	14.6	11.5
Agriculture, hunting and forestry	3.7	5.6	1.8	9.5	11.8	5.9
	2012			**2012**		
Total	**9.8**	**13.3**	**6.4**	**25.2**	**28.2**	**20.6**
Non-agriculture	6.1	7.9	4.3	15.6	16.8	13.9
Agriculture, hunting and forestry	3.7	5.4	2.1	9.5	11.4	6.7

Source: State Statistical Office, LFS, author's calculations.

5) (Aggregate) Non-standard employment rate = sum of self-employment rate, part-time employment rate and fixed-time employment rate as percent of working age population; or as share of total employment.

Figure 1: Non-standard employment rates as % of working age population, 2009-2012.

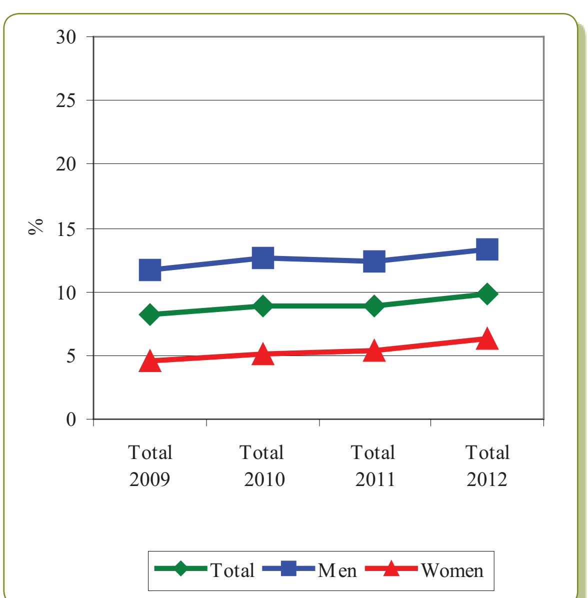
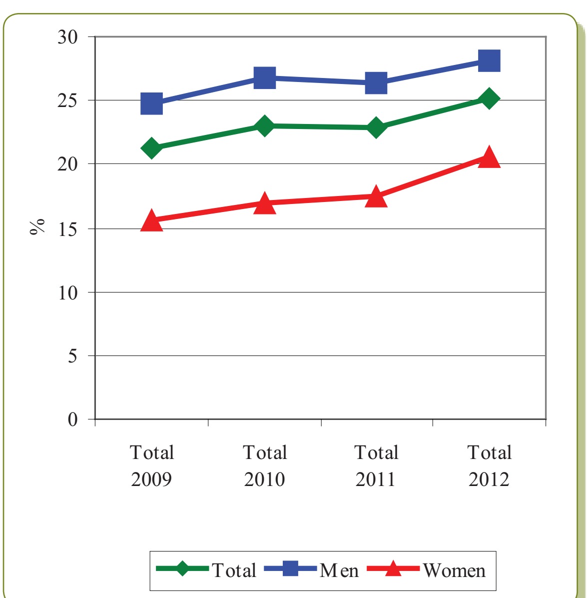


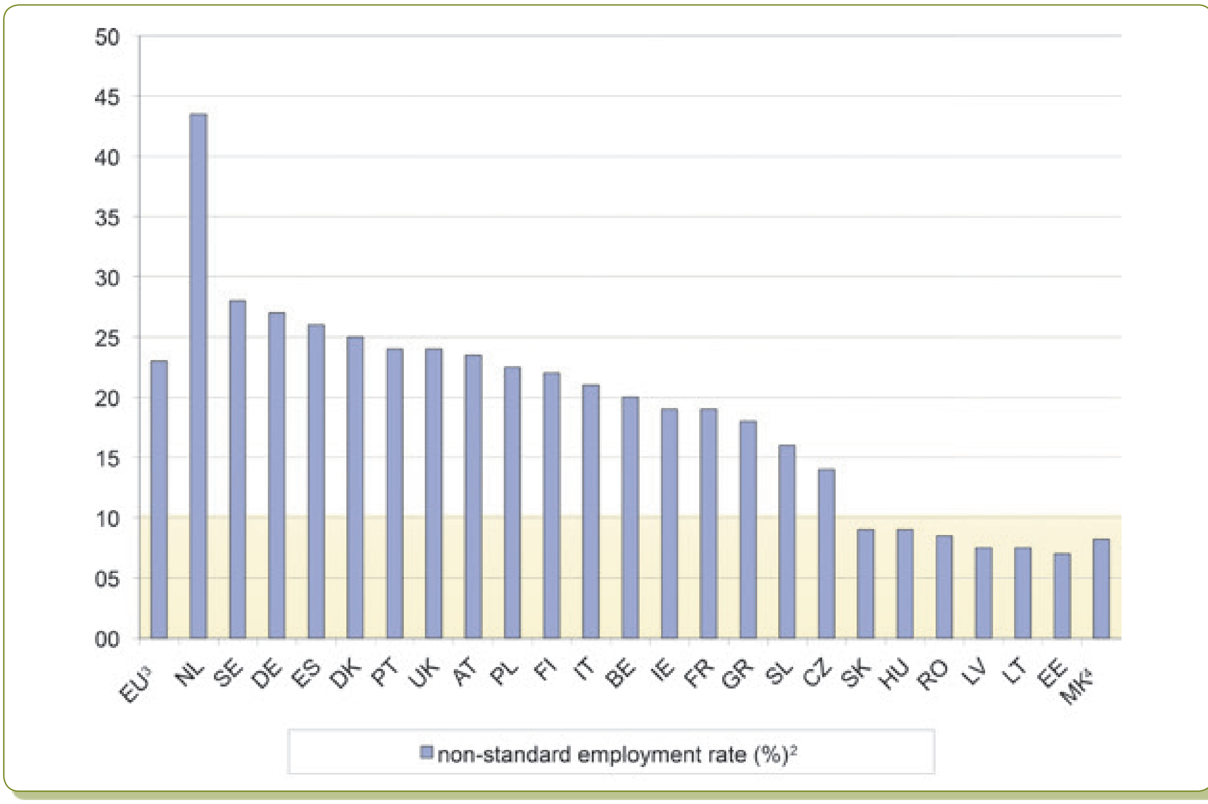
Figure 2: Non-standard employment rates as a share of total employment, 2009-2012.



The above makes questionable the treatment of agricultural employment by policy makers. Are there adequate policy interventions to develop the labour and social position of agricultural workers?

Why should we care about informality/ informal employment and non-standard employment in agriculture? Firstly, all over the world, the share of informal employment in agriculture (that is jobs

Figure 3: Non-standard employment rate in EU countries and in the Republic of Macedonia[4], 2008[1].



1) Data on the EU countries are approximate, and the source is IZA Discussion Paper No. 5087 July 2010 Non-Standard Employment and Labour Force Participation: A Comparative View of the Recent Development in Europe IZA DP No. 5087 July 2010, Günther Schmid

2) (Aggregate) Non-standard employment rate = sum of self-employment rate, part-time employment rate and fixed-time employment rate as percent of working age population

3) Eurostat, Labour Force Survey; Schmid's calculations; the "aggregate" non-standard employment rate includes part-time, fixed-term and own-account work controlling for overlaps; the EU-average excludes Bulgaria, Malta and Cyprus

4) Data are for 2009

performed outside the formal structures that govern taxes, workplace regulations and social protection schemes) is very high. On average, over half of all economic activities in the agricultural sector in less developed economies can be considered informal. Secondly, most agricultural workers are part of non-standard employment. Thirdly, a very high percentage of agricultural workers are part of informal and non-standard employment, at the same time.

This confirms the high risk of poverty and social exclusion of agricultural workers in less developed countries. For reduction of social insecurity and improvement of the economic position of agricultural workers on labour markets in less developed countries, detail measurements of non-standard and informal employment are needed. Policy makers need a more precise picture of the structure of employment as regards the non-standard forms of work and the informality of work.

Comparing the data for the non-standard employment rate, calculated as a sum of own-account employment, part-time and fixed-time employment rate (as percentage of working age population), it is obvious that the new member states, as well as the Republic of Macedonia, have lower non-standard employment rates than other member states (Figure 3). The rates are below 10%, while the EU average is 23%. The main reason for this is that, in the new member states the other forms of employment different from the standards forms are not so developed.

During the period 2009–2012, the non-standard rate in the Republic of Macedonia grew from 8.2% in 2009 to 9.8% in 2012. This shows that the new non-standard forms of employment are slowly developed and implemented on the labour market in the country.

4. Recommendations to improve the measurement of non-standard and informal employment in agriculture

The lack of comprehensive analysis of non-standard and informal employment in agriculture in less developed countries is linked to the lack of well-developed surveys and databases on labour market and the lack of interest for this type of measurements.

Improvement of the measurement of non-standard and informal employment in agriculture depends on: sources of data, the regulatory framework in each country and transparency of measurement results.

"Labour markets in developing countries differ from those in developed countries in many respects. For these reasons, the standard labour indicators and methods should be adapted and complemented with other indicators in order to capture specificities of developing countries' labour conditions"(WIEGO, 2012).

For better measurement it is important to have reliable sources of data. The most often used sources of data for analysis of the labour situation in each country are Labour Force Surveys (LFS) and censuses of population. LFS is the most common source of data for measurement of the structure of employment as regards the formality/informality. When broken down by sector of activity, sex and age, LFS data give us a more precise picture of employment. The census of population is a more limited source of data as regards the employment in agriculture. Census data are more related to identification of agricultural holdings. Censuses of agriculture are well designed to measure the employment in agriculture but with lack of questions for measurement of: status in employment, working time/ hours worked, type of contract, income, etc., or, if there are some of these questions, they are not designed for measurement of informal and non-standard employment in this sector. The main reason for the lack of agricultural surveys as a database for measurement of formality of work in agriculture is the limited interest in this type of analysis for the agricultural sector and the lack of interest to make re-design of already established agricultural surveys. The fact is that the number of studies of non-standard and informal employment in the non-agricultural part of the economy has increased and it is clear that if there are sources of data for measurement of formality/informality in the non-agricultural sector, the same data sets could be used for measurement of employment in agriculture.

The analysis presented in this paper shows that measurement of non-standard and informal employment in agriculture is possible if there is a well-established Labour Force Survey. This means a survey that is entirely focused on measurement of the labour indicators related to all aspects of employment, unemployment and labour force. High quality of data and their availability at disaggregated level is very important.

In the case of the Republic of Macedonia, the main problem was that some questions were not treated as relevant for respondents/workers active in agriculture, and there is a lack of information or bad quality of available data. The main problem was availability of data on fixed-term contracts in agriculture and without data for this category the calculation of fixed-term rates and non-standard employment rates for some years was not possible. This situation has created gaps in the analysis of non-standard employment in agriculture. Measurement problems can be summarised as a lack of data on: type of work contracts, working hours, place of working and employment status of persons active in agriculture. While the Macedonian LFS data make differentiation between part-time and full-time own account employment, there is a problem of overlapping the data for part-time workers and fixed-term workers as the part-timers may be on a fixed-term contract. Nevertheless we can say that as the fixed term employment rate in the Republic of Macedonia is very low in the agricultural sector (0.1, 0.2 or 0.3), there is no big influence on the total non-standard employment rate in this sector. However in the countries where there is a significant fixed term employment rate this differentiation between part-time and full-time own account employment should be done for the analytical purposes.

With regard to the sources of data, LFS can be defined as the main source for measurement of non-standard and informal employment in agriculture; this survey can be used as a support in designing data sets in other regular household agricultural surveys (Farm Structure Survey) and census of agriculture. Thus, good quality data sets will be established. At the same time, comparability between data from different sources of data will be assured. Some analyses of informal employment use the results from the mixed household and enterprise survey, specially designed to study the informal sector, and the Time Use Survey. All these household surveys are good sources of data for the measurement of the structure of employment.

Lastly, the visibility and transparency of measurements of non-standard and informal employment in agriculture are very important for further development of agricultural statistics and establishment of appropriate policy measures for better economic and social position of agricultural workers on the labour market in each country.

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Urbanisation and Youth Employment in Tanzania: preliminary analysis in preparation of a full paper*

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Abstract

In this preliminary scoping note, we use a regionally representative panel of around 2,000 rural African youth, originally surveyed 5 times as children and teens between 1991 and 2004 and one last time as 18-32 year old young adults in 2010. This is a very mobile demographic group and great effort was made to interview both those who remained in their home village as those who had moved out to other villages, towns or cities. For both migrant and non-migrant youth we have detailed data on occupation, schooling and living standards, giving a unique perspective on the interplay between internal migration and youth (un) employment. We find that those who migrate to cities are three times as likely to be employed and twice as likely to be self-employed outside of the agricultural sector. This translates into a consumption growth rate which is higher by a factor of 3, despite similar baseline welfare levels and after taking into account geographical differences in the cost of living. The flip side of the coin is that those who moved to cities are 10 times more likely to be unemployed than those who remain at home. More generally, those factors that are positively correlated with the likelihood of unemployment (for example, education and migration) are also positively correlated to wealth. We argue that this is consistent with the notion of migration and education as risky investments that require time to mature.

1. Introduction

The long-standing view of economists, formulated famously by Lewis over half a century ago in 1954, is that internal migration is a positive force, which channels excess rural labor out of traditional agriculture into industrial activities, where it can be more productively employed. As labor moves out of the rural areas, the marginal productivity of those who remain goes up through an increase in the land to labor ratio accompanied by a surge in demand from the expanding urban areas for food grown in rural areas.

Many current-day observers, however, would not immediately associate internal migration with such an idyllic virtuous circle of development. Instead, they would meet the argument that internal migration is a force for good - because it will fuel a budding industrial sector - with some skepticism. They would point out that fertility and rural-urban migration flows by far exceed job creation and only serve to worsen urban unemployment rates and social problems. These can surface in acute periods of political violence and civil unrest as experienced in the Middle East and North Africa recently.

We contrast these two opposing views through a preliminary scoping analysis of a panel of 2000 African youth, representative of the Kagera region at baseline. These youth, who were 18-32 years old during the final survey round in 2010, were interviewed up to 4 times as children between 1991-1994 and again in 2004. A multi-topic household questionnaire is administered to all split-off households originating from the baseline households, including those who moved out of the baseline location. The strength of the panel data lies in its very long time horizon and the ability to identify exactly who transitions into which type of employment and through which path. Because the survey also interviewed those who moved out of their baseline locations, the link between youth migration and employment can be documented.

This is not a full paper, but a scoping note. It intends to present some initial cross tabulations and analysis on youth employment in Tanzania, and to build the basis for a future full paper. Throughout, no attempt will be made to establish causality; that should be a theme in a follow-up paper. Section 2 will introduce the data set and sample. Section 3 will present our categorization and give fur- ther descriptive details on some categories. In sections 4 to 6 we will then show how demographics, education and migration affect income generating activities and household wealth. Section 7 looks at the effect of job categories on consumption and Section 8 concludes and provides suggestions for how to develop the preliminary analysis in this note into a full paper.

2. Data and sample

The data come from the Kagera Health and Development Survey (KHDS). During the initial rounds of KHDS, a total of 6,353 individuals were enrolled into the panel in four rounds from 1991 to 1994. The sample is regionally representative for the

Kagera region. Everyone being interviewed during at least one of the initial rounds was tracked and re-interviewed during the re-surveys in 2004 and 2010. The data is of particularly high quality and the 2010 round of the survey was conducted using electronic survey questionnaires administered on hand-held computers, with automated skips and validation checks run during the interview when errors could be corrected at source.

To study youth integration into the workforce we select young panel respon- dents, 18 to 32 years old during the 2010 re-survey round, who were 12 to 24 years old during the resurvey in 2004, and 0 to 11 years old at the beginning of the first baseline round in 1991.

KHDS has maintained a highly successful tracking rate. Despite the fact that the younger age co-horts are a particularly mobile group and hard to track, we read from Table 2.1 that 85% of the 18-32 year olds were either located and interviewed, or, if deceased, sufficient information regarding the circumstances of their death collected by 2010. To maintain consistency throughout the paper and with possible future analysis, we restrict the sample already now to those panel members who have been successfully tracked and re-interviewed in both 2004 and 2010. Dropping a further 11 cases because of missing data, we end up with a final sample of 1,932 Tanzanians between 18 and 32 years old, on whom we have data as young adults, adolescents and children.

Table 2.1: Re-interview rates among children aged 0-11 at baseline.

	No.	%
re-interviewed in 2004 and 2010	1,943	68%
re-interviewed in 2004 only	236	8%
re-interviewed in 2010 only	255	9%
deceased	234	8%
untraced	423	15%
Total	**2,855**	**100%**

3. Types of Employment: classification and details

This section starts by describing the classification of employment types used in the remainder of the paper. This classification necessarily fudges interesting detail with respect to some of the categories and the multiplicity of jobs held by a single individual. We therefore spend the last three subsections highlighting these.

3.1 Classification

The employment section of the 2010 KHDS round captures information for the past 12 months on up to two wage employments (including casual labor), any agricultural self-employment and up to two self-employment activities outside agriculture. Individuals engaging in more than one income generating activity are asked for the activity that generates the highest income (accounting for in-kind payment and own agricultural production), as well as which activity they spend most time on.

Table 3.1 describes the different job categories and indicates the number of respondents that fall into each. Each individual is assigned a single category. In case of multiple income generating activities, the activity indicated by the respondent as the one generating the highest income is selected.

Table 3.1: Classification of job categories.

job category	description	Total	N
self ag	individuals self-employed in agriculture or livestock keeping	45.7%	883
self non-ag	individuals self-employed in a non-agriculture (household) entreprise	16.9%	326
casual empl	employed with verbal contract of one month or less	10.3%	199
employed	employed with verbal or written contract of more than one month	7.7%	148
school	individuals currently schooling, regardless of any other in- come activity they might have in addition to schooling	14.1%	273
unemployed	individuals currently not at school and not engaged in any of the above income activities during the past 12 months	5.3%	103
Total		**100.0%**	**1,932**

Individuals grouped under *unemployed* may not be actively looking for work or may be employed domestically and therefore not be unemployed under a strict definition. We will, however, for ease of language, use the term *unemployed* for the remainder of this paper to refer to all individuals that do not fall in any of the employment categories and are currently not at school.

We have tested our results using an alternative classification that groups individuals into the same job categories based on which activity they spent most time on. Our main findings hold for either of the categorizations. We will use job categorization by income for the remainder of this paper. Also, the cut-off point between casual employment and employment is arbitrarily chosen at a contract length of 1 month, but sliding this point back and forth does not affect the main findings below.

Table 3.1 shows that almost half of the youth in the sample fall under the *self-ag* job category, 17% will be considered as self-employed in a non-agricultural enterprise (*self non-ag*), 10% as casually employed (*casual empl*)) and 8% as *employed*. 14% of individuals are students (*school*) and 5% are *unemployed*.

3.2 Multiple jobs

The classification in Section 3.1 hides an important aspect of employment. As elsewhere in Sub-Saharan Africa our respondents hold multiple jobs. The average person in our sample engages in 1.4 different income activities. Table 3.2 shows that 41.6% of individuals in our sample engage in more than one income generating activity, and 8.9% gain their income from three or more different activities.

Table 3.2 also displays additional jobs per job category. Agriculture is by far the most popular additional activity for all categories. Nearly three quarters of our sample gain part of their livelihood from agriculture. Furthermore, individuals whose main income comes from agriculture are most likely to have some form of additional employment (likely casual employment) or a non-agricultural enterprise activities.

3.3 Employment and casual employment further qualified

Table 3.3 summarizes some employment characteristics for four different samples. The first sample contains any youth who reported to be employed, regardless of whether this employment is the primary activity for this individual.[1] The next two samples mimic those from Section 3.1 and Table 3.1 and are the samples that we will carry through to the next sections of the paper. They contain the 199 youth who state casual employment as their primary income source and 148 youth who state employment as their primary income source. The fourth sample is simply the sum of the second and third sample and contains any youth who reports casual or longer-term employment to be the primary income source.

Table 3.2: Holding multiple jobs.
job category*

	school	self ag	self non-ag	casual empl	employed	unemployed	Total
total	14.1%	45.7%	16.9%	10.3%	7.7%	5.3%	100.0%
N	273	883	326	199	148	103	1,932
No. of income activities (row %)							
one	57.5%	57.5%	34.4%	44.2%	43.9%	0.0%	48.1%
two	6.2%	35.0%	46.3%	44.7%	43.9%	0.0%	32.7%
three or more	1.5%	7.5%	19.3%	11.1%	12.2%	0.0%	9.0%
percent with income activity (cell %)							
school	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.1%
self ag	61.9%	100.0%	57.7%	49.7%	43.9%	0.0%	72.7%
one self non-ag	4.4%	20.4%	100.0%	7.0%	16.9%	0.0%	28.8%
two self non-ag	0.0%	1.2%	9.5%	0.0%	0.7%	0.0%	2.2%
one empl job	7.7%	27.9%	18.7%	100.0%	100.0%	0.0%	34.9%
two empl jobs	0.4%	1.8%	0.3%	11.6%	7.4%	0.0%	2.7%

*Refer to Section 3.1 and Table 3.1 for job category definitions.

Employment is strikingly informal in nature. Contracts are mostly verbal and are generally of very short duration. Nearly one third of the jobs are day laboring jobs with a contract length of one day only. Another third of the jobs have typical contracts of one month or less. Only 12% of the jobs have contracts of one year or more, and merely 6% of the jobs in the sample come with a permanent contract. Less than 7% will receive a pension. The bulk of employment is in the private sector, there are some jobs with the government and other employers, such as such as religious institutions, NGOs, or international organizations. Agriculture and fishing are by far the largest employment sector (40%), followed by construction (13%) and trade (8%). The share of jobs in the manufacturing sector is relatively low (skilled trade 7% and factory workers 2%).

When employment is the primary income source, it comes more often with longer-term contracts and is more frequently located in urban areas and outside the agricultural sector.

Table 3.3 highlights some differences between jobs in the casual employment and employed job categories. Individuals falling under the employed job category are more than three times more likely to have a written contract than casually employed individuals. Around a fifth of employed youth will receive a pension or retirement, while nearly none of the casual employed will. Longer-term employment is relatively higher in towns and amongst the youths who had migrated outside Kagera, which we will look at in more detail in Section 6. Private employers are the most important, but the government does account for 20% of longer term employment. Casual employment is more likely to be in the agricultural and construction sector, longer-term employment more likely to be in education, secretarial and administration work.

3.4 Non-agricultural self-employment further qualified

We next look at some characteristics of non-agricultural household enterprises. The 2010 KHDS round records, for each household, all enterprises as well as the household members that are actively engaged in the enterprise and those who are decision makers. Table 3.4 summarizes all household enterprises employing individuals from our sample and stratifies them by household location. This is a larger sample than what we ultimately retain in the remainder of the text, as it also includes enterprises that are not the primary activity in terms of income.

The majority of non-agricultural enterprises are small businesses that employ household members only. In cities, however, these household enterprises create employment outside the household too, with 25% of our sample reporting the hiring of non-household members. Only 14% of the rural sample hire workers outside the household, indicating a lower level of integration in the local economy. This may be due to the scale of the operations, with respondents engaged in non-agricultural enterprises in cities reporting three times more profit compared to those in villages.

Almost 80% of the enterprises sell directly to final consumers. The number of enterprises selling to other businesses ranges from around 10% in towns and cities to 24% in villages, a difference that remains puzzling.

Trading and sales is by far the largest sector amongst household enterprises, accounting for two thirds of the businesses overall. In rural areas nearly three quarters of non-agricultural enterprises are in the sales sector; in towns and cities sales still account for over half of all enterprises. Businesses typically specialize in the sale of food, local brew, cloth, charcoal, firewood, while some are kiosks or shops selling a variety of items. The second biggest sector is skilled trade, which accounts for 15% of the enterprises overall, ranging from 12% in rural areas to 30% in urban areas. Typical businesses in the skilled trade sector are tailoring, carpentry, handcraft and metalwork.

Table 3.3: Further details on employment and casual employment.

			primary income from employment*					
	*any empl		(2) casual empl		(3) employed		(4) 2+3	
contract type	%	N	%	N	%	N	%	N
Verbal	84.9%	574	91%	181	64.2%	95	79.5%	276
Written	15.1%	102	9%	18	35.8%	53	20.5%	71
Total	**100%**	**676**	**100%**	**199**	**100%**	**148**	**100%**	**347**
contract length								
1 day	30.5%	206	47.7%	95	0%	0	27.4%	95
≤ 1mth	36.5%	247	52.3%	104	0%	0	30%	104
< 1yr	15.4%	104	0%	0	42.6%	63	18.2%	63
≥ 1 yr	11.8%	80	0%	0	38.5%	57	16.4%	57
permanent	5.8%	39	0%	0	18.9%	28	8.1%	28
Total	**100%**	**676**	**100%**	**199**	**100%**	**148**	**100%**	**347**
pension								
Yes	6.5%	44	.5%	1	21.6%	32	9.5%	33
No	93.5%	632	99.5%	198	78.4%	116	90.5%	314
Total	**100%**	**676**	**100%**	**199**	**100%**	**148**	**100%**	**347**
location								
village	66.2%	1,280	58.3%	116	45.9%	68	53%	184
town	25.6%	494	25.6%	51	36.5%	54	30.3%	105
city	8.2%	159	16.1%	32	17.6%	26	16.7%	58
Total	**100%**	**1,933**	**100%**	**199**	**100%**	**148**	**100%**	**347**
migration								
local	56.4%	1,089	39.7%	79	46.6%	69	42.7%	148
regional	27.2%	525	34.2%	68	20.9%	31	28.5%	99
further	16.4%	317	26.1%	52	32.4%	48	28.8%	100
Total	**100%**	**1,931**	**100%**	**199**	**100%**	**148**	**100%**	**347**
employer								
government	7.5%	51	1.5%	3	20.9%	31	9.8%	34
private	87%	588	94%	187	73%	108	85%	295
other	5.5%	37	4.5%	9	6.1%	9	5.2%	18
Total	**100%**	**676**	**100%**	**199**	**100%**	**148**	**100%**	**347**
sector								
agriculture/fishing	39.9%	270	25.6%	51	17.6%	26	22.2%	77
trader/merchant/sales	8.3%	56	11.1%	22	10.8%	16	11%	38
transport	5.6%	38	8.5%	17	8.8%	13	8.6%	30
construction	12.9%	87	17.6%	35	9.5%	14	14.1%	49
education	6.7%	45	2.5%	5	16.2%	24	8.4%	29
secretary/other prof/admin	5.8%	39	3%	6	14.9%	22	8.1%	28
factory worker	1.8%	12	1.5%	3	3.4%	5	2.3%	8
restaurant/bar/hotel	4.6%	31	8.5%	17	4.7%	7	6.9%	24
skilled trade	7.2%	49	10.1%	20	7.4%	11	8.9%	31
other	7.2%	49	11.6%	23	6.8%	10	9.5%	33
Total	**100%**	**676**	**100%**	**199**	**100%**	**148**	**100%**	**347**

*Refer to Section 3.1 and Table 3.1 for job category definitions.

Table 3.4: Characteristics of non-agricultural enterprises.

	location				
	village	town	city	Total	N
employees (col %)					
hh members only	85.6%	80.7%	75.0%	83.3%	498
hired workers	14.4%	19.3%	25.0%	16.7%	100
buyers (col %)					
final consumers	73.7%	87.8%	87.5%	79.1%	473
businesses	24.1%	9.9%	12.5%	18.9%	113
other	2.2%	2.2%	0.0%	2.0%	12
sector (col %)					
fishing	5.1%	1.7%	2.1%	3.8%	23
trader/merchant/sales	71.0%	53.6%	54.2%	64.4%	385
transport	3.0%	8.8%	4.2%	4.8%	29
construction	1.4%	9.9%	4.2%	4.2%	25
restaurant/bar/hotel	5.1%	5.5%	2.1%	5.0%	30
skilled trade	11.7%	17.7%	29.2%	14.9%	89
other	2.7%	2.8%	4.2%	2.8%	17
profit (col %)					
mean monthly profit in TSH	33,071	63,483	121,784	49,373	598
Total					
percent	61.7%	30.3%	8.0%	100.0%	598
N	**369**	**181**	**48**	**598**	

4. Demographics

Bearing the multiplicity of jobs described in Section 3.2 in mind, Table 4.1 now cross tabulates the job categories defined in Section 3.1 against demographic characteristics.

The first two panels of this table, which concern the age profile of each category, clearly show how unemployment is concentrated among the youngest age cohorts: a person aged 18-32 years is over three times more likely to be unemployed than a person aged 28-32. The younger cohorts are also much less likely to be self-employed outside of agriculture or employed on a longer-term basis, although one needs to be cautious in interpreting this as 34% of our younger cohort is still in school. While still 8% of the 23-27 year olds are still in school, nearly all the individuals in the oldest cohort of 28-32 year olds have entered the labor market. Here unemployment is at its lowest at 2.6%, and non-agricultural self-employment and longer term employment are at its highest. Clearly unemployment is disproportionately affecting the youngest.

The last two panels in Table 4.1 reveal significant gender differences. Over two thirds of married woman depend on agriculture as their main income source, as compared to 45% of the married men. Married women are nearly four times less likely to be engaged in longer-term employment than married men, and twice less likely to make their main income from a non-agricultural enterprise.

For both, woman and men, marriage decreases the probability of still being at school to almost 0, suggesting that people only marry once they leave school or cannot afford going to school once they are married.

Unemployment is 2.5 times higher among women than men.[2] Marriage amplifies that gap with married women being 12 times more likely than married men to be unemployed. The gap is mainly increased through lower unemployment among married men (0.7% compared to 4.7% among non-married men) than through higher unemployment among married women (8.4% compared to 6.5% among non-married women). One hypothesis is that men wait to marry until they are work secure, while women do not.

Table 4.1: Job categories by demographic characteristics.

job category*							Total	N
mean age in years	20.7	25.7	27.4	25.1	26.3	23.3	25.1	1,932
age cohort								
18-22	33.6%	37.2%	6.8%	9.8%	4.5%	8.1%	100.0%	651
23-27	7.8%	47.7%	17.9%	11.6%	9.5%	5.5%	100.0%	587
28-32	1.2%	52.0%	25.5%	9.7%	9.1%	2.6%	100.0%	694
sex								
female	11.3%	55.4%	15.6%	5.9%	4.3%	7.6%	100.0%	977
male	17.1%	35.8%	18.2%	14.8%	11.1%	3.0%	100.0%	955
sex & marriage								
fml, married	0.7%	68.6%	15.7%	3.8%	2.8%	8.4%	100.0%	574
fml, non-married	26.3%	36.5%	15.4%	8.9%	6.5%	6.5%	100.0%	403
ml, married	1.0%	45.8%	28.6%	13.2%	10.7%	0.7%	100.0%	402
ml, not married	28.8%	28.6%	10.7%	15.9%	11.4%	4.7%	100.0%	553
Total	**14.1%**	**45.7%**	**16.9%**	**10.3%**	**7.7%**	**5.3%**	**100.0%**	**1,932**
N	**273**	**883**	**326**	**199**	**148**	**103**	**1,932**	

*Refer to Section 3.1 and Table 3.1 for job category definitions.

5. Education

5.1 Education per job category

Table 5.1 summarizes, per job category, the average years of completed levels of formal education, as well as the percentage of individuals who have successfully completed certain grades.[3]

The general level of education in the sample is fairly low. A quarter of all individuals has not completed primary education, nearly two thirds (62%) have completed only primary school, and less than 10% secondary school or above. Of the entire sample of 1933 youth, only 8 have completed a university degree, which amounts to less than half a percent.

The table clearly shows how dependence on agriculture as the main source of income is inversely correlated to the level of schooling. Over half of those who have not completed primary school earn their living mainly from self-employment in the agricultural sector. That numbers drops to 25% for those who finished secondary school and none of our 8 university graduates currently states agriculture as the main source of income (not shown in table).

Table 5.1: Job categories by level of education.

job category*							Total	N
yrs of schooling	9.3	5.6	6.6	6.2	8.0	7.6	6.6	1,932
level of education								
primary not compl.	12.4%	56.3%	11.4%	10.1%	5.5%	4.2%	100.0%	542
primary compl.	13.8%	44.2%	20.5%	10.7%	6.4%	4.4%	100.0%	1,201
secondary compl.	21.2%	24.9%	9.5%	8.5%	21.7%	14.3%	100.0%	189
Total	**14.1%**	**45.7%**	**16.9%**	**10.3%**	**7.7%**	**5.3%**	**100.0%**	**1,932**
N	**273**	**883**	**326**	**199**	**148**	**103**	**1,932**	

*Refer to Section 3.1 and Table 3.1 for job category definitions.

Having completed primary education reduces the probability of being self- employed in the agricultural sector, and doubles the chances of being self-employed outside the agricultural sector. Long-term employment is very low amongst individuals who did not progress beyond primary.

Perhaps the most notable feature of Table 5.1 is the fact that the youth who completed secondary education have the highest chance of being in longer-term employment and in unemployment. It seems as if a long period of searching is necessary before finding longer run employment. Furthermore, secondary education is by no means a guarantee to success: a large part of those with secondary education are not able to translate their schooling into higher earning income activities.

Is it possible that only the relatively well-off can afford the cost of education in addition to the cost of a long spell of unemployment? We explore this question in the next two tables. Table 5.2 shows the 1991 mean annualized per capita expenditures in 2010 TSH for each of the education categories.[4] It is clear that higher educated individuals come from relatively better-off backgrounds, but the difference is not dramatic.

Table 5.3 suggests further that the investment slightly better-off households make in education pays off. The overall, per capita consumption growth rate of 118% hides significant differences among sub-categories, with growth rates at 70% for self-employment in agriculture and 197% for those in longer-term employment. Also within each category, there is considerably higher growth among those with more education.

Importantly, Table 5.3 shows that the unemployed are from households that realized high consumption growth, which is consistent with the notion that one needs to afford to have a spell of unemployment before being able to enter into longer-term employment.

Table 5.2: Per capita consumption at baseline by level of education.

level or education	mean	N
primary not comp	312,470	539
primary compl.	339,446	1,191
secondary compl	394,296	188
Total	**337,241**	**1,918**

Table 5.3: Percentage growth in per capita expenditure since baseline by level of education.
job category*

level of education	school	self ag	self non-ag	casual empl	employed	unemployed	Total	N
primary not compl.	152%	69%	175%	101%	176%	177%	105%	542
primary compl.	103%	67%	158%	140%	162%	144%	108%	1,201
secondary compl.	306%	118%	187%	260%	279%	209%	224%	189
Total	**145%**	**70%**	**163%**	**140%**	**197%**	**168%**	**118%**	**1,932**
N	**273**	**883**	**326**	**199**	**148**	**103**	**1,932**	

*Refer to Section 3.1 and Table 3.1 for job category definitions.

6. Migration

Differences in structural development between rural and urban areas make migration another potential key factor determining employment opportunities, particularly amongst young people. Table 6.1 summarizes the migration streams since the 1991 to 1994 rounds. The rows indicate the 2010 household location relative to the baseline household location, the columns stratify the current household location by village, town and city.

The baseline sample in 1991 to 1994 was representative of Kagera, a region with villages and towns, but no cities. This is a highly mobile group: by 2010 we found only 56% of the sample living in the same or neighboring village or town. The remaining 44% of the sample had migrated further away from their baseline locations. But these migration streams are by no means a run for the cities: most youth move to another village in Kagera region (18%), to an urban area in Kagera (9%) and to cities outside Kagera region (8%). The absence of a city in Kagera region accounts for zero local and regional migration into or within cities.

Table 6.2 shows that a move to a town or city coincides with a move away from agriculture, into employment or non-agricultural self-employment, but also into a riskier environment with a larger chance of being unemployed or casually employed.

A case in point is the contrast between the 1,280 youth who we found residing in villages in 2010 and the 159 who moved to cities by that year. While the majority of youth in villages are farmers, only 3% of the youth in city depend on agricultural self-employment. The youth in the city are over 3 times more likely to be employed and nearly twice as likely to be self-employed outside the agricultural sector. On the other hand, 20% of these youth end up in unemployment and another 20% depend on casual jobs for their main income. Strikingly, compared to youth living in the village, they are 10 times more likely to be unemployed and twice as likely to be casually employed.

Table 6.1: Migration streams since baseline.

	2010 hh location							
migration	village		town		city		Total	
	No.	%	No.	%	No.	%	No.	%
local	851	44.1%	238	12.3%	0	0.0%	1,089	56.4%
regional	356	18.4%	169	8.8%	0	0.0%	525	27.2%
further	71	3.7%	87	4.5%	159	8.2%	317	16.4%
Total	**1,278**	**66.2%**	**494**	**25.6%**	**159**	**8.2%**	**1,931**	**100.0%**

Table 6.2: Job categories by migration and location.

job category*	school	self ag	self non-ag	casual empl	employed	unemployed	Total	N
migration								
local	17.7%	51.1%	15.1%	7.3%	6.3%	2.5%	100.0%	1,089
regional	6.9%	52.7%	16.6%	13.0%	5.9%	5.0%	100.0%	524
further	13.9%	15.1%	23.7%	16.4%	15.1%	15.8%	100.0%	317
2010 hh location								
village	13.8%	56.6%	13.0%	9.1%	5.3%	2.2%	100.0%	1,280
town	14.6%	31.0%	24.3%	10.3%	11.0%	8.7%	100.0%	493
city	15.7%	3.1%	24.5%	20.1%	16.4%	20.1%	100.0%	159
N	**273**	**883**	**326**	**199**	**148**	**103**	**1,932**	

*Refer to Section 3.1 and Table 3.1 for job category definitions.

These facts suggest that migration is a risky investment. Table 6.3 shows that it is also one that pays off. While wealth differences between (future) migrants and stayers were relatively small, the differences in growth are huge. Per capita consumption has increased by only 70% for the average young person who remained at baseline location, but it increased by 269% for those individuals who had migrated outside Kagera to a city, and by even 327% for individuals that have migrated to another town outside Kagera, which is nearly five-fold the consumption increase of the individuals that have remained in their village.

Table 6.4 tabulates the main reason to migrate for each of the job categories[5]. Marriage, schooling and looking for work are the main stated reasons for migration. Those migrating for marriage or other family reasons are most likely to end up in agricultural self-employment. Compared to other categories, those migrating for schooling or work are more likely to be self-employed outside agriculture, or to have casual or longer-term employment.

The migration-education bundle seems to be important. Many youth migrate initially for schooling and then end up finding work at their new or another location.

Table 6.3: Average growth of per capita consumption since baseline by migration and location.

	2010 hh location			
migration	village	town	city	Total
% growth in p.c. cons. since baseline				
local	70%	111%		79%
regional	91%	168%		116%
further	151%	327%	269%	258%
Total	**81%**	**168%**	**269%**	**118%**
total p.c. cons. at baseline (in 2010 TSH)				
local	317,292	387,626		332,560
regional	319,118	348,932		328,752
further	371,191	331,554	382,185	366,045
Total	**320,817**	**364,459**	**382,185**	**337,025**

Table 6.4: Motivation for migration by job category.
job category*

mig reason	school	self ag	self non-ag	casual empl	employed	unemployed	Total	N
found work/posted	0.8%	26.0%	22.8%	29.9%	15.7%	4.7%	100.0%	127
to look for work	0.5%	22.6%	32.3%	24.1%	13.3%	7.2%	100.0%	195
own schooling	32.8%	21.6%	14.2%	6.9%	14.7%	9.8%	100.0%	204
health reasons	10.4%	46.8%	16.9%	11.0%	5.8%	9.1%	100.0%	154
marriage/fam. rsns.	2.9%	64.3%	16.7%	6.5%	3.4%	6.1%	100.0%	443
other	14.6%	51.0%	15.9%	9.3%	5.3%	4.0%	100.0%	151
Total	**9.4%**	**43.6%**	**19.2%**	**12.5%**	**8.5%**	**6.8%**	**100.0%**	**1,274**
N	**120**	**555**	**245**	**159**	**108**	**87**	**1,274**	

*Refer to Section 3.1 and Table 3.1 for job category definitions.

7. Job category and welfare

Table 7.1 shows average baseline and endline consumption, as well as the average growth rate between them for the different job categories. We see that youth self-employed in agriculture and casually employed come from the poorest backgrounds, while those in longer-term employment and unemployment come from richer baseline households. The wealth differences across job categories at baseline (when these individuals were

0-11 years old) are not large and certainly dwarfed by the magnitude of the differences in 2010: by then, those in longer-term employment are twice as rich as those in agriculture. Those casually employed or not self-employed outside of agriculture also do well. Young people deriving their main income from agriculture, however, are clearly the poorest performers in the sample. The table highlights, again, how the unemployed are from better off households, both at baseline as during follow-up.

8. Conclusion

This scoping note aimed to establish some key stylized facts that arise from the Kagera Health and Development Survey as well as evaluate whether and how a full paper can be developed.

The descriptive statistics highlighted the following points. First, marriage ex- acerbates the gender employment gap: once married, men are more likely to be employed outside of agriculture, while women are more likely to be unemployed or dependent on agriculture. Second, both migration and education seem to be important correlates of employment and growth. But, while profitable on average and in the aggregate, both migration and education are also risky strategies, with unemployment rates high among the migrants and the higher educated youth. Unemployment, our consumption data tell us, is not an investment the poor can afford to make.

This scoping note did not aim to provide a final analysis. Obviously the issue of causality has not been dealt with and further multi-variate analysis and other techniques could be used to disentangle the factors determining employment. At a data-technical level, we should consider reshaping the data set to be at the individual-job category level (roughly 6*2,000=12,000 observations, including the zeros), rather than the individual level.

As for the future direction of a paper: the migration story seems the most interesting one as it brings out the dynamics best, and it is also the comparative advantage of these tracking panel data. The education and demography stories could be brought to light with other cross-sectional data too. Another potential advantage of the KHDS data, which could be played out more, is to bring the baseline 1991-94 data into the picture to look at the childhood environment in which the young adult grew up. We already did this somewhat by looking at baseline location and wealth, but could take it further by looking at the child's health or the education and employment of the parents.

Table 7.1: Household welfare and growth by job category.

job category*

	school	self ag	self non-ag	casual empl	employed	unemployed	Total	N
hh cons at bl	368,424	314,200	339,832	325,076	391,117	385,051	337,002	1,932
hh cons in 2010	824,678	446,103	757,192	644,657	999,224	867,864	636,889	1,932
growth	145%	70%	163%	140%	197%	168%	118%	1,932
N	**273**	**883**	**326**	**199**	**148**	**103**	**1,932**	

*Refer to Section 3.1 and Table 3.1 for job category definitions.

Endnotes

* Acknowledgements: background analysis for the World Bank's flagship report on youth employment in Sub-Saharan Africa. This preliminary scoping work was team led by Deon Filmer and Louise Fox.

1 In fact, the questionnaire allowed for up to two jobs to be listed, but the details on contract length and type were only recorded for the first one. Therefore any second employment recorded is not included in this sample.

2 As pointed out above, people who only conduct household chores and/or are not actively looking for work are also counted as unemployed.

3 Individuals who have either never been to school or attended primary school, but did not complete primary school are grouped under *primary not compl.*, those who have finished primary or attended secondary school without completing secondary school are grouped in *primary compl.. secondary compl.* comprises individuals who completed secondary school and in rare (8) cases university. Individuals who attended some form of adult education or Koranic school, but did not complete primary education are grouped under *primary not compl.*

4 The lower number of observations is due to missing consumption data for individuals who entered the household after the first wave in 1991-94.

5 Please note that Table 6.4 also includes the reasons for migrating for those who have moved locally, i.e. to a locality close to the original location at baseline and who are grouped under the migration category *local*.

New Resolution Concerning Statistics of Work, Employment and Labour Underutilization and Issues on Work in Agriculture Activities and in Rural Areas

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Abstract

The new Resolution concerning statistics of work, employment and labour underutilization was adopted by the 19th International Conference of Labour Statisticians that was conducted by the International Labour Organization in Geneva, in October, 2013. It was a remarkable event since the more complete resolutions on labour statistics have been developed and adopted in the 1980 and 1990 decades. The request for updating the international recommendations on statistics was motivated by the need for better description of the labour market and of its recent evolution. Regarding this requirement, the concepts of work and of the different forms of work were established in the new Resolution. Here, the discussion on work in agriculture and in rural areas is underlined and then two forms of work are presented in more details: own-use production work, comprising production of goods and services for own final use, and employment work, comprising work performed for others in exchange for pay or profit. Some topics are highlighted as they have particular relevance on the statistical measurement of work in agriculture or in rural areas: the short reference period for observation of each form of work; the working-age population; the practical considerations on distinguishing the engagement in own-use production work or production for the market work (employment); the employed persons on temporary absence from an employment connection; the criterion of effectively search from employment as part of the unemployment concept. The paper has three central objectives: the description of general aspects of the process for developing the resolutions on work statistics by ILO orientation; the emphasis on the more important concepts of the new Resolution; the focus on topics concerning of work in agriculture and rural areas.

1. The process for adoption of the Resolution concerning statistics of work, employment and labour underutilization and its general framework

The Resolution concerning statistics on work, employment and labour underutilization (RWELU)[2] updates international technical agreements on labour statistics and establishes a point of inflection in the production of these statistics. Considerations on the impetus for the RWELU establishment and on the process carried out for its adoption are relevant for understanding the importance of the new standards. This introductory chapter discusses these topics and provides the general objectives and the framework of the RWELU.

The 19th International Conference of Labour Statisticians (ICLS), promoted by the International Labour Organization (ILO), after drafting process and extensive technical discussions, adopted, in 2013, the RWELU. The ICLS is a five-year Conference in which themes on labour statistics are debated and new resolutions are discussed and adopted. In general, the resolutions address the measurement and the evaluation of quantitative and qualitative aspects of population attachment in work or in labour market and of the workers living standard. Regarding the more recent examples, the 17th ICLS discussed and adopted resolutions on consumer price indices and on household income and expenditures statistics and the 18th, on the measurement of the working-time and on child labour statistics.

In the face of observed changes in the work world, the institutions responsible for producing official statistics have been adopting practices to adjust the international recommendations in force or have been putting on the agenda the need to improve those recommendations. Such initiatives were carried out in order to measure the productive work paid and unpaid, to apprehend the implications of flexible, low or excessive journeys and to complement the unemployment rate for getting more accuracy in the identification of the demand for employment among population. In addition, for offering better support for policies on promotion of income and employment, there was recognition of the necessity to produce advances in statistical analyses,

providing more comprehensive framework on social and economic causes and consequences of persons to be involved in different forms of work.

The 18th ICLS held in 2008 analysed the existing resolutions and practices, which included conducting the seminar "Employment and unemployment: Revisiting the relevance and conceptual basis of the statistics". During the seminar, experiences, difficulties and concerns of countries in the application of the recommendations were discussed, especially regarding the "Resolution concerning statistics of the economically active population, employment, underemployment and unemployment" adopted in 1982. As a conclusion, the 18th Conference requested the ILO to conduct a process, in cooperation with countries and interested organizations, regarding to update the 1982 resolution and to propose measures of labour underutilization by creating a set of indicators on this topic, complementing the unemployment rate for measuring the discrepancies between employment supply and demand. It was expected that such process would produce new recommendations for discussion and subsequent submission for adoption by the 19th ICLS.

In order to meet the requests of 18th ICLS, ILO established, in 2009, a working group of experts on labour statistics. Several documents were prepared, including the proposal for a new resolution, which were discussed and improved in the working group and in regional and global meetings promoted by ILO. The effort aimed to reflect the different patterns of employment and other forms of work interactions inside countries and among them, to include well-structured labour markets and those with inferior degree of organization and to take into account urban and rural areas. The documentation produced was submitted for examination and adoption by the 19th Conference. The discussion during the Conference took place in a technical Committee, with the participation of Governments, represented generally by the national statistical offices and by the ministries responsible for labour policies, and representatives of workers and employers. Different international organizations joined the Conference as observers and their remarks were welcomed. The whole process took place under the competent and committed coordination and technical guidance of the ILO Department of Statistics.[3]

The RWELU, as adopted by 19th ICLS, includes international recommendations with broader scope that previously adopted standards. These new recommendations provide a wide and integrated approach of engagement in the various forms of work and more complete measure of the unmet need for employment among population. A consistent conceptual framework was built and three concepts stand out as essential to the understanding of the RWELU general guidelines: work, labour force and labour underutilization.

The concept of work is crucial to eliminate an important gap in the analyses of different categories of attachment in the production of goods and services and the influence of that link on quality of life. Work is defined as all activities performed by people of any sex or age, in order to produce goods or services for own use or for the consumption of others. The RWELU defines five forms of work: own-use production work, employment work, volunteer work, unpaid trainee work, other work activities. These definitions are consistent with the conceptual framework of the System of National Accounts 2008. The RWELU presents details of the first four forms of work mentioned.

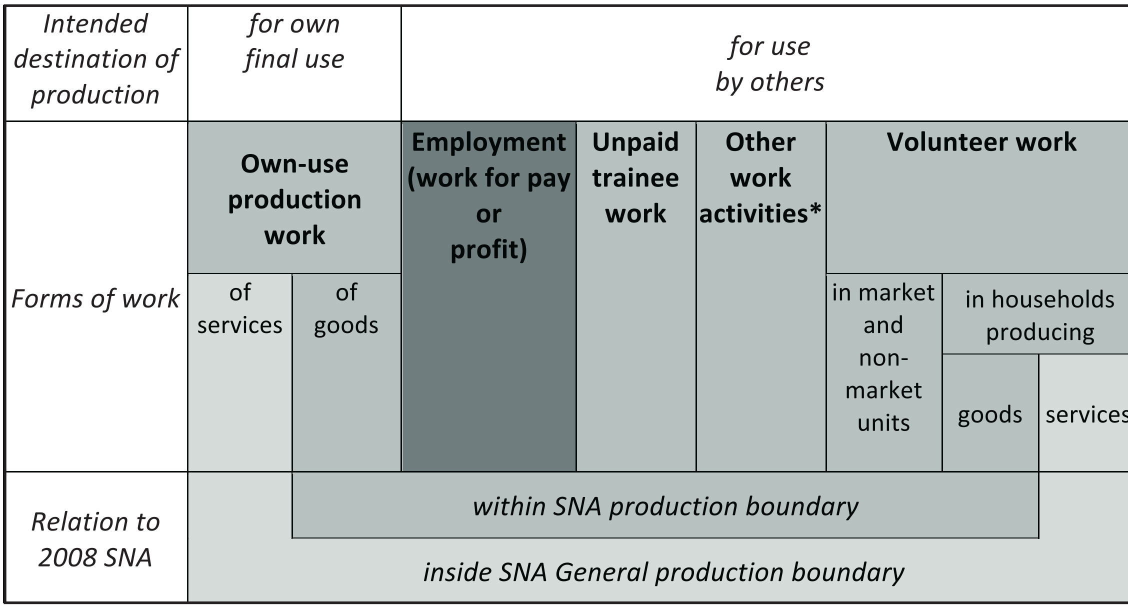
The concepts of labour force and of labour underutilization refer to employment, the form of work that is performed for others in exchange for pay or profit. This form of work is targeted by income-generating policies. The labour force comprises people engaged on employment and those in condition of unemployment (the RWELU does not change the traditional unemployment concept). The improvement of those policies requires more accurate measurement of the mismatches between employment supply and demand. The concept of labour underutilization refers to this need offering a broader approach than the usual focus only on the unemployment rate.

Details on the previously cited concepts and on some points of RWELU that are more directly related to the production of statistics on work in agricultural activities are described in Sections 2 and 3. Those aspects on agriculture work, along with others, are detailed in section 4. The last section covers challenges to the implementation of the new RWELU and conclusions.

2. Concept of work and some issues in agricultural activities

The concept of work is set consistently with the framework of the System of National Accounts 2008 (2008 SNA) and, as seen previously, it comprises all activities performed by people of any sex or age for the purpose of producing goods or services for own use or for the consumption of others. The five forms of employment and their association to the 2008 SNA production boundaries are presented in the diagram

Figure 1: Forms of work and the System of National Accounts 2008.



*Includes compulsory work performed without pay for others.

extracted from the version of the RWELU submitted for adoption by de 19th ICLS.

The RWELU focuses on measurement and detailed analysis of four forms of work which are distinguished by destiny of production or by the type of transaction in exchange for their achievement. These forms are defined as follow:

- Own-use production work – corresponds to the production of goods and services for own final use.
- Employment work– comprises work performed for others for pay or profit.
- Unpaid trainees work – comprises work performed for others without pay to acquire workplace, experience or skills.
- Volunteer work – corresponds to non-compulsory work performed for others without pay.

The clear delimitation of the concept and forms of work allows the analysis of the interactions among the various forms of work, in order to promote appropriate public policies on promotion of employment, intended to improve quality of life, to reduce poverty and inequality of opportunity according to gender and other characteristics.

Two forms of work are more frequently associated with agricultural activities: employment and own-use production work, in which food production mainly for subsistence deserves special attention. The analysis of the incidence and quality of insertion in these forms of work says a lot about the grade of organization of agricultural activities and on the quality of life around it.

The short reference period is a support definition for identifying the attachment of persons at work. The short reference period is defined for each form of work taking into account intensity and organization of working time. The periods defined for employment and own-use production work are:

- Own-use production of goods – four weeks or calendar month.
- Own-use provision of services – one or more 24 hours days within a seven-day or one-week period.
- Employment – seven days or a week.

A person is considered as a worker in a particular form of work if, during the short reference period, performed such form of work for at least one hour.

The RWELU emphasizes that the above periods provide more accurate information and that its use should be considered, including in circumstance that the aim is to cover a long period, for example, a full year. This is the case of Agricultural Census, which use to adopt one year or a seasonal production period as the

reference period of information. The REWLU proposes solution for this issue that will be discussed in section 4.

Own-use production work

Persons in own-use production work are defined as all those of working age[4] who, during a short reference period, performed any activity to produce goods or provide services (household chores) for own final use. The own-use production of goods, as mentioned previously, in terms of agricultural activities, can correspond to food production mainly for subsistence. This kind of production has implications on quality of life of workers and their families, as well as on their interaction with the labour market. This form of work is of high value to the debate on gender equality witch is relevant in the context of work in agriculture. It is true, specifically, in countries where the agriculture activities are intensively dependent of household production. In this case, analysis should be carried out taking into account sex and age of the workers and the measurement of time dedicated to household chores and to foodstuff production for subsistence.

Employment

Persons in employment are defined as all those of working age who, during a short reference period, were engaged in any activity to produce goods or provide services for pay or profit for at least one hour.

The concept includes persons who were temporarily absent from work. In this context, the classification of workers as employed in agricultural activities per season requires definition of specific criteria as can be observed in session 4.

The employment also includes persons who work for pay or profit payable to the household or family: in market units operated by a family member living in the same or in another household; or performing tasks or duties of an employee job held by a family member living in the same or in another household. This type of insertion in the employment also is present in agricultural activities and once more the gender approach is relevant.

3. The concepts of labour force and labour underutilization and topics on agricultural activities

The labour force is defined as the persons who are working in employment and those that are unemployed. The RWELU maintains the traditional definition of *unemployment, in which* people are considered in this condition when, from age determined, were not in employment during the short reference period, held job search activities in the period of four weeks or a month and were, in the short reference period of employment (or, in special cases, in small extension of it), available to engage a new job. So, persons can be classified as unemployed even if they are at an own-use production work (including food production for subsistence) or engaged in other forms of work. The effective job search activities are not always easy to identify or feasible in less formal labour markets or in rural areas and this is one of the aspects which puts under question the unemployment concept as the most important one in measuring discrepancies between employment supply and demand.

The concept of labour underutilization arises with the goal of providing the best possible estimate of the exceeding demand in face of existing supply of employment, complementing the unemployment rate. The REWLU identifies three mutually exclusive components of this concept. Two components are in the labour force:

- Persons in time related unemployment (persons who, during a short reference period, wanted to work in employment additional hours, whose working time in all jobs was less than a specific hours threshold, and who were available to work in employment additional hours given an opportunity for more work); and
- Persons in unemployment.

The third component, named as "potential labour force" corresponds to the sum of two groups of persons:

- Persons who are seeking employment and are not available to work; and
- Persons who are not seeking employment and are available to work, having presented some desire to work.

The extended labour force is defined as the following two groups:

- Persons who are in the labour force; and
- Persons who are in the potential labour force.

The RWELU, taking into consideration those components, proposes a basic set of indicators on labour underutilization in order to get a more complete picture of people needs or interest to improve his or her employment attachment or to get an employment.

Unemployment rate

- Numerator- Persons in unemployment x 100
- Denominator- Labour force

Combined rate of time-related underemployment and unemployment

- Numerator- (Persons in time-related underemployment + persons in unemployment) x 100
- Denominator- Labour force

Combined rate of unemployment and potential labour force

- Numerator- (Persons in unemployment + potential labour force) x 100
- Denominator – Extended labour force

Composite measure of labour underutilization

- Numerator- (Persons in time-related underemployment + persons in unemployment + potential labour force) x 100
- Denominator – Extended labour force

As mentioned before, there are countries or localities where the labour market is less structured (less favourable to the existence of means to the search for employment). In these cases, the indicator that can best express the mismatches between employment supply and demand is the combined rate of unemployment and potential labour force. This view can be extended to exceeding demand for employment in agricultural activities especially in rural areas.

The difficulties for the sudden change in national statistical practices are recognized and, in face of them, the RWELU indicates countries to release at least two of the above indicators during the transition period defined for implementing the recommendations.

4. Agricultural Statistics and the recommendations of the RWELU

The previous section pointed out a set of topics concerning agricultural statistics that stood out from the description of the general framework and of the fundamental reference concepts of the RWELU. The complete reading of the RWELU highlights a set of points on work agricultural statistics exposed in this section of the paper, which includes more details on the issues mentioned in the previous sections and explanations on other connected aspects.

Data collection periodicity and reference period of information

The RWELU suggests that information on employment, labour force, labour underutilization, including unemployment and data on food production for subsistence must be collected at intervals of time shorter than the annual, in order to ensure the monitoring of short-term behaviour and observation of seasonal variations. From the point of view of work statistics in agricultural activities, two types of needs linked with temporal approach arise.

The first one is the inherent seasonality observed in agricultural production, which requires continuous collection of labour statistics or at least, indicates that the data collection should cover high and low seasons. This topic is satisfied by the proposed continuous periodicity regarding data collection in REWLU.

The second temporal approach makes desirable the study of production, costs, investment and work in agriculture referred to a complete cycle of one year. Generally this is the method adopted, for example, in Agricultural Census. In this case the REWLU takes into consideration that the long period of observation requires care on choosing a recall method to make things easier for the respondents. As in situation of limited resources for data collection, it is suggested a one-time survey to produce current and annual estimates by applying, respectively, the short reference period and a retrospective question about work over longer observation period of interest.

Working-age population

Labour national statistical systems must cover the population in all age groups in consistency with the concept of work presented in section 1. Although, the definition of age limits for establishing the working-age population is a requisite to meet statistics to support different policy purposes, as is the case of the promotion of employment and the eradication of child labour, which makes the delimitation of the minimum age for working particularly significant. Moreover, in many countries the involvement of children and young people in work in agricultural activities is relevant.

The resolution concerning statistics on child labour adopted by the 18th ICLS also addresses this issue and, as well as the new RWELU, suggests to determine the minimum age for work, according to the countries legislation on child labour or the age for completing compulsory education. Consequently, children or teenagers at work are considered to be in child labour if they are below the defined minimum age.

Regarding the definition of the upper limit age for working-age population, it was not established in order to allow analysis of the engagement in work of aged people and the transition to retirement.

Own-use production work

Persons in own-use production work are defined as all those of working age who, during a short reference period, performed any activity to produce goods or provide services for own final use. It includes work in agricultural production of goods.[5] Producers in subsistence agriculture are important subgroup of those who produce for their own consumption and are defined as those that produce food from agricultural activities, fishing, hunting or hunting and gathering which contributes to the survival of the family, at home or out of it.

The detailed study of this form of work, particularly in the case of food production for subsistence, may have relevant impact on policies for the eradication of poverty, for promotion of income improvement, food security and gender equality and for child labour abolition.

Temporary absence of people in the employment

Persons in condition of temporary absence during the short reference period are those having worked in this employment did not for short-lived, but kept the link with the employment during this temporary absence.

The RWELU exposes that there are types of absences, such as maternal leave, which clearly involve maintaining the employment connection. On the other hand, there are others that require verification about maintaining the link with the employment, such as: licenses for study, care of other, and for other personal reasons, reduction of economic activity, disorganization or suspension of work due to bad weather, technical, mechanical or communication technology failures, among others. Link checking must involve the receipt of remuneration and or a duration limit for absence not exceeding three months. When the return to work is guaranteed, under national circumstances, this time may be longer.

This condition of temporary absence is of importance in the identification of the employment in agricultural activities when outside the season. The RWELU offers solution, considering as persons employed, those that in out-of-season period, perform specific tasks related to the employment, regardless of receiving remuneration. On the other hand, persons are considered outside the employment in out-of-season period if do not perform such tasks or are restricted to fill forms or compliance with administrative obligations such as payment of fees.

Interaction among the different forms of work

The framework proposed by the new RWELU allows analysis of the interactions among the different forms of work, once persons can engage simultaneously in more than one form of work, can also have more than one employment and work in more than one activity at own-use production work. This type of study can shed light on issues such as decent work or employment quality, policies on the welfare in society and equality of gender matters. In this context, it is useful, for instance, to produce analysis on persons in own-use production of services and goods work, subsistence agriculture work and persons in volunteer work according with situations, such as, persons inside or outside labour force or persons labour underutilization condition.

Other interaction of interest in agriculture work is that concerning employment, own-use production of goods and/or production of food-stuffs for subsistence. It reports on the degree of formalization, organization and presence of adequate conditions to the worker in the workplace under analysis.

As mentioned before, another point to consider in this context is the inherent challenge of agriculture work statistics on identifying if the production is mainly for own final use or mainly for market. It is not trivial, especially in investigations of more general scope, such as the Agricultural Census. The RWELU recommends auto declaration from the respondent and defines "for final use" as production where the intended destination of the output is mainly for final use by the producer in the form of capital formation, or final consumption by household members, or by family member living in other households. The resolution suggests, for operational purposes, as a test too verify the subsistence or market main nature of the activity, to confirm if the work is done without workers hired for pay or profit. Moreover, it is recommended to obtain the following information that, in addition to their intrinsic value, can be used as data control on the information of the destiny of the production: working time in own-use production with identification of activities, for example, rice production; estimate of the value of production and of the total consumed or retained for own consumption; estimate of total and/or any part of the value of production sold or exchanged; estimate of expenditure incurred for this production.

The search for employment as a requisite for unemployment and other measures of labour underutilization

It was mentioned that in localities or countries where the labour market is less structured (less contributing

to the existence of means for seek employment), one indicator that can better express in these cases the discrepancies between employment supply and demand is the combined rate of unemployment and the potential labour force. Also it was seen that this statement could be extended to the measures of the exceeding demand for obtaining employment in agricultural activities, specifically in rural areas. This section presents more details on this topic.

Persons in unemployment are defined as those of working age who are not working in employment, carried out effective actions of search for employment and are available for work. From the point of view of agricultural activities, it was seen that this concept may be difficulty to be applied in rural locations where the labour market is less organized, particularly with regard to the criterion of effective actions to search for employment proposed in the RWELU.

These effective actions to seek employment comprise the following examples and it is easy to notice that some of them are not predictable to be existent in localities in which the labour market does not present a solid organization, which also applies to some rural areas.

- Financial resources, authorizations, licenses;
- Lands, properties, machinery, materials, agricultural inputs;
- Support from friends, relatives or other type of intermediaries;
- Through records or contacts with public or private services of jobs;
- Through direct contact with employers, browse websites, gates of factories or farms, markets or other public squares;
- Through placing or answering newspaper ads or online ads;
- Through placement of professional profile along the professional or social online networks.

In face of those examples, it is perceived that there are situations in which it is pertinent the understanding that the prerequisite of effective search for characterizing the need of population for employment is an excessive requirement. There are concrete situations where labour markets do not offer some search modalities. This was another motivation for the requirement of a more wide-ranging concept, as it is the labour underutilization.

Irrespective of of the labour underutilization approach, the REWLU considers one special situation when persons not performing employment activities, not searching and having the guarantee to initiate a new employment in a period not exceeding three months are in unemployment. This situation can be observed in agricultural activities for which the seasons are relevant and well-known, which permits that agreements for job can be done in advance.

Finally, it is of interest for analysis the constraints for people not seeking employment or, taking into consideration others elements of labour underutilization, for not being currently available for employment. These restrictions can be caused by personal reasons, family issues, motivations related to the labour market (previous difficulty to find a decent job, lack of experience, qualifications or employments offered are not suitable to the skills, considered too young or too old) and the lack of infrastructure (properties and possessions, roads, transportation, inadequate employment services). Some of these motives are frequently associated with work in agricultural activities and in rural areas. So, the studies on labour underutilization should take in consideration those aspects.

5. Challenges for implementing the RWELU and final considerations

The RWELU includes important progresses for the broader understanding of the production of goods and services work. One of the essential improvements is the establishment of the concept of work and the provided elements for studying the interaction among the different forms of work. Thus, the concept of work and, consequently, the concept of persons at work become central, replacing in prominence the definition of economically active population, established in the resolution of 1982 replaced by the REWLU.

The clear delimitation of the employment, as the form of work associated with attainment of income by the worker or his family is another positive aspect of the RWELU. Since this concept is similar of the intuitive understanding assigned for employment by non-specialist users of work statistics, it makes the information easier to be apprehended and closer to be effectively used as an instrument of citizenship. On the other hand, this new definition of employment, from the point of view of historical series of data, requires some care for ensuring temporal comparability. It is required to split the old data because in it people in other forms of work (as defined in REWLU), such as the own-use production of goods, under certain conditions, were considered in the employment. This is not a difficult

operational solution, but this point is particularly sensitive to countries and locations where the amount of workers in own-use production of goods considered as employed, in the context of the former definition, were expressive. The fact that in the RWELU the two forms of work are distinguished is positive as provides clearer perception of the importance of both insertion of population in them. Also, it offers the possibility of measurement and monitoring own-use production work and its interaction with employment, which are useful on gender issues, child labour and quality of life. Similarly it has an impact on the measurement and analysis of agricultural work in countries or areas more household production dependent.

The other reference concept, the labour underutilization, in fact, improves the measurement of the mismatches between employment supply and demand. This approach also breaks a paradigm in the statistical analysis of work because it emphasizes that the exceeding demand on labour market for employment is more complex than that usually expressed, mainly, by the unemployment rate. Policy makers and users of information must adopt the new measures, with a view to make more effective and comprehensive the policies of employment and income promotion and to improve the evaluation of the impact of those policies and macroeconomic decisions on the labour market and the work world.

Finally, in addition of the need to ensure required resources for adapting the production of statistics in order to implement the new standards, national statistical offices and others producers of official statistics concerning work should promote actions for preparing users for the correct use and interpretation of data obtained in accordance with the new RWELU. The ILO, aware of the sensitivity of this implementation process and in accordance with the recommendations of the 19th ICLS on future work, is attentive to promote exchange of experiences observed around the world. Regarding work in agricultural activities, as was seen, the REWLU presents a set of issues. Similarly with this focus, required resources should be guaranteed and discussion with users and exchange of experiences are welcomed.

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Endnotes

1 The author belongs to the technical staff of the Brazilian Institute of Geography and Statistics and the content presented here is completely under her responsibility. The paper reflects her participation in the VI International Conference of Agriculture Statistics in Rio de Janeiro in October, 2013, when the new Resolution and its impacts on statistics concerning of work in agriculture were presented and discussed.

2 Concerning the concepts and definitions proposed in the new Resolution, the author adopted the procedure to made literal transcriptions of the approved version of the new recommendations.

3 In particular, I had the opportunity to participate in the ICLS for three times. I have attended: the group of experts and technical Commission, which drafted the resolution on consumer price indices adopted by the 17th Conference; the Group of experts and the technical Commission of the 18th ICLS, referring to the resolution considering statistics of child labor, approved by the Conference; finally, I've attended the early work of the group of experts and chaired the Technical Committee that discussed and submitted the new resolution to the plenary of the 19th Conference for adoption. It is remarkable the role of the ILO Statistical Department ensuring relevance, accuracy and the inclusive application of the resolutions adopted according to this procedure, which brings together technical expertise of the ILO staff, Governments, workers and employers representatives and adding contributions from international bodies. This 90 years old process for construction of recommendations on labor statistics should be assessed by statistical institutions in general, in order to take advantage of the positive points of this experience.

4 The lower limit of working age is proposed to be defined according to national legislation or practices on child labor and others criteria. There is no proposal for the upper limit. Section 4 takes up this issue.

5 Persons engaged in this production for the purposes of leisure and entertainments are not considered in work for own-use production. It is suggested that statistics on this group should be identified and reported separately.

APN 5
Measuring Contract Farming

Organizer: James MacDonald, USDA/ERS
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Contract farming is an important and growing phenomenon. The term refers to pre-harvest arrangements between farmers and buyers that specify quality attributes, outlets, and delivery windows for products and compensation formulas for farmers. Contract farming provides challenges for existing statistical systems. Commodity price data may not be observed if farmers are paid for the services that they provide rather than for products. Even when farmers are paid for products, meaningful price data must also convey information on product attributes. Contractor-provided inputs may not be tracked in statistical systems.

Papers should address the methodological challenges posed for statistical systems by contract farming. What statistics need to be collected on contract farming, and with what frequency? Does contract farming change the universe of entities that ought to be surveyed, and how should statisticians respond to that challenge? Do contract systems change the timing between production and payments, and do statistical systems need to take account of that change? How should samples be designed? Can data systems rely on random samples of contract producers, or must they also cover contractors? Does contract farming alter the methods by which we should collect production and price information? How should we measure the economic performance of contract farming systems, and what do we know about their relative performance?

Papers:

- Decio Zylbersztajn (Brazil), "Empirical Research in Contracts: watch your step"
- William D. McBride, James M. MacDonald (USA), "Assessing Production Contracts in U.S. Hog Production"
- Marcelo Miele (Brazil), "Contracts in Brazilian Pork and Poultry Meat Chains: implications for measuring agricultural statistics"
- André Bastos, Márcia Moraes (Brazil), "Vertical Integration and Sugarcane Production Costs in Brazilian Regions"

Empirical Research in Contracts: watch your step

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Abstract

The present study contrasts the evolution of the theory of economic organization and the structure of agricultural contracts data that is being collected. In a nutshell, if the goal of organization economists is to study how the real economic system works, then I raise the argument that the use of data collections of agricultural contracts, does not provide sufficient information and only captures part of the structure of incentives present in most of the institutional arrangements. The proposition is that if data based on existing contract collections is used not considering the transaction dimensions governed by other means than formal contracts or not considering dynamic relational and learning aspects embedded in the contractual relation, the results can lead to false conclusions.

Keywords: agricultural contracts; collecting agricultural information; informal transaction mechanisms.

1. Introduction

There are strong motivations for scholars to engage in empirical analysis of contracts. Coase (1991) in his speech at the Swedish Academy[1], stated that there is a large amount of information available about business contracts that are unknown to economists. New initiatives of research of contracts applied to agriculture and more generally to law and economic organization have been observed since then, as well as initiatives to collect contracts and organize databases to facilitate the research focused on the institutional structure of production[2] (Sikuta,2001 ; Vavra,2009). As a result of the insights of Coase, different research centers around the world initiated consistent collections of business contracts. Examples are found in US, European as well as in Latin American universities. The US agricultural census and the USDA initiatives focusing agricultural contracts also work in the direction of collecting information on contracts. Similar efforts are seen elsewhere.

The motivation for the present study is to contrast the evolution of the theory of economic organization and the structure of the data of contracts that is being collected. In a nutshell, if the goal of organization economists is to study how the real economic system works, then I raise the argument that the use of data collections of contracts, does not provide sufficient information and only captures part of the structure of incentives present in most of the institutional arrangements. The proposition is that if data based on existing contract collections is used not considering the transaction dimensions governed by other means than formal contracts or not considering dynamic relational and learning aspects embedded in the contractual relation, the results can lead to false conclusions.

The basic question discussed in this paper is if and how the data collections are actually handling the real information of the entire set of incentives embedded in the formal and informal mechanisms that conform the Coasian institutional structure of production. The discussion sheds light on the categories of dynamic contractual elements that affect the mechanisms of governance and should be controlled. The contribution of the paper is directed to the organizations dedicated to contracts data collection, aiming to highlight that the written contract represents only the legal exchange of property rights, which does not consider the exchange of economic rights. The argument "per se" is not new, but is largely ignored. The paper contributes by adding that the contract collections tend to miss dynamic elements that characterize the observed institutional arrangements, broadening the traditional discussion observed in the literature.

Two points are relevant in support for a revision on the existing expectations related to the performance of empirical studies based on contract data bases. First, if scholars access a contract data collection without being informed about the real conditions that were in place when the contract was actually designed, then relevant missing information might distort the analysis. Second, if one ignores the existence of a relational evolution of the entire contract relation, and/or if one disregards the dynamic elements that characterize the relational aspect of the transaction from the time when contract data is actually collected to the time

when the empirical studies are carried, then biased conclusions are expected to result.

The paper reveals the difficulties attached to the empirical study of contracts, adopting a descriptive theoretical analysis to support the main research argument. The paper also presents cases where large parts of the property rights transacted are typically of economic instead of legal nature.

The paper is organized as follows. In part two, I present the concept of contract raising the issue of formal and informal elements of a transaction. I focus on economics of organization and the contract approach to the study of organization and governance, reviewing some of the different empirical approaches in economics of contracts. In part three, the contribution focus mainly on the balance between formal and informal transaction elements and the discussion of dynamic aspects usually absent from contract databases, pointing to the expected empirical biases of research based on collection of contracts. Part four presents examples of informal norms and reputational mechanisms that are not captured in traditional contract data collections, and concludes, exploring possible ways to handle the collection of information.

2. Empirical Work in Contracts and Organizations: Taking Step

Contracts are defined as agreements that are enforceable by the legal system (Masten, 1998). This definition contrasts with the focus of the study of the institutional structure of production, as presented by Coase (1991) and expressed in the mechanisms of governance discussed by Williamson (1996) who aims to explain and predict the strategy of organizations as observed in the way they govern, design and perform value generating transactions. From Coase's and Williamson's perspectives, contracts are seen as one of the mechanisms to enhance human cooperation in production, allowing the protection of value and functioning as incentives for joint production efforts. Transactions and contracts are different theoretical constructs, the second meaning a sub-set of the mechanisms that are designed to govern the first. Contracts consider only the legally enforceable part of an agreement, while the transaction represents an exchange of property rights that far exceeds its legally protected dimensions.

The sharp distinction between the empirical applications based on agency theory (Holmström, 1979, 1982; Holmström and Milgrom, 1991, 1994) and transaction cost economics in its governance version (Williamson, 1996) is relevant for the purpose of the present study. The governance mechanism is seen as an answer of economic agents that consider possible future strategic decisions of the parties involved in the transaction, presentation being a relevant concept. Ex-post adjustments dominate in transaction cost theory while ex-ante decisions are the key elements in agency theory.

Masten (op.cit) presents a topology of different sub-fields of research in contracts, ranging from formal principal-agent models anchored in optimal allocation of incentives and risk, to the literature of law and economics anchored in the role of courts and the judicial system. The author discusses a wide range of elements in both the formalized theory of contracts (including the complete contracting based on full rationality), and the incomplete contracting framework (emphasizing bounded rationality as the most common explanation for contractual incompleteness). Masten also covers the relational contract theory which suggests the contract is a dynamic frame that bounds the realization of transactions.

Masten and Saussier (2002) present an overview of the literature on econometrics of contracts. The authors restrict the chapter to focus on transaction cost economics and agency approaches. Their contribution is relevant to set the field in terms of the dominant empirical approaches, but leaves ample room for other approaches, as resource based view and the vein of measurement cost, as treated by Barzel (1997). The typical studies pointed by the authors as examples are related to contract choice, contract duration, franchising and case studies on contracts, mainly related to the research of court cases[3].

The adoption of case studies, in particular, is a relevant venue for research in economics of organization. As stated by Alston (2008), cases are useful tools to better understand the impacts of institutional changes have on institutional arrangements. He also states that cases improve the ability to first understand an issue prior to modeling it[4].

Sykuta (2001, 2008) comments on the empirical research on contracting and organizations, and discusses the existence of consistent efforts applied to the organization of collections of contracts to feed the empirical efforts on economics of organization and governance. The author states that since

contracts are difficult to obtain, studies are often driven by fortuitous access to contract information of a particular sort.

In more general terms, empirical research in any field of knowledge is faced with the barrier of availability of useful data. In neoclassical economics, market prices and quantities are sufficient, but not always represent the real dimensions of the transactions. Many transaction margins are left out from markets, being allocated by other (non-market) means. In contract analysis, some dimensions are captured by the data, but not always in a consistent way with the theory. Coase (op. cit.) points to the need to enhance contract data collection and systematization. He concluded that the lack of data represents the main obstacle faced by researchers. In this regard, a conference held in 1990 at the University of Chicago[5] was a landmark that motivated efforts for more consistent efforts to organize the information about contracting[6].

Recognizing the relevance of the continuous efforts on contract data collection made by research centers up to the present date, my objective in the next session is to contribute by raising some limitations of the existing data for the purpose of carrying empirical research in institutional structure of production. My objective is to reveal the existing structural limitations in order to permit consistent use of the data.

3. Contracts and Norms

The relevance of non-contractual transaction dimensions, based on norms as well as dynamic elements of contracts has been discussed in the field of economics of contracts and organization. Meanwhile two aspects of the theory are not receiving the necessary attention by the authors and professionals dedicated to the effort of collecting data to feed the empirical efforts applied to contract analysis and to give support to public policies. The two aspects are (i) the contract and agreement dichotomy, and (ii) the relational dimension of the contract. This evidence paves the road for this section.

The literature on relational contract is the starting point to base my argument. As stated by Macneil (1978), transactions are rarely discrete, disconnected from the past and independent from its likely future impacts. Macneil is even more critical when he states that "... the existence of the market that the discrete transactional system presupposes eliminates the necessity for economic relations between firms."(Macneil, op.cit, p.861). The author considers that at the neoclassical branch of contract theory, the original contract is just a reference point and the truly relational approach devises the entire relation as being the relevant scenario. He adds that the written part of a contract function as constitutions establishing legislative and administrative process for the relation (p.894) and a great deal of change in contractual relations comes through dynamic adjustments (p.895). This point was later adopted by Williamson (op. cit) as one of the main pillars of the governance mode of transaction cost economics. He observes that contracts just put in motion a complex transaction structure.

Macneil´s approach is aligned with Klein´s analysis on self enforcement of implicit contracts (Klein, 2000). Klein (2000) states that contracts leave many elements of intended performance unspecified and unenforceable by courts; on the other hand, his view is that contract parties are expected to engage in the effort of making explicit terms not only because this might help courts to make future decisions in case of contract breaches, but also because transacting parties learn about each other while drafting contracts. Klein focuses his analysis on the private self-enforcing mechanisms that shape the transaction.

The relevance of informal norms to bound economic transactions is discussed by Dixit (2004). He points to the importance of the law and at the same time the problem of the imperfect mechanisms of legal institutions. Even if one considers the relevance of law, Dixit (2004) states that without informal groups and societies too much potential value would go unrealized. He adopts specific definitions for institutions and organizations, and point to the interactions and feedbacks between both. Based in Greif (2000), Dixit (2004) defines institutions as systems of social factors – such as rules, beliefs, and norms. He defines organizations as groups of individuals that operate within the general framework of institutions, and implement the rules and norms of the institutions. Organizations enable and constrain the actions of individuals.

Dixit bridges the concepts of macro and micro institutions and considers that norms can, in many cases, develop rapidly as society needs to implement adjustments. This point departs from the existing and dominant view, prevailing in

transaction cost economics, that institutions can be taken as exogenous, since they change slowly. His main concern is with micro issues of governance of transactions, specifically with property rights and contracts (p.8).

Informal norms are also discussed in Hart (op. cit.), being defined as non-legally enforceable agreements. He points that economic agents rely on formal norms enforced by courts to uphold the relationships, but recognizes that many economic activities are sustained by self-enforcing mechanisms. After considering that norms are difficult to handle empirically, Hart states that norms have not added a great deal to our understanding of such issues as the determinants of firm boundaries. Differently from Dixit and others, Hart considers that social norms can be taken as given, since they change in a very slow fashion. He concludes that trust, seen as an informal norm, does not change the conventional wisdom about the determinants of the boundaries of the firm.

I consider the above theoretical controversy to be relevant to the discussion of strategies of data collection on contracts. If informal rules are not relevant as proposed by Hart, then existing collections of contracts might be sufficient to carry balanced studies on organizations. I argue that the contrary holds, based on the three following arguments: Firstly, informal institutions should not be taken as given. As stated by Dixit (2004), informal institutions change even in short periods of time. Second, if we ignore norms, many institutional arrangements become unexplained by formal norms. This point has been examined by Ostrom (2010) in common pool natural resources exploration and Greif(2008) in the analysis of the role of reputation to enforce contracts among Maghribi traders. Third, Hart assumes macro institutions as exogenous, and his analysis focuses on inter-firm relations. Hart investigates neither the internal organization of firms, nor the macro-institutional norms.

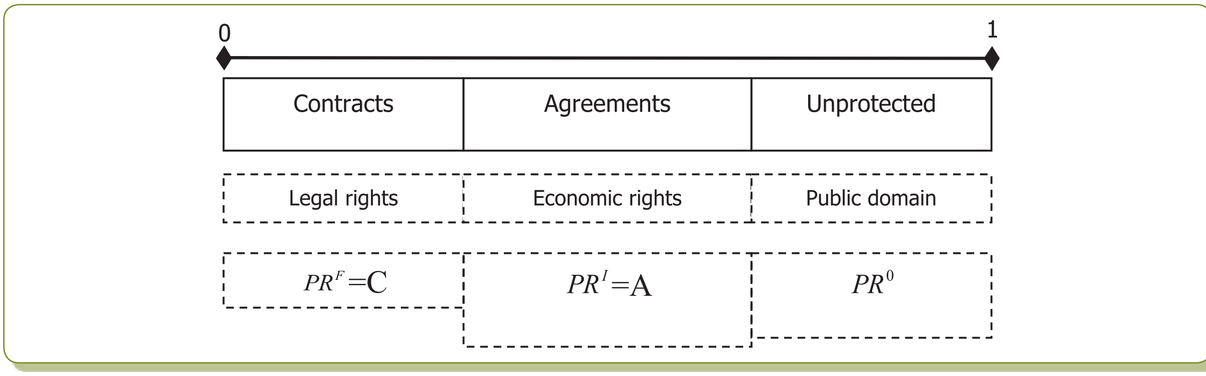
Transaction cost economics, on the other hand, is rooted in different elements that highlight the need to adopt careful approach to the use of contract data bases. I have already mentioned that Williamson´s view is based on the relational contract theory. Likewise the measurement branch of transaction cost economics as proposed by Barzel (1989, 2002) offers an argument. Barzel´s approach is based on property rights designed to handle both inter and intra firm organization, opening room to complement this analysis on data collection on contracts. Barzel observes that the institutional structure of production is affected by the way that agents succeed in measuring variability associated with inputs and outputs of any transaction.

The particular contribution of measurement cost theory proposed by Barzel (1989, 2002) represents a strong element in supporting the relevance of mechanisms other than contracts that frame the transaction relations. The measurement branch of Transaction Cost Economics suggests that a transaction can be decoupled in many attributes. Each attribute has a distinct characteristic in terms of measurement costs. Under this perspective, easy to measure attributes are exchanged based in contracts since courts are able to allocate property rights in case of contract breach. This part of the transaction represents the exchange of "legal rights" based in formal contracts. Difficult to measure attributes, on the other hand, are also potentially present at the transactions. In this case, however, the courts are expected not to perform efficiently, due to measurement costs and imperfect observability. As a result, transaction parties choose extra court mechanisms to protect difficult to measure attributes. Based on measurement cost approach, "economic rights" instead of legal rights are exchanged and a particular transaction dimension is not contracted but instead is exchanged supported mainly by reputation mechanisms[7].

An empirical point then emerges: because the perfect measurement of the attributes of an asset is always costly (Barzel, 1997), contracts explicitly describe some attributes of the transaction, implicitly delineate others, but do not consider all transacted dimensions. Even so, attributes whose measurement is too costly remain part of the transaction. As a result, contracts and long-term informal relationships coexist in an exchange process, and should be taken into account in any empirical investigation.

As expressed in Barzel (2006) contracts delineate some, but not all relevant attributes in a transaction. Attributes associated with product and factors of production are susceptible to variability raising the possibility that part of the transaction value fall in public domain, being subject to capture. Measurement costs of transaction dimensions might preclude the optimal allocation of factors, raising the risk of capture.

Figure 1: Property Rights Index Model.



Source: author

A Conceptual Model: Barzel (2006) states that contracts are simple while transactions are complex and characterized by many unpriced margins. Transactions usually have many agents and many margins each characterized by some degree of measurement difficulty. Figure 1 represents the value embedded in a given transaction. Assume that transactions generate value. The protection of value is approached by a property value index ranging between zero and one, meaning that if it equals zero no property right is protected, and if it equals one, transactors leave in a world of zero transaction costs. There are two relevant dimensions to be considered. Contracts govern value represented in figure 1, by area "C" and agreements by area "A".

First, as proposed in Barzel (1996) the measurement cost model suggests the existence of easy to measure attributes related to legal rights. These attributes are suitable to be contracted since agents and judges are able to measure transaction attributes, making decisions based on measureable and observable evidences. Difficult to measure attributes are not contracted and therefore agents are expected to develop alternative mechanisms of protection to protect value that are independent from courts. If both mechanisms fail to protect rights associated with the transaction, then some value remain in public domain, being subject to capture.

Second, the relation between C and A changes through time obeying different patterns. There are many variables that affect the allocation defined by C/A. Shifts in the C/A ratio may result from:

a) Development of relational aspects of the transaction lowering the costs of informal mechanisms to protect property rights. A decrease in C/A implies in more informal transactions.

b) Development of more efficient (i.e., lower cost) measurement mechanisms increases the C/A ratio, implying in more formal transactions.

c) Development of trust and other informal relational mechanisms lower C/A implying in more informal transactions.

d) Changes in the costs of functioning of courts and formal legal institutions. It might work in both directions, depending if courts improve or deteriorate the costs in face of the needs of the society.

e) Dynamic learning elements both among transaction parties and competence formation of judges are relevant to explain the limits between easy and difficult to measure attributes.

A possibility is that external impacts hit the transaction and are not matched by formal or informal mechanisms; in this case value in public domain is expected to increase. At the limit, the particular transaction might not be performed, since the value in public domain is too large. Examples of easy and difficult to measure attributes are presented in the next session and implications of the points raised are discussed in the final session.

4. Examples and Conclusions

Examples of difficult to measure attributes are abundant in agriculture. The literature developed by Elinor Ostrom, models common pool exploration, based in cases of governance mechanisms that are rooted in social rules. Governance mechanisms in agro-based networks are explored in Lazzarini, Chaddad and Cook (2001), pointing to the relevance of informal, social mechanisms. Studies of formal

agricultural marketing contracts point to the relevance of unwritten reputational mechanisms in addition to contract clauses (Leles, Zylbersztajn) revealing that contracts govern part, but not the entire set of attributes transacted.

The evidences raise the question of how to improve the efforts to collect agricultural contract data and at the same time to place this information in the difficult to measure social relation where it is embedded.

The contribution of Ronald Coase opened room for the evolution of the modern family of theories of the firm. His main motivation is to depart from the concept of production function, moving towards the real world of organizations. The increase in the empirical analysis of contracts is a result of the motivation generated by his insights. Organizing and handling contract information is the keystone for the study of economic organization. Examples of studies based on data collections of contracts are found in the literature, as can be observed as in the papers published by Joskow (1987) based on the existing collection of contracts of coal in the US. Another typology of studies is based on contract relations from original survey and interviews with actual contract parties, exploring reputational mechanisms in addition to static characteristics of transactions. This kind of study based on primary contract data is found in Zylbersztajn and Lazzarini (2005).

In order to perform empirical work on contracts as relates to the institutional structure of production, scholars must be aware that the contract represents only part of the bundle of property rights actually exchanged. Each case should consider the information on economic property rights, which are not usually presented and collected in the existing data collections on contracts. Also, in each case it is necessary to check how the relational aspects of the transaction has evolved, particularly when the analysis aims at matching the contract characteristics defined when the contract was drafted and the existing observed institutional arrangements.

The aim of the research in economics of contracts as relates to the institutional structure of production is to study contract choice and contract structure. Not only vertical integration but also transactions carried inside the firms are subject of analysis. The other motivation to gather contract information is based on the need to design public policies. For this purpose it is also necessary to consider the economic rights associated to the difficult to measure aspects of transactions.

In this paper I am interested in how the existing collection of data on contracts matches the theoretical construct in economics of organization.

The governance branch of transaction cost economics offered a rich vein for empirical analysis, since it is based on observable information of inter-firm transaction arrangements and transaction characteristics. For no other reason, the alignment hypothesis (Williamson, 1996) is successful in generating empirical studies – mainly for the make or buy decision. One should be aware, however, that relational contracts and the concept of presentation are also considered as being of fundamental relevance for the transaction cost economics theory. In this regard, the theory points to the relevance of norms and reputation mechanisms. The empirical work however is reductionist in the sense that collapses all relevant information in the categories of asset specificity, frequency and uncertainty. This is a good start, but restricted to the three aspects, remains distant from the real world of transactions governance mechanisms.

I do not consider that the treatment given to informal norms is being properly handled in the empirical literature. It does not seem a good empirical strategy to take as granted that informal institutions change too slowly so that institutions can be considered as given; one should also not ignore the short term dynamic transformations that the firm, seen as a micro-society, presents. My comment on that is that micro and micro norms are interconnected as expressed by Dixit (2004) and we need to apply our analytical effort to reveal the characteristics of the theoretical connections.

My main proposition is that all the dynamic aspects might evolve through time and therefore the originally drafted contract is likely to disconnect from the actual governance mechanism. If our aim is to study what goes on in the real world, then I suggest two ways to handle the problem. First the careful examination of the key institutional environment that bounds the players at the time the data on contracts is collected. This is a way to facilitate the future use of contract information in the presence of likely dynamic changes presented in this paper. More effort to identify the causes of change between easy and difficult to measure attributes is at the edge of measurement cost theory.

Costs to organize, maintain and use contract data basis are affected by the points discussed in this paper. First the difficult to measure transaction elements represent a structural bias at the time

to collect the contract data. What is written is what potentially enforceable by courts, therefore measurable. The existence of difficult to measure dimensions in a contract might be associated with invisible enforcement mechanisms that, once ignored, might lead to incorrect analytical results. Contract collections focus on classical contract law while the real world is characterized by relational contracts.

Agency theory makes explicit the basic analytical elements, being suited for an ex-ante analysis of risk and incentives allocation. Judiciary cases are relevant to allow the study of ex-post property rights enforcement, but face the problem of dealing with difficult to measure transaction attributes, unknown to courts.

The empirical efforts in economics of organization should consider that the goal of studies of the institutional structure of production is to capture determinants of contract choice and contract structure. Our goal is also to incorporate the existing dynamic elements in the theory designed to explain the existing micro-institutional arrangements and its evolution. In order to understand micro-institutions it seems relevant to keep the efforts to unbundle some important concepts. One is the empirical treatment given to relational contract elements. Second is the treatment given to difficult to measure transaction dimensions. Third is to move on in the direction of adopting a dynamic view introducing the contract institutional perspective, recognizing that institutions change through time. Fourth is to embrace the effort to better connect micro and macro institutions. Work effectively each of these challenges is not a simple task, but the advancement of the empirical analysis depends on overcoming these limitations. The way is open for new developments.

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Endnotes

1 http://www.nobelprize.org/nobel_prizes/economics/laureates/1991/coase-lecture.html.

2 Institutional structure of production is the title of the Nobel Prize Lecture given by Professor Coase in 1991. The concept is well explained in the document available at the site of Swedish Academy.

3 I am aware that any attempt to cover the existing empirical literature on contracting is likely to be incomplete, due to the large number of publications based on different approaches. New dimensions of econometric analysis of contracts are emerging. One example is the econometric analysis of judiciary data bases to study contract breaches and second order effects of courts decisions. Existing information on courts databases are useful for empirical analysis of contract breaches as seen in Leles and Zylbersztajn (2007).

4 I would add that case studies might be one solution to up-date the dynamic aspects of the contract relation allowing for a better use of contract data collections.

5 Contracts and the activities of firms: a conference sponsored by the John M. Olin Foundation and the Lynde and Harry Bradley Foundation. University of Chicago Law School, June 1990.

6 The pioneer effort on contract collection was made by the Center for the Study of Contracts and the Structure of Enterprise at the University of Pittsburgh, followed by the Contracting and Organization Research Institute at the University of Columbia-Missouri.

7 Based on Barzel's argument, Monteiro et al (2012) claim that any empirical investigation in the agribusiness sector should be based on three fundamental levels: (i) the basic structure of the market, (ii) the formal contractual arrangements that govern relations within the production system, and (iii) the transaction dimensions governed by non-contractual means. The authors present specific evidence on the bias that is generated when one does not take account of non-contractual dimensions.

Assessing Production Contracts in U.S. Hog Production

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Abstract

Agricultural contracting has become increasingly common in the United States, creating challenges for survey design and data collection. In the U.S. hog industry, growth in the use of production contracts, in which the contractor exercises control over most production decisions and farmers are paid a fee for services rendered, has been particularly rapid. Hog operations with production contracts accounted for only 3 percent of U.S. hog operations and 5 percent of hog production in 1992, but grew to 51 percent of operations and 71 percent of production in 2009.

Production contracts govern one type of transaction in the industry—that with growers who raise hogs for the contractor, also known as an integrator. Some integrators are meatpackers that also own and operate slaughter and processing facilities, and transfer market hogs directly to those facilities from contract farms. Other integrators operate only in hog production, and use marketing contracts to govern transactions with meatpackers. Integrators often own and operate specialized farrowing facilities, but some buy weaned pigs in cash markets, and some obtain them through further contract arrangements. In short, production contracts form one link in a complex web of arrangements in the industry.

This paper indicates how data on agricultural contracts are collected in USDA's Agricultural Resource Management Survey (ARMS). Data collection issues highlight the proper definition of different contractual arrangements, the appropriate target respondents for different types of contract questions, and the benefits and costs of obtaining these data from farmers as opposed to contractors. The paper further discusses approaches to summarizing, reporting, and analysing these data, using the example of hog production contracts. Finally, we summarize ERS research on the impact of production contracts on the productivity of U.S. hog farms, indicate what this means for the structure of U.S. hog production, and discuss the implications for U.S. pork producers and consumers, and the environment.

Keywords: production contracts; hog production; Agricultural Resource Management Survey.

1. USDA Surveys and the Identification of Contracts

The U.S. Department of Agriculture's (USDA) Economic Research Service (ERS) and National Agricultural Statistics Service (NASS) collect data about agricultural contracts in the annual Agricultural Resource Management Survey (ARMS). Over time, USDA has developed precise guidance for enumerators and respondents to use in providing responses to contract questions in the ARMS. Such guidance is necessary because different respondents have different conceptions of what constitutes a contract, as well as what constitutes a marketing contract and a production contract. The guidance is used to develop the text of questionnaires (that is, questions, placement, and parenthetical instructions), to train enumerators, and to provide enumerators and respondents with supporting information for filling out questionnaires.

USDA refers to an "agricultural contract" for purposes of the ARMS as an arrangement for the production and disposal of a commodity. Contracts for the acquisition of inputs are dealt with occasionally, but the proper identification of commodity contracts is of primary importance for the measurement of revenues and costs in ARMS. Contracts are defined as an agreement, reached prior to harvest or prior to the completion of a livestock production stage, which specifies a commodity, an outlet for delivery of the commodity, and a compensation arrangement. Contracts can be oral, as long as there is an implied commitment and it is understood that there will be penalties for breaching the agreement. Timing is important to this definition—agreements reached after crops are harvested or animals are raised are not contracts, but are classed as cash sales. The specified timing rule allows for clean delineation of a range of transactions.

USDA then distinguishes marketing from production contracts. Marketing contracts set a price or a pricing formula, as well as a marketing outlet, for a commodity. This guidance is specified in the questionnaire, while background documents

tell enumerators that the farmer retains ownership of the commodity during production; that marketing contracts often tie price incentive to product attributes; and that the contracts may or may not specify precise quantities to be delivered. The background documents also provide examples of marketing contracts.

ARMS questionnaires define production contracts as setting terms, conditions, and fees to be paid by the contractor to the operation [the farmer] for the production of crops, livestock, or poultry. The questionnaire also states that contractors own the commodity during production, and often provide production inputs. Supporting documents provide examples of production contracts, and alert enumerators that they are widely used in poultry and hog production, and in the raising of dairy heifers.

Individual farms may have production and marketing contracts, and they may act as contractees and as contractors. For example, a dairy farm may market its milk through marketing contracts, and may also raise dairy heifers for other farms under production contracts. In each case, the dairy farm would be a contractee. A hog farm may produce pigs in farrowing facilities onsite, act as a contractor in production contracts with growers who raise the pigs to market weights, and may then sell the hogs to slaughter plants as the contractee under a marketing contract. ERS and NASS focus on issues of timing, contract definition, and contractor/contractee status in training materials developed for enumerators and staff.

2. Agricultural Production Contracts and Agricultural Statistics

Contracts covered 40 percent of the value of U.S. agricultural production in 2011, according to data gathered in the ARMS (MacDonald and Korb, 2011). Marketing contracts covered 60 percent of the value of agricultural production under contract, and were used to market many crop and livestock commodities, while production contracts, widely used in livestock production, covered 16 percent of all U.S. agricultural production in 2011.

Production contracts specify services to be provided by a farmer for a contractor, also known as an integrator, who owns the commodity while it is being produced. Contracts cover: 1) specific services to be provided, 2) the manner in which the farmer is to be compensated for the services, and 3) specific contractor responsibilities for provision of inputs. Production contracts are especially prevalent in hog and poultry production, where integrators provide animals, feed, and veterinary services to growers who raise the animals under contract. Such contracts are also common in raising dairy heifers and in fed cattle production.

Production contracts present challenges for estimates and analyses of agricultural production because key information is dispersed among different groups. As a result, surveys must be carefully designed with close attention paid to the knowledge base of respondents, and statistical agencies may have to combine information from multiple sources to provide accurate estimates.

Contract growers can speak authoritatively about on-farm practices (for feeding, sanitation, and manure management, for example), and technologies (such as equipment and housing design). They can provide accurate information on quantities of production and of inputs used. However, they usually do not know the expenses associated with feed, chicks, feeder pigs, and veterinary supplies, since those are provided by integrators. Since integrators also dispose of the animals, either through sale to a meatpacker or transfer to the integrator's own processing facilities, growers possess only limited information on the value of those animals.

Integrators can provide detailed production and revenue data, and they can provide detailed expense information for the expenses that they bear. However, they cannot provide accurate information for the expenses associated with inputs that they do not provide, such as the labor and capital used, and they cannot provide farm-level information on grower practices and technologies unless directly specified in the production contract.

Packers can provide information on flows of animals to processing plants, and on their disposition in those plants. They can also provide transactions data on prices paid for animals, with details for different animal attributes and times of sale. But they can provide no information on farm production expenses and on-farm technologies, practices, and farm financial performance.

3. Production Contracts in U.S. Hog Production

Hog production contracts govern the relationship between growers (hog producers) and hog owners ("integrators," or "contractors"), specifying the inputs provided by each party (feeder pigs, feed, labor, capital, energy, transport, and veterinary services and supplies) and the compensation due to each.

Contractors typically retain ownership of the hogs on contract operations and provide the feed fed to the hogs. Growers typically provide the production facilities and labor and are compensated based on a fee-for-service arrangement, often including incentives for feed efficiency, death loss, and/or other performance measures.

Such arrangements allow individual contractors to grow into substantial operations because the significant capital costs of hog production facilities are paid by contract growers. In 2009 and 2010 the 3 largest contractors owned about a quarter of the national sow herd (Successful Farming, 2010). Many of the largest contractors are also pork packers that are vertically integrated, obtaining hogs under production contracts directly with growers. Contract growers obtain economies of size by specializing in a single phase of production, and benefit from reduced risk exposure to changes in hog and feed prices. However, growers do face the risk of contractors failing or refusing to place pigs on their operations if there is a downturn in production.

Marketing contracts typically govern the relationship between hog owners and hog packers. Marketing contracts specify expected hog quantities and qualities, the location and timing of delivery, and compensation, expressed, as a hog price or a price formula. The same hog produced under a production contract between a contractor and grower can be sold to a packer under a marketing contract between the contractor and a packer.

4. Hog Production Contracts and the ARMS

USDA collects data from all three groups linked to production contracts—integrators, contract growers, and processors—via multiple channels. The ARMS, is the Department's primary source of farm financial data, and a primary contributor to the agricultural component of the national economic accounts. The survey is also valued because it links farm and farm household financial outcomes to production decisions, resource use, and production practices. In this section, we describe how the ARMS, as applied to hog production contracts, is managed to reach its goals under the constraints imposed by dispersed information.

The ARMS is used to track farm-level use of technologies and management practices, and in the case of hogs to provide information on manure management practices in the industry. The survey is also used to fulfill demands for farm and farm household financial information. Each of those features can only be met by surveying the hog contract growers themselves.

The ARMS is also used to meet a Congressional mandate for ERS to produce estimates of the costs of production (COP) for major field crop and livestock commodities. Hog contract growers can provide some, but not all of the necessary information—in fact, no single group has all of the information needed. Finally, the ARMS is used to support ERS estimates of aggregate net farm income for the sector; again, contract growers can provide some but not all of the information.

Hog producers appear in the survey in each year, but USDA designs a survey version that is specific to hog producers, and has administered it in 1998, 2004, and 2009 (with an earlier 1992 version appearing as part of a predecessor survey). The specific version, with detailed questions focused on the hog enterprise, supports COP baseline estimation and analyses of on-farm practices and technologies.

The hog version focuses on commercial producers, and therefore aims to avoid surveying operations that raise hogs as a hobby, for home consumption, or for show. To that end, the target population is farms with 25 or more hogs on the operation at any time during the year. Thus, the sample includes contract growers, farmer-integrators who had hogs on their operated acreage, and non-contract operations that had hogs on their operated acreage.

Farms are selected from a list frame of operations, developed with information from other USDA surveys and administrative data, producer association membership lists, and other sources. Earlier in the year, operations selected for inclusion are approached to determine if they are still in business and still producing hogs. To improve the efficiency of survey administration and estimates derived from the survey, farms are selected for the sample with a probability that varies with farm size, location, and production specialty.

NASS uses trained local enumerators to approach producers and elicit their cooperation in responding to the survey. Enumerators receive specific training in contracts in order to ensure that questions are well understood and consistently interpreted. Enumerators are supervised by NASS staff in State and regional field offices. Field office staff are expected to approach and develop relationships with integrators in each State.

Large-scale integrators usually operate processing facilities and feed mills, but may not operate farms, and may therefore not be in the ARMS universe for

sampling purposes. Nonetheless, they are important to agriculture, and are important sources of information as well as users of estimates. NASS field staff obtain estimates of average integrator expenses, by State, stage of production, and type of animal, and apply those average expense estimates to the responses for growers, who are unlikely to provide estimates of integrator expenses in the survey. ERS obtains state-level estimates of average prices for animals from other surveys, and applies it to the value of animals removed from contract grower operations. In this way, ERS is able to develop COP and farm sector income estimates from ARMS and supplemental sources.

5. Hog Survey Findings

Each surveyed farm in the ARMS represents a number of similar farms in the population as indicated by the surveyed farm's weight. The survey weight is determined from the farm's selection probability and thereby expands the sample to represent the target population. The expanded samples in each of the four hog specific surveys represented more than 90 percent of the hog and pig inventory on U.S. farms in each survey year (USDA, NASS, 2010, 2006, 1995-99). However, the hog samples expanded to cover only about a third of the farm operations that had any hogs or pigs due to the 25-head threshold. Thus, the share of farms with fewer than 100 head is significantly lower in ARMS than in NASS statistics. But, while these small hog operations represent about 70 percent of U.S. hog farms, they include less than 1 percent of the hog inventory.

Estimates from the four hog surveys (1992, 1998, 2004, and 2009) are comparable because of the consistent way in which they were conducted and processed. Each survey had broad national coverage, represented the same target population (operations with 25 head or more), involved a complex sampling scheme designed to represent the target population, was conducted the same way (hand enumerated) by the same organization (NASS), and collected much the same information in a similar format. Specialized hog finishing operations (feeder-to-finish) are the focus of this study because they repesented about three-fourths of finished hog production in 2004 and 2009 (table 1), and very few non-specialized hog finishing operations (farrow-to-finish) produced hogs under contract.

Hog operations with production contracts accounted for only 3 percent of overall U.S. hog operations and 5 percent of U.S. hog production (sales and removals) in 1992, but grew to 48 percent of operations and 71 percent of production by 2009. Nearly three-fourths of feeder-to-finish operations and 79 percent of production on feeder-to-finish farms were under production contracts in 2009 (table 1).

The average size of hog finishing operations increased fastest from 1992 to 2004 for those producing under contract. Contract feeder-to-finish operations averaged 1,000 more head produced in 1992 than did non-contract operations. By 2004, the difference had reached 4,500 head. Between 2004 and 2009, the increasing size of contract operations slowed, while the average size of non-contract hog finishing operations more than doubled.

Table 1: Structural characteristics U.S. feeder-to-finish hog producers, 1992 to 2009.

Producer/Item	1992	1998	2004	2009
Operations (percent of operations)	19	31	40	47
Finished hogs sold/removed (percent of hogs)	22	55	77	73
Finished hog sales/removals (head per farm)	804	2,756	4,730	7,222
Production contract operations:				
Percent of operations	11	34	50	74
Percent of production (head sold/removed)	22	62	73	79
Head removed under contract per farm	1,696	5,154	6,988	7,850
Non-contract operations:				
Percent of operations	89	66	50	26
Percent of production (head sold/removed)	88	38	27	21
Head sold per farm	696	1,452	2,486	5,440

Source: McBride and Key, 2013.

High feed prices during 2008-2009 created an incentive for small higher-cost hog finishing operations to exit the hog industry by 2009, and may be an important reason for the shift to much larger non-contract feeder-to-finish operations. Many small non-contract hog finishing operations also produce corn and soybeans and at crop prices during 2008-09 they may have decided to sell crops directly as opposed to feeding hogs. Contract hog finishing operations were less affected by higher feed prices possibly because of their larger size and lower production costs, and because large integrators are better able to handle input price risk.

In 2009, the average farm value of production on contract feeder-to-finish operations was nearly $300,000 greater than on non-contract operations. Contract operations produced about $400,000 worth of hogs more than what was sold from non-contract operations. However, average net farm income on non-contract operations was about $60,000 per farm higher than on contract operations. Much of farm income on contract operations was earned from fees paid by contractors, comprising a small percentage of the total value of hogs produced. Despite having smaller operations, non-contract producers earned the total value of hogs sold plus earned more income from crops produced and sold.

6. Hog Contracts and Farm Productivity

Production contracts offer several potential advantages over independent production that help explain their growing use: contracts can reduce information asymmetries between growers and processors, improve coordination and timing of product delivery, and lower income risk for growers. Production contracts also may raise farm productivity by improving the quality of farm management decisions, speeding the transfer of technical information to growers, improving growers' access to credit, and facilitating the adoption of more efficient technologies.

ERS research has shown a link between the use of production contracts and hog farm productivity. Using the 1998 ARMS survey of feeder-to-finish hog farms, Key and McBride (2003) compared the productivity of similar independent operations and contract operations, controlling for unobservable differences that might be associated with the decision to contract. The authors found that production contracts were associated with an average increase in total factor productivity of about 23 percent. In a second study using the 2004 ARMS data, Key and McBride (2008) used an instrumental variables technique to isolate the effect of contracts on productivity. As in the earlier study, the authors found that contract operations were substantially more productive than similar independent operations. A 10-percent increase in the prevalence of contracting would increase average total factor productivity by 5 percent. Estimates of this magnitude suggest that these productivity advantages contributed to the growth of production contracting in the hog industry during the 1992-2009 period.

7. Scale of Operation and Farm Productivity

Increases in scale of hog operations contributed significantly to productivity gains between 1992 and 2009 as farms grew in size to take advantage of increasing returns to scale. Estimates of returns to scale provide insight into farmers' incentives to further expand farm size and integrators' incentives to expand the size of contract grower operations.

The top half of table 2 shows the change over time in the share of hog production from feeder- to-finish farms in various farm-size categories. This period is characterized by a shift in production towards the largest operations. Farms producing at least 5,000 head represented less than 10 percent of total production in 1992. By 1998, these operations accounted for nearly 65 percent of total production, and their share rose to about 80 percent by 2004 and to over 90 percent by 2009.

The bottom half of table 2 reports the estimated scale elasticity for farms in various size categories and the mean scale elasticity for all farms in each survey year. The scale elasticity indicates the improvement in productivity from an increase in the scale of production. Scale elasticities decline as farm size increases—large farms obtain smaller gains from increasing scale than do small farms. In every year the mean scale elasticity was greater than one, implying increasing returns to scale in all periods and incentives for farms to become larger. However, as farm size increased between 1992 and 2009, the share of farms in the larger size categories increased, which caused the mean scale elasticity to decline over time from 1.15 to 1.04. The mean scale elasticity of 1.04 in 2009 indicates that a 10-percent increase in hog production inputs used results in a 10.4 percent increase in hog production for the "typical" farm.

Table 2: Share of production and scale elasticity estimates by farm size for U.S. feeder-to-finish hog producers, 1992 to 2009.

Size category[1] (hog sales/contract removals)	1992	1998	2004	2009
	Share of total production (percentage)			
Less than 500 head	14.7	1.9	0.5	0.1
500-1,249 head	35.0	6.7	3.0	1.0
1,250-4,999 head	41.0	26.5	16.7	8.0
5,000-12,499 head	9.3	29.2	36.3	46.1
12,500 head or more	id	35.7	43.4	44.8
	Scale elasticity[2]			
Less than 500 head	1.20	1.23	1.21	1.26
500-1,249 head	1.12	1.14	1.14	1.13
1,250-4,999 head	1.06	1.08	1.07	1.07
5,000-12,499 head	1.05	1.04	1.03	1.01
12,500 head or more	id	0.97	0.96	0.97
All farms (mean)	1.15	1.13	1.09	1.04

[1]Size categories shown in the source were presented as a measure of hundredweight gain. This was converted to the approximate number of head using an average of two hundredweight gain per head.

[2]See Key and McBride, 2007, for the methods used to compute the scale elasticities.

id=insufficient data for legal disclosure.

Source: McBride and Key, 2013.

In 2009, farms producing less than 5,000 head could still improve productivity substantially by increasing their scale of production. However, beyond about 5,000 head the productivity gains from expanding farm size appear limited. Farms producing between 5,000 and 12,500 head had an average scale elasticity of 1.01 in 2009. The technology used by farms in the largest size category exhibited slightly negative returns to scale. About 91 percent of hog production from feeder-to- finish operations in 2009 originated on farms producing at least 5,000 head. Hence, there appears to be little scope for additional productivity gains from increases in scale for feeder-to-finish operations using current technologies, including production contracts.

8. Conclusions

The U.S. hog industry underwent a dramatic restructuring during the 1990's and 2000's toward larger operations that were more specialized and more tightly linked together through contracts. The shift affected the industry's performance, but also created new challenges for USDA surveys. This paper describes how USDA designs a survey and supporting data-gathering efforts to develop the information needed for industry monitoring and policy-making. Data collected in USDA's Agricultural Resource Management Surveys of U.S. hog producers are used to illustrate the issues assciated with data collection, summary, and analysis in an industry that has seen rapid growth in the use of production contracts.

The share of U.S. market hogs produced under contract from feeder-to-finish operations increased steadily from 1992 to 2009. At the same time, the size of these operations increased dramatically to take advantage of scale economies. However, scale economies available to U.S. market hog producers were estimated to be mostly exhausted by 2009. Consequently, there appears to be limited scope for further productivity gains in U.S. market hog production from using production contracts on increasingly larger operations, with current technologies.

ARMS data are collected from operations (i.e., sites) that had hogs and not from the hog owners that include large multi-state, multi-packer integrators. Most of the market hogs produced on the feeder-to-finish operations were produced under contract for large integrators. The limited scope for productivity gains from larger hog operations found in this study pertain to the grower operations and not to the integrators. Findings suggest that integrators are more likely to expand hog production by expanding the number of

operations (i.e., sites) producing hogs, rather than expanding the scale of current or new hog operations.

Productivity gains from contracting and the increasing size of hog operations have likely benefited U.S. consumers in terms of lower pork prices and enhanced the competitive position of U.S. producers in international markets. Evidence of this is seen in relatively flat pork retail prices and expanding pork exports during 1992-2009 (McBride and Key, 2013). The environmental impact of these structural changes are less clear. Environmental risks posed by concentrating hogs on larger operations with limited land for manure application, such as those from excess nutrient runoff or manure storage leakage, are increased. These may be offset to some extent by less nutrients excreted due to improved producitivty resulting from improvements in feed efficiency. Also, concentrating manure sources in fewer locations potentially affects fewer people and may also make some manure treatment technologies feasible (e.g., energy from bio-waste, or processing into concentrated fertilizer).

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Contracts in Brazilian Pork and Poultry Meat Chains: implications for measuring agricultural statistics

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Abstract

The predominant supplying strategies of the main Brazilian pork and poultry meat companies and cooperatives rely on coordination through contracts. According to the last Brazilian agricultural census, there were 61.5 thousands contracted poultry and swine producers in 2006. This organization model is named by practitioners as integration, in which the producer is tied to a slaughterhouse or a processing industry which, in most cases, also coordinates the feed production and other upstream activities. Contracts importance is increasing in all Brazilian regions and poultry and swine production systems. The goal of this study was to characterize contracts in Brazilian pork and poultry meat chains in order to highlight its implications for measuring agricultural statistics. The results can carry to a better comprehension of this world consolidated trend, and also can help statistical organizations to better focus surveys and census.

Keywords: animal production; contracts; costs; prices; statistics.

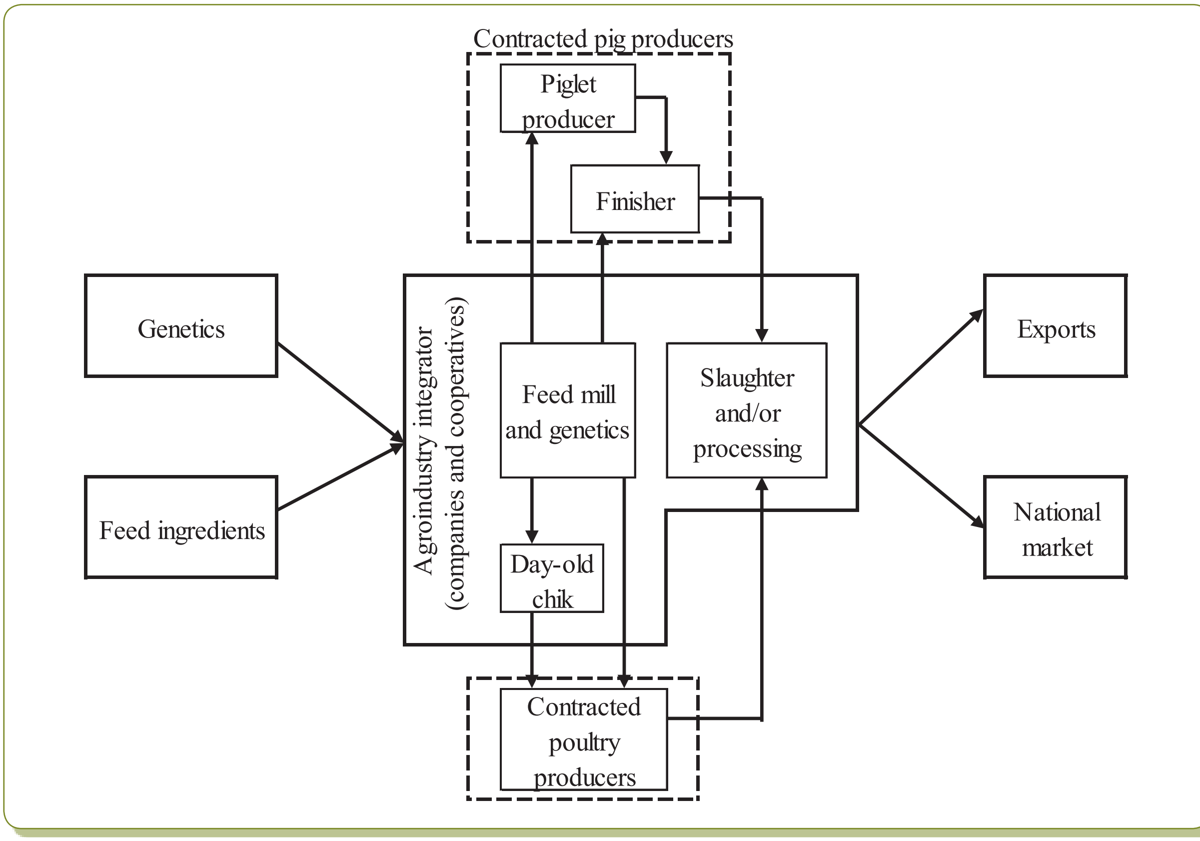
1. Introduction

The predominant supplying strategies of the main Brazilian pork and poultry meat companies and cooperatives rely on coordination through contracts. More than 39.9 thousands poultry producers and 21.6 thousands swine producers were contracted in 2006 (IBGE, 2006). Despite the economic success of these agribusiness chains, emphasized by Brazilian leading position on global markets, the contracting system is being questioned by its critics and analysed by governments, legislators and researchers. The central question is its capacity to continuously improve efficiency and competitiveness and, at the same time, provide conditions to producer's sustainability. Underlying criticisms there is a lack of information disclosure on contracts spread among different Brazilian regions and poultry and swine production systems and, above all, on its impacts on farms income, profitability and long term economic sustainability. The goal of this study was to contribute to statistics improvements in order to consider deep organizational changes occurred in Brazilian pork and poultry meat chains, which are continuously more contracted, and subject to conflicts regarding added value distribution and rural development. To attain this objective, it is presented contract main characteristics and their impact on costs, prices and risk exposure and related criticisms. The paper finishes with proposals to improve agricultural statistics and institutional bases in Brazil.

2. Brazilian pork and poultry supply chains leading organization and contracts characteristics

Brazilian pork and poultry supply chains have experienced a huge development during last two decades, with increasing production and exports. Nowadays, the country produces 11.5 million tons of poultry meat and 3.5 million tons of pork meat per year (IBGE, 2012), and represents 39% of poultry meat world exports, ranked in first position, and 9% of pork meat world exports, ranked in forth position (USDA, 2012). This has been attained thanks to increasing sanitary controls, massive technology adoption, grain supply at international competitive prices and last, but not least, due to its organization model focused on the supply chain coordination, where contracts have been playing a central role. This organization model (Figure 1) is named by practitioners as integration, in which the producer is tied trough a contract to a slaughterhouse or a processing industry which, in most cases, also coordinates the feed production and other upstream activities. In Brazil, leading companies diversify its activities both with pork and poultry meat (ALTMANN, 1997; IPARDES, 2000a, 2000b; GUEDES, 2001; NOGUEIRA, 2003; CARLETTI FILHO, 2005; MIELE & WAQUIL, 2007).

Figure 1: Typical integrated pork and poultry supply chain.



In geographical terms, these activities are concentrated in the South region, which represented 60% and 65% of slaughters of poultry and pigs, respectively, in 2010 (IBGE, 2012), and 74% and 76% of exports, respectively (MDIC, 2012). This region embraces most of contracted producers, most of them small farms with familiar labour (Table 1). In general, swine production is less integrated than poultry, where almost all producers are contracted. Swine finishers are also almost contracted, and among piglet producers contracting is the predominant supply coordination form (MIELE & WAQUIL, 2007). The expansion that is taking place by leading companies from the South toward Southeast and above all Central West region is changing predominant supply chain organization in this region toward contracts.

Table 1: Participation (%) of contracted producers and small producers with familiar labour on total swine and poultry producers, by region, in 2006.

Region	Poultry*		Swine**	
	Contracted	Small producers with familiar labour	Contracted	Small producers with familiar labour
South	91	83	72	80
Southeast	72	47	11	35
Central West	84	51	18	38
Others	52	45	3	55
Brazil	**85**	**72**	**58**	**72**

Source: Developed by the author from IBGE (2006).

* Includes poultry, laying hens and other bird producers with more than 5.000 heads.

** Includes producers with more than 100 pig heads.

Agricultural contracts in Brazilian swine and poultry production can be classified based on liabilities, tasks and property rights division between producers and integrators (Table 2). In a typical production contract, the integrator company or cooperative supplies feed, genetics, veterinary inputs, logistics and technical support, while producers provide investments on housing and equipment, their maintenance, labour, water, energy (electricity, firewood and gas), litter and manure handling. Moreover, integrators use to settle technical specifications and to determine new housing patterns and equipment investments, with a high level of interference on farm decisions.

Property rights are quite different between production contracts and marketing contracts. While in production contracts (named "partnership" by supply chain practitioners) the integrator owns feed and animals which are transported until farm where the producer will ultimately provide a growing or breeding service, in marketing contracts producers are owners of all inputs and outputs, even when the contract specifies its origins or destination. Regarding this, marketing contracts are quite similar to risk exposure and working capital demands faced by independent producers trading on spot market, except by the fact that the last are free to auction with different suppliers and customers, without interference on farm decisions. Independent producer's income depends on scale, productivity and efficiency, live or carcass weight and, above all, on spot market prices. In the other hand, production contracts determine remuneration rules based on efficiency criteria (based on feed conversion ratio, mortality and relative performance) and conformity to best available techniques. Most integrators often use ranking systems, what represents a competitive and selective process between contracted producers.

Table 2: Production and marketing contracts and spot market characteristics.

Dimension	Production contract	Marketing contract	Spot market
Market access	Assured	Assured	Not assured
Production control	Slaughterhouse	Slaughterhouse	Producer
Producer inputs ownership	Labour, electricity, firewood, poultry litter, buildings and manure handling.	Feed, genetics, medicines, labour, electricity, firewood, poultry litter, buildings and manure handling	Feed, genetics, medicines, transport, labour, electricity, firewood, poultry litter, buildings, manure handling and veterinarian support
Producer output ownership	Growing and breeding service and manure nutrients	Piglets, finished swine and birds and manure nutrients	Piglets, finished swine and birds and manure nutrients
Remuneration formula	Base price x Efficiency ratio (based on feed conversion ratio, mortality and relative performance)	Base price + Bonus (based on a weight target and a check-list of best practices)	Spot market price + Bonus (based on carcass yield)

Source: Authors based on IPARDES (2000a, 2000b); Guedes (2001); Talamini et al. (2005) and Miele & Waquil (2007).

3. Challenges posed for statistical systems by contracts

Challenges posed for statistical systems by contracts derive from their impact on agricultural costs, prices and on farm risk exposure. It becames more and more an important issue not only because the wide spread of this organizational change trough Brazilian pork and poultry supply chains. In fact, the increasing lack of public information held private by integrators, and continuos conflicts for a more equitative division of the aded value along these supply chains, require inovation on public policies, what reinforces the need for improved information and statistics.

3.1. Impact of contracts on costs, prices and risk exposure and related criticisms

Contracts and spot market differences (Table 2) determine that farms operating with production contracts have total costs (operational costs + capital cost) that correspond to 12% to 28% of a farmer's cost trading through marketing contracts or in the spot market, depending production system analyzed. When comparison is made with the income, this share drops to 9% to 19% (Table 3).

Table 3: Production, gross income, operational and total costs and gross margin of different types of contracts and production systems, Santa Catarina state, Brazil, in 2010.

Type of contract and production system	Poultry finisher on sport market	Poultry finisher with production contract	Farrow to finish pig producer on sport market	Pig finisher with production contract	Piglet producer with marketing contract	Piglet producer with production contract
Production scale	16,000 heads/flock	16,000 heads/flock	50 sows	750 heads/flock	500 sows	500 sows
Full time workers (n.)	1	1	1	1	5	5
Production (ton/year)	253	253	138	258	276	276
Investment (US$ th.)	101	101	111	112	567	567
Annual results (US$ 1,000/year)						
Gross income	205	22	165	18	604	111
Operational cost*	191	16	149	8	484	63
Gross margin	14	6	16	10	119	43
Working capital cost**	6	0.5	4	0.3	15	2
Capital cost**	9	9	10	10	52	52
Per live kg results (US$/live kg)						
Price	0.813	0.085	1.199	0.070	2.187	0.403
Operational cost*	0.750	0.061	1.082	0.033	1.755	0.221
Gross margin	0.063	0.024	0.117	0.037	0.432	0.176
Working capital cost**	0.023	0.002	0.032	0.001	0.053	0.007
Capital cost**	0.036	0.036	0.073	0.040	0.187	0.187
Per worker results (US$ 1,000/worker/year)						
Investment	101	101	111	112	113	113
Gross income	205	22	165	18	121	22
Operational cost*	191	16	149	8	97	13
Gross margin	14	6	16	10	24	10
Working capital cost**	6	0.5	4	0.3	3	0.4
Capital cost**	9	9	10	10	10	10

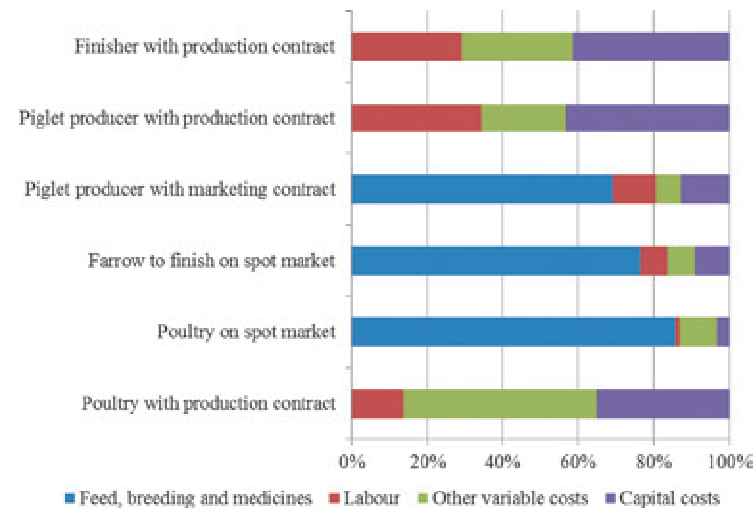
Source: Estimated by the author from Miele et al. (2010a; 2010b; 2011); Santos Filho et al. (2011).

* Includes family labour opportunity cost.

** Considers a capital opportunity cost of 6% per year.

There are also cost composition and risk exposure differences. While feed is the main cost of independent pig and poultry producers which operate on spot market (68% to 70%) and of piglet producers with marketing contracts (59%), among farmers with production contracts prevails capital, labour and energy costs (Figure 2). It is important to highlight that production contracts represent an increasing capital's share over total costs and income, and also higher asset specificity, represented by the impossibility to the farmer to change customer without high setup and transaction costs. By the other way, producers under production contracts have less working capital demands (Table 3).

Figure 2: Cost composition of different types of contracts and production systems, Santa Catarina state, Brazil, 2010.



Source: Estimated by the author from Miele et al. (2010a; 2010b; 2011); Santos Filho et al. (2011).

Spot market is more speculative, without marketing guarantees and linked to international meat and grains markets behavior. This kind of producer is a risk taker and its gross margins are highly volatiles. The example of Table 3 shows a profitable year for independent producers (2010), but this situation has been alternated with negative gross margins and equity losses, leading to a sharp decrease on spot market herd. By the other hand, production contracts guarantee market access and reduce income variability, transferring price risk to integrator. However, net margins used to be very tights and several producers are not being able to reach productivity patterns that allow them to be top ranked on integrator's payment schemes, receiving price that doesn't remunerate all their productive factors. Contracts also enable technical support and technology and finance access, but farm decision process is highly limited by integrator's choices, and several contractual hold-ups and market power abuses are often related by producer's representative organizations (MIELE & MIRANDA, 2013). Criticisms relative to agricultural contracts in Brazil mainly derive from the asymmetric relationship between producers and integrators associated to an increasing lack of public information on prices, contractual terms and number of contracted producers coming in and going out integrations.

3.2. Proposals for improved statistics on agricultural contracts in Brazil

There are several statistics that could be collected on contract farming. The two most important are the spread of contracts through geographical regions, through both pig or poultry systems, and also the different types of contracts. It is therefore useful to map differences on liabilities, tasks and property rights division between producers and integrators (Table 2) to determine at least three main kinds of transaction governance existing on agricultural activities, namely: spot market, marketing contracts and production contracts. Regarding property rights assignments, it is important to address special attention to remuneration formulas. Mapping these differences may be the best way to determine whether a producer is contracted or not, and through which kind of contract. This is highly recommended because several different terminologies are being used on regional and also corporate level to identify a same kind of contract, which can puzzle researchers and statistics (MIELE & WAQUIL, 2007).

The main impact of this categorization is to allow separated statistics on prices and cost differences shown in Table 3, that demonstrate that while producers on spot market and with marketing contracts sell products (piglets and finished pigs and birds), producers under production contracts provide growing and breeding services, with

totally different cost structure, price level and risk exposure. Beyond prices and costs, this statistics segregation can also allow a better understanding of technical efficiency differences among these organizational forms.

Moreover, transactions continuity and contractual hold-up occurrences are important issues related by practitioners. Thus, statistics should monitor unilateral contract interruption before producer's life time investment has been reached, and also input quality problems and logistics delays (genetics and feed deliveries and finished pig and poultry shipments). Beyond integrators hold-ups, it is also important to enlighten contract interruptions due to producers' inefficiencies and opportunistic behaviour. In order to better understand contract relationships and economics, it would also be useful to collect statistics on the contractual transaction characteristics like exclusivity on input origin and output destination, technical specifications, the faculty to change suppliers and customers and also number of transactions with the same customer, and number of different customers with which a producer traded in a determined period.

To deal with this broad universe of information and also operationalize proxies it is necessary to address different statistical and data systems and define priorities. This paper suggests that Brazilian authorities should first develop legislation and technology information to implement contractors mandatory reporting on three different kinds of data and information, namely:

- Cadaster of contracted producers by type of contract and production system. Although agricultural contracts should not be classified as a labour relationship, the Brazilian Labour Ministry experience with the Employment and Unemployment General Cadaster (CAGED) and the Annual List on Social Information (RAIS) should be taken as examples.
- Contract library to catalog the types of contracts and their clauses, as actually done by the United States Department of Agriculture (USDA).
- Periodically paid price reporting by type of contract and production system, as actually stated by the US Livestock Mandatory Reporting Act of 1999.

To explore more detailed relationships between type of contracts, production systems, main farm characteristics and performance, it is necessary to improve the Agricultural Census conducted by the Brazilian Institute of Geography and Statistics (IBGE) and, moreover, support this institution with supply chains knowledge and also with financial means to develop the innovative proposal of a National System of Farms Sample Survey (SNPA), which projects an specific module on contracts. Finally, there are several national and regional statistical and agricultural economics agencies and institutes, both private and public, which collect prices on a daily or weekly base, which should format its statistics to address prices differences between contracted and spot market production.

4. Final considerations

The main underlying theme of this article is competition promotion and defense through information disclosure. It is important to highlight that there are in course on Brazilian national Congress two bills which focus on agricultural contract regulation. Despite its valuable proposals, their discussion has taken long time without practical effects and, moreover, has occurred mostly between legislators, producers and slaughterhouses representative institutions, government officials responsible for agriculture and rural development and also some researchers. However, statistical and agricultural economic institutions have not taken part in this process as needed. Their role is quite important to monitor and better understand contracts evolution and impacts on agricultural competitiveness and rural development.

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Vertical Integration and Sugarcane Production Costs in Brazilian Regions

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Abstract

Few studies in the Brazilian literature take into account the regional characteristics of the presence of backward vertical integration by the Brazilian sugarcane mills and distilleries. This article presents and analyzes data on the acquisition of sugarcane by industrial units in recent seasons, adopting a regional division of production. Regional vertical integration indexes are calculated and the incentives for the adoption of this strategy are analyzed based on the observation of sugarcane prices and production costs in each region. The results confirm that significant regional differences in the rates of vertical integration exist. Estimates cited on the literature that approximately 65% of sugarcane output in Brazil currently comes from vertically integrated governance structures are supported. In traditional sugarcane regions of the Center-south region, among which stands out the state of São Paulo, the largest producer, the vertical integration index is the lowest in the country and the independent suppliers represent a high share of the processed sugarcane. The recent introduction of the 'Sistema Consecana' in determining the price of sugarcane enforced contractual guarantees so that suppliers could remain in this activity. In the Center-west region and in the state of Minas Gerais, where the cultivation of sugarcane expanded quickly in recent years, the vertical integration index is higher, indicating a preference for vertical strategies to obtain inputs by the younger processing units, a strategy adopted mainly due to the uncertainty of the existence of a reliable network of suppliers. In the states of the Northeast region, vertical integration is also high and this has been stable over the last seasons. With respect to the behavior of vertical integration indexes in relation to production costs and the price paid for sugarcane in each region, it was found that in the traditional Center-south region the price of this input stands below the cost of total agricultural production (including the land rents and the depreciation of equipment), which has strengthened the demand for the production from independent suppliers. In the expansion areas in the Center-south region, the market price of sugarcane has been higher than the cost of production, which helps to explain the higher levels of vertical integration observed in this region mills and distilleries.

Keywords: sugarcane; vertical integration; Brazil; Consecana.

1. Introduction

This article presents and analyzes data on the acquisition of sugarcane by industrial units in the last Brazilian crops, using a regional division of the Brazilian production. The presence of vertically integrated structures in the acquisition of sugarcane is calculated in each region and the changes in the vertical integration index are analyzed by the observation of the gap between the price of sugarcane in each region and the cost of agricultural production.

The first objective of this article is to provide regional data on how the sugarcane is obtained by the industry in the main producing areas in recent years. This analysis is performed by observing the origin of sugarcane informed by a sample of mills and distilleries. The second objective is to analyze if the price-cost margins are related to recent changes in the regional index of vertical integration.

Regional indexes of vertical integration are calculated for and their changes are analyzed within the Perry (1978) monopsony model that relates the difference in the price of obtaining an input market and cost of domestic production as the main determinant of the choice of the level of integration by the industry.

2. Regulatory environment

The production of sugarcane for industrial processing in Brazil does not have relevant technical differences due to cultivation be done by the industry itself or by

independent farmers. In general, what determinates the type of governance structure is the right of ownership or use of the area in question. As reported by several authors, including Neves, Waack and Marino (1998) and Pedroso Junior (2008), transactions in Brazil can also be characterized by the definition of which agent performs the harvesting and transportation of sugarcane to the mill.

It is common in Brazil the leasing of farms for the cultivation of sugarcane. As will be discussed ahead, the transportation of sugarcane from the harvest site to the mill or distillery represents a significant portion of production costs and, therefore, the mills prefer the areas near to the industrial unit. The asset structure of a typical plant in Brazil does not usually include the ownership of all the land where the processed sugarcane is grown.

The definition of the agent responsible for the harvest and the average distance between the fields and the plant has a direct relationship to the costs incurred in this stage of production. However, mechanization of harvesting operations is not always accessible to farmers that supply sugarcane to a local mill, due to the declivity of the land where they grow or the reduced scale of production, which hinders the ability to purchase equipment. With the recent increase in the participation of foreign investors in the production of sugar and ethanol in Brazil, it should be noted that Brazilian law provides restrictions for the acquisition of agricultural land by Brazilian companies controlled by foreigners. This limitation of land acquisition by foreign investors sets up an entry barrier, reinforcing concern with ensuring supply of sugarcane to mills located in areas of agricultural expansion. This may contribute to higher vertical integration in younger industrial units.

3. Data and methodology

Data on the price of sugarcane in each region of Brazil, the production cost of one hectare and the origin of sugarcane processed by a sample of Brazilian sugar mills and distilleries are used in the study. Recent studies are available with estimates of the cost of production of sugarcane collected separately in regional associations of suppliers and mills and distilleries cultivating sugarcane for internal processing in various regions.

Data on the price of the tonne of sugarcane and the production cost in each year were obtained in more documents published by the "Cost of production of sugarcane, sugar and ethanol in Brazil" project"[1]. In this study, the data of these final reports published in four consecutive years between 2008/2009 and 2011/2012 were collected. The Brazilian production of sugarcane is segmented into three regions (Traditional Center-South, Expansion Center-South and Northeast) [2].

The second source of data used consists of the annual editions of the *Anuário da Cana* (Yearbook of Sugarcane)[3], the only regular publication that provides information on the level of sugar mills and distilleries and presents the amount of sugarcane crushed (in tonnes) in each season (separated into internal production and sugarcane from suppliers). To form the sample, data were collected from all plants and distilleries that responded to the questionnaire section on the origin of sugarcane processed each season[4].

To be able to evaluate the optimal amounts of input in the acquisition of market and production itself, a cost function which represents the total expenditure of the company at every level of vertical integration is defined (a quantity of the input X_{ijt} is produced by the company j in the crop year t and an amount X_{ejt} is acquired from suppliers). Thus, we define the total amount of input (sugarcane) obtained by the firm in the harvest.

$$X_{\mathrm{jt}} = X_{\mathrm{ijt}} + X_{\mathrm{ejt}} > 0$$
$$X_{\mathrm{ijt}} \geq 0$$
$$X_{\mathrm{ejt}} \geq 0$$

The level of vertical integration of each company is then calculated as the ratio between the share of internally produced and the total amount of inputs used. Similarly, the subscript j refers to each of the n plants that comprise the sample of a region and the subscript t refers to the crop year.

$$\lambda_{\mathrm{jt}} = \frac{X_{\mathrm{ijt}}}{X_{\mathrm{jt}}}$$

Aggregating all j industrial units belonging to a given region, the regional level of vertical integration is calculated:

$$\lambda_{\mathrm{kt}} = \frac{\sum_{j=1}^{n} X_{\mathrm{ijt}}}{\sum_{j=1}^{n} X_{\mathrm{jt}}}$$

The results are presented in two groups of industrial units selected from the available data: the first group, called "Population", covers all the mills and distilleries who answered the questionnaire on the origin of sugarcane on each season. Therefore, the number of units in each year varies, since units

started or stopped answering the questionnaire. The second group, called "Sample A", considers only the mills and distilleries who answered the questionnaire on the origin of sugar cane processed in all crops analyzed here (thus, the number of units is fixed and considers the same units in all crops).

The second analysis in this chapter has as main reference the method proposed by Perry (1978), who relates the level of backward vertical integration of a monopsonist of an essential input as a function of cost minimization which encourages the company to acquire and internalize the factors of production input or buy them on the market. The current situation in most regions producing sugarcane in Brazil is not exactly a monopsony. The crushing of several mills or distilleries is partially met by independent suppliers cane and also by areas owned or leased by the industry. The main incentive for upstream vertical integration by a monopsony company is the possibility of producing the input incurring lower costs than the price to get it on the market. The model is, therefore, a comparison of the cost minimization to obtain the company's inputs in a situation in which it is possible to integrate vertically behind the production or purchase from suppliers.

It is understood that the case of monopsony in agricultural production of sugarcane corresponds to reality only part of the cultivated area, depending on the number of mills and distilleries present in a region and the situation of oligopsony (where a given supplier of sugarcane has a limited number of potential buyers) is the most common. However, the model is among those available, best suited for an empirical analysis of vertical integration, as there is a methodological approach to reality and the data sources available on the sector supply cane sugar in Brazil are presented compatible.

A variable cost function for the production of inputs is defined, using a single factor of production, with limited availability, which justifies the positive slope of the supply curve of the input. The variable cost of production function of input is defined and has the properties of constant returns to scale. Having defined above λ_{jt} as the share of production in vertical integration and the variable cost function, the existence of incentives for the monopsony to increase or decrease the amount of inputs produced in an integrated manner is analyzed. The total expenditure on integrated production and the purchase of inputs from suppliers is:

$$CT_{jt}\left(X_{jt}, \lambda_{jt}\right) = C_{ijt}\left(X_{jt}, \lambda_{jt}\right) + C_{ejt}\left(X_{jt}, 1-\lambda_{jt}\right) > 0$$

The choice of the level of vertical integration by the monopsonist is made to minimize the total expenditure on the purchase of inputs. Thus, we define the problem of cost minimization:

$$\min CT_{jt}\left(X_{jt}, \lambda_{jt}\right)$$

$$\text{s.t. } 0 \leq \lambda_{jt} \leq 1$$

This methodology will be used to evaluate if the share of the total input that is produced by the industrial units in various Brazilian regions (vertical integration index) behaves according to the behavior of the production costs and the price of sugarcane in each region.

4. Results

In this section are presented the results of regional indexes of vertical integration, calculated from data of the crushing of mills and distilleries selected in the last four crop years[5]. The Table 1 below describes the number of industrial units considered in each region and in each year, the total of input processed and the percentage of sugarcane obtained by vertically integrated structures.

In the 2011/2012 season, a share of 64.1% of sugar cane processed by mills and distilleries Brazilian originated in vertical structures (the complementary part suppliers accounted for 35.9%), based on sugar mills and distilleries whose data access was possible. The rate of vertical integration proved higher in the Expansion Center-south region, where it reached 70.4%. In the Traditional Center-south region, the rate was much lower, reaching 58.7% in the same season. In the Northeast, the results indicated a share of 67.9% of sugarcane being self-supplied by the mills and distilleries.

The change in the index of vertical integration in the last four seasons is explained by observing the results of the group "Sample A", since the group "population" is subject to selection bias caused by the fact that individuals in each year are not the same. Comparing the regions and the country as a whole, there was an overall increase in the indices of vertical integration in all regions during the period between 2008/2009 and 2011/2012 and a lower degree of variation only in the Northeast. The index of vertical integration in Brazil increased approximately four percentage points in the period.

Traditional Center-south region concentrates all production of the state of São Paulo, the largest producer of sugarcane in Brazil. The presence of more structured supplier associations, the introduction

Table 1: Vertical integration index on Brazilian regions in 2009-2012 crops.

Region	Year	Population			Sample A		
		n	Crushing (ton)	λ_{kt}	n	Crushing (ton)	λ_{kt}
Brazil							
	2008/09	114	177.145.865	61,7%	69	115.172.260	63,0%
	2009/10	211	324.661.611	64,6%	69	116.697.320	64,0%
	2010/11	237	377.410.621	65,4%	69	119.039.996	64,4%
	2011/12	272	417.608.244	64,1%	69	106.876.885	67,4%
Traditional Center-south							
	2008/09	65	119.704.810	61,4%	34	73.095.351	61,2%
	2009/10	104	201.851.973	63,2%	34	75.099.760	61,6%
	2010/11	103	214.823.197	60,6%	34	77.593.010	62,3%
	2011/12	128	241.663.423	58,8%	34	64.804.863	64,9%
Expansion Center-south							
	2008/09	28	36.902.246	59,3%	17	23.960.747	64,7%
	2009/10	67	88.336.029	66,4%	17	25.333.883	65,5%
	2010/11	87	121.011.380	73,3%	17	24.336.811	68,3%
	2011/12	92	125.448.239	72,9%	17	23.673.378	72,3%
Northeast							
	2008/09	21	20.538.809	68,1%	18	18.116.162	68,1%
	2009/10	40	34.473.609	67,8%	18	16.263.677	72,6%
	2010/11	47	41.576.044	67,5%	18	17.110.175	68,3%
	2011/12	52	50.496.581	67,9%	18	18.398.643	69,7%

Source: Prepared by the authors based on Anuário da Cana (2009-2012).

of the Consecana System and the existence of a history of relationship between industry and farmers explains the consolidated presence of suppliers in this region. As for the index variation, we observed an increase of three to five percentage points, according to the result of regional results shown in the Table 1.

The index of vertical integration in the Mid-South Expansion Center-south is higher than the national average. Institutional factors explain much of this difference from the traditional regions. The competition for land with other agricultural crops and the fact that most of the sugarcane in expansion areas did not exist at the 1940's (time of the Statute of Sugarcane Crop[6], when a mandatory share of suppliers in crushing was determined by Federal Government) determined a higher level of vertical integration. For the same reasons, the associations of cane suppliers in these regions are less representative and do not have much capacity to bargain for joint negotiations against the mills owners. As for the index variation, there was a significant increase, indicating the smaller representation of the activity of sugarcane supply in the regions of sugarcane expansion.

In the 2011/2012 season, the Northeast region had vertical integration index close to 70%. There was no clear trend of reduction or increase in rates of "Sample A", unlike what was observed in other regions. Increase in the area planted with sugarcane varied little during the study period, which is why we observe almost none variation in the amount of crushing and in the indexes of vertical integration. The results indicate that the activity of sugarcane supply in the Northeast region is consolidated and stable since no significant structural changes were observed.

Analyzing the relationship between vertical integration and incentives posed by the prices and cost of production of cane sugar, Table 2 presents data on the average regional price of sugarcane and the nominal production cost[7] of one hectare between seasons 2009/2010 and 2011/2012 in each of the sub-regions, as collected in PECEGE (2010-2012). The three seasons elapsed between 2009/2010 and

2011/2012 were marked by a significant increase in production costs of sugar cane in Brazil. According to PECEGE (2012), the price of sugarcane has been just enough to pay the operational costs of the crop in a crop in most sugarcane regions of Brazil. Simultaneously, this period was marked by a worsening financial crisis among industry groups, which significantly reduced their investments in the agricultural stage. This reduction in investment in the cane fields, coupled with unfavorable weather conditions in the south-central region, led to a significant reduction in agricultural productivity from the 2010/2011 season.

When considering the total production cost, including expenses with remuneration of the factors and depreciation, the production of sugarcane has not been economically viable as long-term activity. As can be seen in the Table 3, the Expansion Center-south region was the only one to register a positive economic margin, with the price paid for sugarcane produced in one hectare exceeding the total production costs.

It was also found that the economic margins are improving overall. Although the data sources consulted did not provide information for all years, it is possible to compare the results of the costs of obtaining sugarcane and confirm that the current levels of levels of vertical integration and its variation are supported by recent theory Perry (1978).

In the Traditional Center-south region, more intense participation of suppliers in total sugarcane processed shown consistent with actual data, which indicate production costs higher than the price that has been paid by the sugarcane. Despite the apparent dilemma between the situation of production costs and increasing the participation of suppliers, it is important to note that the cost of production indicates reported expenses related to the cultivation of an average hectare with the completion of all maintenance activities of sugarcane, fact that often does not occur in practice, especially in the period in which the sugarcane industry faces financial difficulties. The mills and distilleries in the Traditional Center-south region (particularly the state of São Paulo) currently work with a higher level of confidence in the existing network of suppliers.

The high levels of vertical integration in the Expansion Center-south region were also in line with the evolution of the margins of economic activity, because sugarcane has been sold for a higher value of total production costs. Particularly in areas of expansion, we cannot leave aside the analysis the fact that the industrial units have happened without the presence of regulatory instruments similar to the Statute of Sugarcane Crop and the supply assurance concerns emerges as an important determinant of choice of vertically integrated structures, regardless of profitability of supply. Uncertainty regarding the marketing, the characteristics of oligopsony and high

Table 2: Sugarcane price and total production cost per hectare in Brazilian regions.

Region	2009/2010		2010/2011		2011/2012	
	Price	Production Cost.	Price	Production Cost.	Price	Production Cost.
	R$/ha	R$/ha	R$/ha	R$/ha	R$/ha	R$/ha
Traditional Center-south	3.517	5.018	4.379	5.305	4.958	5.793
Expansion Center-south	3.817	3.961	4.681	4.311	6.019	4.409
Northeast	3.124	3.817	3.773	4.209	...	...

Source: Prepared by the authors based on PECEGE (2010-2012).

Table 3: Price-cost margins of sugarcane production in Brazilian regions.

Region	2009/2010	2010/2011	2011/2012
Traditional Center-south	-29,91%	-17,46%	-14,41%
Expansion Center-south	-3,63%	8,58%	36,51%
Northeast	-18,15%	-10,36%	n/a

Source: Prepared by the authors based on PECEGE (2010-2012).

level of specificity of the assets involved in sugarcane cultivation hinder the emergence of a strong network of suppliers, spontaneously, in a region where cultivation is not traditional.

Were verified economic margins close to zero in the Northeast region, indicating that prices and production costs do not present conclusive information on the increase or reduction in levels of vertical integration. The rates of vertical integration did not show great variation in the observation data on the origin of cane sugar mills and distilleries in the area. The slow expansion of the area cultivated with sugar cane in this region (restricted topography typically tilted) and the high number of suppliers operating with very small scale production prevented the technical advance, keeping agricultural practices manually, with agricultural productivity lower than those observed in the center-south. The limitations to technological progress in the agricultural stage restricted the possibility of acute institutional changes in recent harvests, contributing to the maintenance of regional indexes of vertical integration.

5. Conclusion

The participation of sugarcane suppliers in the total crushing of mills and distilleries in Brazil has significant regional differences. Approximately 65% of sugarcane currently processed in Brazil comes from vertically integrated production.

In the Expansion Center-south region, vertical integration rates are higher than national average, especially in more recent industrial units. The uncertainty of the existence of an established network of suppliers, with a tradition of sugarcane cultivation induces self-sufficiency. Associations that can adequately represent the interests of suppliers are not as relevant as in the traditional region. The easier adoption of mechanized planting and harvesting (due to lower declivity of lands) and cheaper land prices are advantages that also encourage vertical integration.

In the Northeast region of Brazil, where the industry is consolidated and area expansion is not observed, production of suppliers corresponds to approximately 32% of the processing of sugarcane by sugar mills and distilleries (vertical integration index close to 68%). This indicator has been stable over the last four seasons.

With respect to the behavior of vertical integration relatively to production costs and the price of sugarcane in each region, it was found that in the Traditional Center-south region the price of this input is below the total variable cost of production, which has strengthened the demand for the production of suppliers. Questions may arise as to the viability of this activity, but the price-cost margin of agricultural production has been improving in the last three years. In the Expansion Center-south region, the price of sugarcane is higher than the cost of production, which explains the higher level of vertical integration observed in mills and distilleries in the region, particularly in the states of Goiás and Mato Grosso do Sul.

The decision by a company that has monopsony power to vertically integrate input supply may result in a behavior to eliminate local suppliers. Although one cannot say that such a situation would prevail in a market without any regulation in the sugarcane sector, this warning emphasizes the importance of sectorial negotiations in maintaining the activity of suppliers, as the Consecana System allows the quality and prices of final products (sugar and ethanol) to determinate the price of sugarcane.

Regarding the limitations of the work are not considered here two characteristics of sugarcane production: the limited economic-feasible geographical area of cultivation of sugarcane to be processed in a mill or distillery and the adoption of the cane pricing through the Consecana System. With the effectiveness of this system, the amount received by independent suppliers not only behaves as a function of supply and demand for the product in the region, which brings additional incentives for the maintaining or exit of sugarcane producers from the market, therefore changing the level of vertical integration result that would prevail without Consecana System. This study has limitations as well as the fact that the methodology does not take into account the attributes and regional differences in transaction costs, an important variable for the complete understanding of the vertical boundaries of firms. Future research may contribute to the identification and construction of variables that allow applied studies using the tools of Institutional Economics.

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Endnotes

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2 The results with more detailed geographic breakdown (subregions) can be found in Bastos (2013).

3 Anuário da Cana (2009-2012).

4 All units were classified to one of the regions, according to their location. In the case of the groups that reported the production of all units together, the total crushing was split by the number of units, maintaining values equal in all units.

5 Database on crushing and vertical integration of each industrial unit can be found on the appendix of Bastos (2013).

6 Brazil (1941).

7 Nominal production cost of one hectare of sugarcane were collected on a survey with mills and distilleries (regions) and the interviews with suppliers associations managers and are presented on the reports of PECEGE (2010-2012).

APN 6
Agricultural Prices and Markets

Organizer and chair: Jacques Delincé, EC-JRC

Agricultural prices and market orientations are essential indicators for agricultural policies assessment and food security outlooks. Where available (i.e. FAO, IGC, IFPRI or GTAP databases), the end users has to question their cost of collection, their reliability, their timeliness and their adequacy to the policy needs. This "prices and Markets" session will address the data collection costs, the modeler's needs, the prices transmission and volatility.

Possible topics for papers include: food price statistics; prices transmission: ranking drivers as CBOT, energy, biofuels; modeling international trade in agriculture: the data needs; measuring and monitoring agri-food price level and volatility: the G20 Amis approach

Papers:

- Yegnanew Alem Shiferaw (Ethiopia), "Modeling Volatility of Price of Some Selected Agricultural Products in Ethiopia: ARIMA-GARCH applications"
- Lovemore Nyongo (Malawi), "Maize Price Differences and Evidence of Spatial Integration in Malawi: the case of selected markets"
- Ousmane Badiane, Anatole Gounda, Mahamadou Tankari (Senegal), "Time Path of Price Adjustment in Domestic Markets of Non-tradable Staples to Changes in World Market Prices"
- Abdinardo Oliveira, Júlia Matos, Brenna Souza (Brazil), "Management of Market Risk for Fruits: propositions, analyses and reflections on Juazeiro Producer Market, Bahia, Brazil"

Modeling Volatility of Price of Some Selected Agricultural Products in Ethiopia: ARIMA-GARCH applications

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Abstract

Currently change of price in agricultural products is a global problem. GARCH models were employed to capture the log-return price volatility under the study. GARCH (1,1), GARCH (1,2) and GARCH (2,1) models were fitted models for volatility of the log-returns of price of Cereal, pulse and oil crops respectively.

Keywords: GARCH; ARCH; price volatility; forecasting.

1. Introduction

1.1 Background of the Study

A classical technique requires one to assume that the error terms have a constant variance. This assumption is often not very plausible. Most conventional financial time series models assume that the conditional variance of an asset returns is constant overtime. However, many researchers such as Hageman (1978) and Lau *et.al.* (1990) have found that the significantly non-normality of disturbances of stock returns. It is well known that the presence of heteroscedasticity in the disturbances of an otherwise properly specified linear model leads to consistent but inefficient parameters estimates and inconsistent covariance matrix estimates. As a result, faulty inferences will be drawn when testing statistical hypotheses in the presence of heteroscedasticity. Violations of homoscedasticity can yield hypothesis tests that fail to keep false rejections at the nominal level, or confidence intervals that are either too narrow or too wide. As a matter of fact, financial markets react "nervously" in the presence of political disorders, economic crises, war or fear of war, or in the event of a major natural catastrophe or man-made disaster, which is believed to threaten human society. During such stress periods the prices of financial assets usually fluctuate strongly.

In statistical terms, the conditional variance given the past, i.e., $Var[X_t \mid X_{t-1}, X_{t-2}, \ldots]$ is not constant over time and the underlying stochastic process (X_t) is conditionally heteroscedastic. Econometricians would also say that the volatility $\sigma_t = \left(Var[X_t \| X_{t-1}, X_{t-2}, \ldots]\right)^{1/2}$ changes over time (Daniel, 2005). This question often arises in financial applications where the dependent variable is the return on a price and the variance of the return represents the risk level of those returns. This motivates the development of alternative volatility models which can capture the characteristics of volatility more accurately. Such models are ARCH and GARCH models. ARCH and GARCH models, which stand for autoregressive conditional heteroskedasticity and *generalized* autoregressive conditional heteroscedasticity, have become widespread tools for dealing with time series heteroskedastic models such as ARCH and GARCH. The goal of such models is to provide a volatility measure like a standard deviation that can be used in financial decisions concerning risk analysis, portfolio selection and derivative pricing. (Engle, 1982). In this paper we need to employ time series econometric models to explore the nature of domestic price volatility for some selected agricultural commodities in Ethiopia by developing separate GARCH models with Box-Jenkins model for conditional mean specification.

1.2 Statement of the Problem

Concern over the degree of commodity price fluctuations or volatility has attracted increasing attention in recent economic and financial literature and has been recognized as one of the most important economic phenomena (Engle, 1982). It has been argued that price volatility reduces welfare and competition by increasing consumer costs (Zheng, Kinnucan and Thompson, 2008). Apergis and Rezitis (2011) noted that price volatility leads both producers and consumers to uncertainty and risk and thus volatility of commodity prices has been studied to some extent. Commodity prices in general are volatile and in particular agricultural commodity prices are renowned for their continuously volatile nature (Newbery, 1989). Even though cereal market policies in Ethiopia have undergone dramatic changes over the past several years (Rashid, 2007), the desirable outcome of any policy measure or other system of intervention to prevent the markets from going into market price volatility,

however, remained very unsatisfactory. Findings on (Rashid, 2007) indicated that price volatility in markets of major cereals crops remains high in the country. Besides, agricultural food price volatility in financial assets is still an area in which little empirical attention has been paid in Ethiopia. Hence it appears worthwhile to devote effort to modeling agricultural commodity prices with GARCH models. As a result the following research questions will be addressed by this study.

- Is there domestic market price volatility on the selected agricultural commodities?
- Which of the selected commodity is highly volatile in price?
- Is there any model that fit the domestic price volatility?
- Which model is highly fit to forecast the domestic price volatility?

1.3 Objective of the Study

General Objective**:** the main objective of this paper is to model and examine the country level variance effects of some selected agricultural commodity price returns using GARCH models.

Specific Objectives:

- To develop appropriate model for domestic price volatility for some selected consumer products under consideration.
- To identify the pattern of domestic price volatility of consumer products under study.
- To compare the pattern of price volatility in domestic markets for the consumer products.
- To make prediction on the domestic price volatility for these products.
- To make suggestions for policy makers.

1.4 Significance of the Study

To study the pattern of Crop domestic price volatility and its determinants are widely recognized as an important input into food balance sheets in mitigating price instability and risks, food insecurity, to make food policy decisions and strategic plans, granting of licenses for private firms to import or export. Similar effects of domestic price instability can occur at production levels, investment and income stability of consumers, whole sellers, producers and as well as at the macro level of the country. Especially, since domestic food prices are much more volatile than the corresponding global prices (FAO, 2008), it has been found highly significant with the following founding's of the study.

- Contributes to the identify the pattern of domestic price volatility for the purpose of being able to make more informed decisions when choosing one crop over another and to regulate its movement.
- Assist in the identification of the underlying pressures on the domestic price volatility of the agricultural commodities market especially for the purpose of setting monetary policy in a price stabilization–targeting regime.
- Contributes to examine the health of agricultural commodities markets for the crops under consideration.
- Furthermore, the result of this study will be used as a basis to other researchers for further investigations.

1.5 Organization of the Paper

This chapter is divided into four sections. The first section gives introduction, the second section gives data and methodology, the third section presents about results and discussion and the fourth section is concluding remarks.

2. Data and Methodology

2.1 Data

The data relevant to this study has taken from secondary source recorded data by the central statistical agency. The time series data used in this analysis consists of the monthly commodity prices of selected products with the sample covers from May 2001 to April 2011 G.C. and has a total of 120 observations. All the prices are in Ethiopian birr. Commodities under Study are: Cereal crops, Pulse crops and Oil crops.

Variables of the Study: the variables of the study in this research was the price average monthly domestic closing price returns (Y_t) and conditional variance (σ_t^2) at time t for each selected commodity as dependent variables.

Dependent variables: Average monthly domestic closing price returns (Y_t) for mean equation and conditional variance (σ_t^2) at time t for each selected commodity under consideration.

Independent variable are:

-Past shock of dependent variable $(\epsilon_{t-1}^2, \epsilon_{t-2}^2, \ldots, \epsilon_{t-q}^2)$

-Past conditional variance $(\sigma_{t-1}^2, \sigma_{t-2}^2, \ldots, \sigma_{t-q}^2)$

2.2 Statistical Model Specifications

This study will attempt to model the volatility of monthly commodity price return using the ARCH/ GARCH model. Let's briefly present the conditional variance models as follows.

2.2.1 Conditional Variance (Volatility) Model

ARCH Models: Autoregressive conditionally heteroscedastic (ARCH) models, introduced by Engle (1982). The ARCH (q) regression model can be Expressed as u_t^2 in terms of past values of u_t^2.

That is, $u_t^2 = \omega + \alpha_1 u_{t-1}^2 + \ldots + \alpha_q u_{t-q}^2 = \omega + \sum_{i=1}^{q} \alpha_i u_{t-i}^2$

GARCH (Generalized ARCH) Models**:** is a model that is mainly used to model volatility (Bollerslev, 1986). It generalizes the ARCH model in the same sort of way that an ARMA model generalizes an MA model. The GARCH (p, q) model can be expressed as:

$h_t = \omega + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j}$ with the constraints $\omega > 0$, $\alpha_i \geq 0$, $i=1, \ldots, q$ and $\beta_j \geq 0$, $j=1, \ldots, p$

2.2.2 Basic Procedures for GARCH Family Model Building

Testing Stationary in Time Series: if a time series is stationary, it's mean, variance and auto-covariance (at various lags) remain the same no matter at what time we measure them.

Dickey Fuller (DF) Test: there are many tests available to determine whether the series is a stationary or non-stationary, but the most common test used is the Dickey-Fuller test. The test is basically focuses on determining value ρ, whether it is equal to one, or it is less than one. Dickey-Fuller model can be expressed as:

$$\Delta y_t = \gamma y_{t-1} + \epsilon_t$$

where $\gamma = \rho - 1$ and $\Delta y_t = y_t - y_{t-1}$. The hypotheses are as follows:

H_0: The series is non-stationary or contain a unit root: $\gamma = 0$

H_a: The series is stationary: $\gamma < 0$

Testing for ARCH effects: according to Tsay (2005) the LM test was employed. The test statistic is defined as Obs.R^2 and follows a chi-square distribution with q degrees of freedom (Engle, 1982). If the value of test statistic is greater than the critical value from the Chi-square distribution indicates the evidence of ARCH(q) effects.

Order Selection for GARCH Family Model:

ARCH Effect: If an ARCH effect is found to be significant, the PACFs of ε_t^2 are useful to determine the order of ARCH model. This is due to the expectation that ε_t^2 is linearly related to $\varepsilon_{t-1}^2, \varepsilon_{t-2}^2, \cdots, \varepsilon_{t-q}^2$ in a manner similar to the AR (q) model.

GARCH Effect: In the presence of several competing models, with different number of parameters to select the model with appropriate order, both AIC and BIC employed. In general a desirable model is one that minimizes the AIC or the BIC and on the significance tests for each parameter. The formal expressions for the above criteria in terms of the log-likelihood are:

AIC= -2ln(log-likelihood) +2r

BIC = -2ln(log-likelihood) + (r +r(lnN))

Estimation of GARCH Models: parameter estimation of all of the above models can be achieved most simply using maximum likelihood Estimation (MLE), since the GARCH model is non-linear. Even if the true ϵ_t are not conditionally Gaussian, consistent parameter estimates could be obtained by maximizing this log-likelihood function.

Model Adequacy Checking: when a model has been fitted to a time series, it is advisable to check that the model really does provide an adequate description of the data. The properties of standardized residuals are employed to define the best fit data models. When the model fits the data well under normality assumption: the histogram of standardized residuals should be approximately symmetric, the normal probability plot should be a straight line and the time plot of residuals should exhibit random variation.

3. Results And Discussion

3.1 Stationary in Time Series: Unit Root Test

Table 3.1: Dickey-Fuller Test for Unit Root for Raw Prices.

Commodities	Test Statistic	1% Cr.Value	5% Cr.Value	10% Cr.Value	MacKinnon app. p-value
Cereal	-0.849	-3.534	-2.904	-2.587	0.8044
Pulse	-0.808	-3.534	-2.904	-2.587	0.8166
Oil	-0.401	-3.534	-2.904	-2.587	0.9099

The null hypothesis assumes that the data set is non-stationarity such that one can reject the null hypothesis if the t-statistic is less than the critical value(s). Table 3.1 presents as usual raw prices are non- stationarity. Because of their corresponding p-values from DF test statistic were greater than 5% level of significance to test null hypothesis of non-stationarity was not rejected. Thus, there is no evidence to reject null hypothesis of non-stationarity at 5% level of significance. If a time series is non-

stationary, it is necessary to look for possible transformation that might induce stationarity. In practice, econometricians usually transform financial prices into log-return series forms. The log return series is given by $y_t = \log\left(\frac{p_t}{p_{t-1}}\right)$, where y_t is the log-return series of the real raw data of prices, p_t and p_{t-1} are raw real price series at times t and (t-1). Return prices (in natural logarithm) are stationary (see Table 3.2 below). This is because of p-values corresponding to each commodity were less than 1%, 5% and 10% level of significance, implying that null hypothesis of non-stationarity was rejected at 1%, 5% and 10% level of significance respectively.

Table 3.2: Dickey-Fuller Test for Unit Root for log-Return Prices.

Commodities	Test Statistic	1% Cr.Value	5% Cr.Value	10% Cr.Value	MacKinnon app. p-value
Cereal	-11.277	-3.535	-2.904	-2.587	0.0000
Pulse	-9.660	-3.535	-2.904	-2.587	0.0000
Oil	-9.549	-3.535	-2.904	-2.587	0.0000

It is a typical property of financial log-return series to exhibit skewness and kurtosis (See Table 3.3 below).

Table 3.3: General Summary Statistics for the Return Series.

Commodities	Skewness	Kurtosis	Jarque-Bera	P-value
Cereal	-5.262558	8.13856	4541.052	0.010425
Pulse	0.282812	5.275928	19.24923	0.0366
Oil	-0.742198	6.944698	62.17423	0.0000000

Table 3.3 presents summary statistics for the price of log-return series for Ethiopian selected commodities. The skewness and kurtosis respectively measure the asymmetry and peakedness of the probability distribution of returns. The two parameters are expected to be zero and three for normal distribution. The Jarque-Bera statistic with skewness and kurtosis are used to signify the distribution characteristics of log-return series. The data shows positively and negatively skewed this implied that the log-return series distribution has significantly fatter tails than does the normal distribution. The more kurtosis statistic which is equal to 8.13856, 5.13856 and 6.944698 indicates the Leptokurtic characteristics of the return distribution. The implication of non normality is supported by the Jarque -Bera test statistic which point out the null hypothesis of normal distribution is rejected. The above facts clearly pointed out that the monthly log-return series is not normally distributed. Moreover, the return series of Cereal, Pulse and Oil crops have kurtosis and excess skewness are hints for conditional heteroscedasticity

3.2 Modeling of Volatility

This stage consists of the following four stages: testing for ARCH effects; specifying a volatility model, carrying out a simultaneous estimation of the mean and volatility equations; diagnostic tests and forecasting.

3.2.1 Testing for ARCH Effects

Since the P-value less than 0.05, the null hypothesis of no ARCH effects is rejected. This indicates the evidence of ARCH (q) effects. Table 3.4 shows the results of ARCHLM test indicates that there is an ARCH effects in each of the three cases. This results that the log-return price series are volatile and need to be modeled using ARCH or GARCH models.

Table 3.4: ARCH LM test summary statistics.

Commodities	Obs*R-squared	t-Statistic	P-Value
Cereal	44.469	4.382	0.000
Pulse	38.632	2.994	0.003
Oil	41.233	5.452	0.001

3.2.2 Specifying a Volatility Model

The series presented ARCH effect at least until lag 15, and the estimation residuals became white noises after the estimation of the models. As can be seen ARCH(2) for cereal, ARCH(1) for pulse and ARCH(2) for oil prices are identified as significant (best fit and reasonable lag structures). In this study both AIC and BIC were employed to select an appropriate GARCH model for the sample of the data available. Table 3.5 displays the summaries of the AIC and BIC of different GARCH models. As it is mentioned earlier the smaller the rank sum the better model. Therefore GARCH(1,1), GARCH(1,2) and GARCH(2,1) models are the best volatility models for the prices of cereal, pulse and oil crops respectively.

Table 3.5.1: GARCH model selection for the monthly log-returns Cereal Crops using AIC and BIC.

Statistics	GARCH(1,1)	GARCH(1,2)	GARCH(2,1)	GARCH(2,2)
AIC	-154.5444 (1)	-150.509 (3)	-152.0709 (2)	-150.2998 (4)
BIC	-144.869 (1)	-140.8336 (3)	-142.3955 (2)	-140.6244 (4)
Rank Sum	2	6	4	8

Table 3.5.2: GARCH model selection for the monthly log-returns Pulse Crops using AIC and BIC.

Statistics	GARCH(1,1)	GARCH(1,2)	GARCH(2,1)	GARCH(2,2)
AIC	-173.194 (2)	-173.9287 (1)	-169.3289 (3)	-167.9358 (4)
BIC	-163.5187 (2)	-164.2534 (1)	-159.6536 (3)	-158.2605 (4)
Rank Sum	4	2	6	8

Table 3.5.2: GARCH model selection for the monthly log-returns Oil Crops using AIC and BIC.

Statistics	GARCH(1,1)	GARCH(1,2)	GARCH(2,1)	GARCH(2,2)
AIC	-381.4066 (2)	-202.8639 (3)	-385.1804 (1)	-189.5158 (4)
BIC	-375.3306 (2)	-193.1885 (3)	-379.1043 (1)	-179.8404 (4)
Rank Sum	4	6	2	8

3.2.3 Simultaneous Estimation of the Mean and Volatility Equations

Here it is tried to simultaneously model the mean and variance of the selected agricultural commodity prices by considering GARCH models for conditional variance. Table 3.6 shows the final refined results of the estimated parameters of both the mean and volatility equations. The estimates of GARCH (1,1) model for cereal crop shows that all the coefficients of mean and variance equation are statistically significant at both 1% and 5% level of significance. Estimates of GARCH(1,2) model for pulse crops shows that all the coefficients of mean and variance equation are statistically significant at 5% level of significance except θ_1. In a similar manner, estimates of GARCH (2, 1) model for oil crops shows that in the variance equation the values of α_0, α_1, β_1, and β_2 are statistically significant at 5% level of significance.

3.2.4 Model Adequacy Testing

Model adequacy checking in the standardized residuals is performed for the models with significant parameters which have been explained in the previous section (Tsay, 2002 and Gouricroux, 1997). These models include GARCH(1,1), GARCH(1,2) and GARCH(2,1) models.

Table 3.7: Model Adequacy Checking in the Squared Normalized Residuals.

Commodities	Models	Skewness	Kurtosis	Jarque-Bera
Cereal	GARCH(1,1)	0.417369	4.405180	9.127012
Pulse	GARCH(1,2)	0.103571	4.734611	11.53978
Oil	GARCH(2,1)	-0.583691	5.913047	35.38155

As compared to the statistics from the original returns series (see Table 3.7), the model adequacy test's result in table above points out that the coefficients of skewness and kurtosis measures slightly reduces in absolute values for GARCH(1,2) and GARCH(2,1) estimated models. The diagnostic checking based on the distribution of standardized residuals indicates the capability of GARCH type models to capture the asymmetry and fat tailed characteristics in residual distribution as well as the squared return autocorrelation in the selected Ethiopian commodities. GARCH models can capture the non-normality characteristics of return series to some extent, the excess skewness and kurtosis statistics are still exposed.

Table 3.6: Maximum Likelihood Estimates of GARCH (1,1), GARCH(1,2) and GARCH(2,1) models.

Selected Commodities	Cereal			Pulse			Oil		
Mean Equation	**Coef.**	**Std.Err**	**P>|z|**	**Coef**	**Std.Er**	**P>|z|**	**Coef.**	**Std.Err**	**P>|z|**
AR(1) ϕ_1	-1.0275	.049844	0.000	.9900	.01987	0.000	.06716	.1380262	0.626
AR(2) ϕ_2	-	-	-				.14236	.1143012	0.087
MA(1) θ_1	1.0216	.0651777	0.000	-.046	.13782	0.737	.12764	.1397535	0.361
Variance Equation									
α_0	.00001		0.0033	338.98	127.98	0.008	.0014	.0008552	0.010
α_1	.37228		0.005	.48219	.21526	0.025	.8003	.3820417	0.036
α_2				-0.495	0.124	0.03	-	-	-
β_1	.53841		0.001	.32016	.23540	0.007	0.036	0.036	0.026
β_2	-		-	-	-	-	0.462	0.1457	0.040

4. Conclusions and Recommendations

4.1 Conclusions

Little study has been done on the domestic price volatility of consumer products in Ethiopia. This study aims to examine the volatility of some selected agricultural products over a period of 2001-2011. In order to contribute to the literatures of Ethiopian financial market, this study investigates the estimation and forecast ability of univariate GARCH models for conditional variance for selected agricultural products. The main findings of the study are as follows:

- Like other asset prices, commodity prices volatility can be modeled by GARCH family models.
- Return prices show persistent volatility across the samples.
- It is observed that GARCH(1,1), GARCH(1,2) and GARCH(2,1) are the most appropriate fitted models to use one has to evaluate the volatility of the log-return price of Cereal, pulse and oil crops respectively. Prices volatility is persistent in all three categories (Cereal, pulse and oil crops) of selected consumer goods.
- Regarding the forecasting capability, after obtaining the three satisfactory GARCH models, the forecast process is analyzed. This study tried to illustrate the proper procedure for testing the relative forecast accuracy of different GARCH models based on root mean square error (RMSE) with an application to three different commodity prices. The analysis favour the GARCH (1,1), GARCH(1,2) and GARCH(2,1) models for cereal, pulse and oil crops respectively. Findings of this study could give good insight to forecast volatility of price of agricultural products in Ethiopia.

4.2 Recommendations

This study has provided several important insights into the volatility of prices of some selected agricultural commodities. An in-depth understanding of domestic price volatility is essential for the society as well as policy makers; policy makers should address the importance of considering the sub-national factors in formulating the national commodity prices. The data that we have used in this study is a period of almost for eleven years and this is limited data to apply GARCH models. Hence the findings should be treated with great precaution.

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Maize Price Differences and Evidence of Spatial Integration in Malawi: the case of selected markets

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Abstract

This study tests the long-run and short-run integration of maize markets in Malawi using co-integration approach within the Vector Autoregressive modeling framework. The analysis is extended to Wald-F Granger Causality tests to see the direction of causality between maize markets. A total of six maize markets, two from each region, were analyzed. Three are urban markets while the other three are rural markets with two of the three rural markets being border markets. The study uses monthly maize retail prices for the period January 2000 to May 2008. Study findings show that nine out of fifteen market pairs are integrated in the long-run but the degree of short-run market integration is very low implying that the transmission of price information is very slow. On the other hand, transaction costs seem to have a significant impact on market pairs involving border markets. Furthermore, there is no market that qualifies to be a central maize market in this study. Based on the research findings, the study also discusses some policy implications to improve the degree of maize market integration and food security in Malawi.

Keywords: market integration; co-integration; transaction costs; price transmission.

1. Introduction, background and motivation for the study

In countries where majority of the people are net food buyers, strengthening markets is one of the key strategies to achieving food security. In such a situation, spatial market integration becomes a useful tool in allocating food within the economy. By definition, spatial market integration refers to a measure of the extent to which demand and supply shocks in one location are transmitted to another location (Negassa *et al.,* 2003). If markets are well integrated, price changes in one location are consistently related to price changes in other locations thereby facilitating interactions among market agents. In spatially integrated markets, competition among arbitragers ensures that a unique equilibrium is achieved where local prices in regional markets differ by no more than transportation costs. According to Sexton *et al.* (1991) information of spatial market integration provides indication of competitiveness, the effectiveness of arbitrage and the efficiency of pricing.

If markets are not integrated, the information they convey may not be accurate therefore sending inaccurate price signals that might distort both producers' and consumers' marketing decisions. In the end, traders tend to exploit the market and benefit at the expense of both producers and consumers (Goodwin and Schroeder, 1991). On the other hand, in more integrated markets, farmers specialize in their production, consumers pay less and the society benefits from economies of scale (Goodwin and Schroeder, 1991). In addition, the degree of market integration informs policy makers in their analysis of food security and appropriate responses to a food crisis.

This study analyzes spatial maize market integration in the Malawi economy. The importance of maize as a staple food crop and maize markets in Malawi underlines the relevance of this study. Specifically, the study has the following objectives:

1. To investigate the price transmission mechanism across selected maize markets in the economy.
2. To establish if there are central maize markets in the economy.
3. To assess the impact of transaction costs on maize market integration.

Although households grow a wide diversity of crops, maize is the most important food crop in the consumption basket of most Malawians. In their study, Chirwa and Zakeyo (2003) reported that 93.2 percent of all sampled farming households cultivated maize. Secondly, the country's Consumer Price Index (CPI) is dominated by maize and any change in its supply on the market has a significant impact on the level of inflation (GoM, 2007)[1].

The literature on market integration is very vast. For Malawi, however, there are four main studies that have analyzed domestic maize market integration. Three of them have used co-integration methods (Goletti and

Babu, 1994;, Chirwa, 1999; Mulaga, 2007) while one has used Threshold Autoregressive (TAR) (Myers,2008). Co-integration approaches have been criticized for not taking into account transaction costs (Faminow and Benson, 1990). In order to capture these costs, this study used transportation costs as a proxy for transaction costs within the Vector Autoregressive (VAR) modeling framework. By incorporating transaction costs this study therefore goes beyond other studies on maize market integration that have been conducted in Malawi.

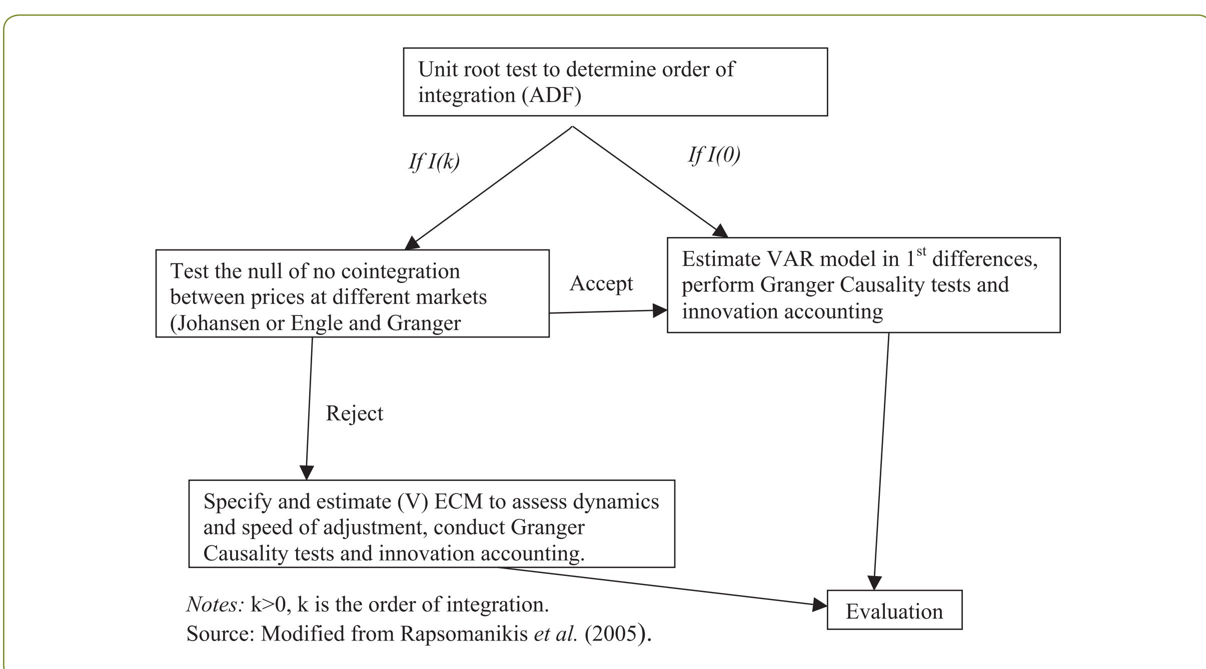
2. Brief theoretical literature

In a market driven economy, the marketing system serves at the micro and macro levels as a mechanism to transmit information that is useful in decision-making to market participants. Pricing signals guide and regulate production, consumption and marketing decisions over time, form and place (Kohls and Uhl, 1998). According to Negassa *et al.* (2003), the price relationships between spatially separated markets are generally analyzed within the framework of spatial price equilibrium theory developed by Enke (1951), Samuelson (1964) and Takayama and Judge (1964). The key assumption underpinning the theory is that price relationships between spatially separated competitive markets depend on the size of transaction costs. When the price difference between markets exceeds transaction costs, arbitrage opportunities will be created and profit seeking merchants will purchase commodities from a low-price surplus market and transfer them to a higher-priced deficit market.

3. Sample description, data sources and estimation

This study uses monthly retail maize prices for the period January 2000 to May 2008 in order to meet study objectives. During this period, maize marketing was almost fully liberalized except for sporadic government interventions depending on maize availability. Data was collected from various sources including the Ministry of Agriculture and Food Security, National Statistical Office and FEWSNET Malawi. Data on fuel prices was collected from British Petroleum Malawi Limited. Six geographically separated markets were sampled across all regions of the country. At least one commercial center (Mzuzu, Lilongwe and Limbe) and one rural area in each region (Chitipa, Ntchisi and Muloza) were included in the study. The study used the analytical framework adopted from Rapsomanikis *et al.* (2005) as presented in Figure 1 below.

Figure 1: Analytical Framework (Cointegration Analysis Procedure).



Notes: k>0, k is the order of integration.
Source: Modified from Rapsomanikis *et al.* (2005).

3.1 Co-integration Analysis and Error Correction Model

If geographically separated markets are integrated, then there exists an equilibrium relationship among these markets (Sexton *et al.*, 1991). The long-run equilibrium relationship to study market integration, according to the theory of law of one price (LOP), is specified as:

$$P^i_t = \beta_1 + \beta_2 P^j_t + \varepsilon_t \quad (1)$$

Where P_t^i and P_t^j are price series for market i and j respectively in period t and ε_t is an error term assumed to be stationary. β_1 is a constant which is assumed to account for transport and other transfer costs (Chirwa, 2004). β_2 is the parameter to be tested. If ε_t is stationary and β_2 is unity, we can conclude that the markets are completely integrated and this implies that a price change in one market will be transmitted to the other market. In the study, the relationship in equation 1 was modified to include other variables that are found or assumed to influence market integration based on the literature reviewed. Firstly, natural logarithms are introduced within Vector Autoregressive framework so that the estimated coefficients are interpreted directly as elasticities (Gujarati, 2003). Secondly, transaction costs (TC) are included to capture transfer costs from one market to another[2].

The model is as follows:

$$\ln p_t^i = \beta_1 + \sum_{i=1}^{n} \alpha_i \ln p_{t-i}^j + \sum_{l=1}^{n} \eta_l \ln p_{t-l}^i + \beta_2 \ln TC_t + \varepsilon_t \quad (2)$$

where ln = natural logarithm, p^i_{t-l} and p^j_{t-i} are lagged prices in market i and j. TC_t is transaction cost in period t and is an exogenous variable. β_1 is an intercept term β_2, α_i and η_l are slope parameters while ε_t is an error term.

The long run relationship in equation 2 may not satisfy at each time period. If the existence of co-integration is established, the relationship between markets can be expressed in an Error Correction Model (ECM) which depicts the process of adaptation between prices in the short run (Engle and Granger, 1987). Therefore, a Johansen Co-integration test was conducted to see if price series were co-integrated. To determine the number of co-integrating relations in the system, the study invoked the Johansen Trace test and Maximum Eigenvalue. Failure to accept the null hypothesis of no co-integration confirmed the need to re-specify equation 2 as a Vector Error Correction Model (VECM) as in equation 3 below:

$$\Delta \ln p_t^i = \beta_1 + \sum_{l=1}^{q} \alpha_l \Delta \ln p_{t-l}^i + \sum_{l=1}^{q} \theta_l \Delta \ln p_{t-l}^j + \lambda_i \chi + \phi_1 \ln TC_t + \nu_t \quad (3)$$

Where ν_t is a stochastic disturbance term assumed to be white noise, $\chi = \ln p_{t-1}^i - \mu \ln p_{t-1}^j - \pi$ is a co-integrating equation and μ is the co-integrating parameter that characterizes a long run relationship between the two prices. The parameter of interest is λ_i, the speed-of-adjustment, indicating the speed at which the system returns to equilibrium in case of a shock. If these parameters are equal to zero, then there is no adjustment to the deviation from the long-run equilibrium while an absolute value of one suggests rapid adjustment. $\lambda_i\chi$ is an Error Correction Term (ECT) since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. θ_l and α_l are short run parameters capturing price transmission. β_1 is a constant while ϕ_1 is a slope coefficient for transaction costs. The rest of the variables are as defined before. To appreciate the impact of transaction costs, equation 2 and 3 were estimated with and without transaction costs for each market pair.

The Granger causality test was conducted to determine the direction of price adjustment (Bassolet and Lutz, 1999). The test was used to determine the existence of central markets in the process of price transmission. We conducted the Wald F-test for linear restrictions to find out if one market's lagged prices and transaction costs jointly contribute to predictability of maize prices in another market. Equation 2 was used to conduct the test.

4. Results and interpretation

4.1 Unit Root Test Results

Graphical presentation of the series indicated the presence of both intercept terms and stochastic trend terms. As such, the study invoked a unit root test equation with both the intercept term and the time trend term. To have an idea on stationarity, Autocorrelation Functions (ACF) and Partial Autocorrelation Functions (PACF) were computed[3]. For all price series, the ACF were statistically significant at the beginning and exhibited a sine wave pattern as the lag length was extended to 36 lags. On the other hand, the PACF had a significant spike at lag 1 in all series indicating 1 lag for each series. This provides evidence for nonstationarity which can be buttressed by ADF tests. To formally determine the appropriate lag length, AIC and SIC were used. Both statistics suggested 1 lag for all maize prices except Chitipa which required 2 augmentations to whiten the residual.

4.2 VAR Order Determination

The VAR order selection used a maximum lag length of 12. Specification results indicated VAR (1) for Mzuzu-Lilongwe, Lilongwe-Ntchisi, Lilongwe-Chitipa, Limbe-Muloza and Mzuzu-Ntchisi equations. VAR (8) for Chitipa-Mzuzu, Ntchisi-Chitipa, Limbe-Chitipa, Muloza-Chitipa, and Muloza-Ntchisi. Ntchisi-Limbe is VAR (6) while Limbe-Mzuzu required VAR (7) specification. Lilongwe-Muloza required a VAR (2) model. Lilongwe-Limbe required 10 lags while Muloza-Mzuzu required a VAR (15) equation.

4.3 Johansen Co-integration Test Results

The unit root tests established that all maize price series are integrated of order 1. As such, the variables could potentially be co-integrated meaning that there exist long run relationships among them. Therefore, the study conducted the Johansen Co-integration test to ascertain this. Each market pair was subjected to the test with both trend term and an intercept. P-values were used to evaluate the test statistics which are reproduced in Eviews 5. All market pairs were consistently evaluated at 5% significance level.

The results indicate that out of the 15 market pairs analyzed, 9 had 1 co-integrating relationship while 6 (Mzuzu-Ntchisi, Lilongwe-Ntchisi, Limbe-Ntchisi, Ntchisi-Chitipa, Limbe-Chitipa and Muloza-Chitipa) had no co-integrating relationships. The long run relationships imply that a price rise in one market will lead to a price decrease in the other market. Ntchisi seems to be more separated from the rest of the markets. Out of 5 market pairs involving Ntchisi, 4 indicate the absence of a long-run relationship. Muloza is the only market that Ntchisi is linked with; yet they are physically disjointed. Chitipa is another market which is also separated from the most of the markets. Out of 5 pairs, 3 are not integrated. For Ntchisi, the lack of long run relationships may not be surprising because Ntchisi was chosen to represent chronically maize deficit regions of the country. Hence and the lack of integration could be the major reason for the perpetual maize deficit in the district. Poor transport infrastructure connecting Ntchisi to other districts could be the major reason for the lack of long run relationships[4]. Chitipa is not integrated with both markets from the southern region and this could be due to the long distances separating Chitipa and these markets. Secondly, poor transport infrastructure connecting Chitipa to other districts may have played a role as well. There is also a possibility of Chitipa trading with Tanzanian markets.

Therefore, the study proceeded to estimate a VEC model (equation 3) with 1 co-integrating relationship for the 9 co-integrated market pairs. The existence of co-integrating equations in these market pairs confirm that the dynamic causal relationships among the maize prices can also be investigated using Granger-causality tests and innovation accounting within the environment of VEC models (Mangani, 2005). A linear deterministic trend was assumed in estimating the VEC. For the equations that had no co-integrating relations, a VAR model (equation 2) was estimated and this was followed by Granger causality tests and innovations accounting.

4.4 Impact of Transaction Costs

According to the results, transaction costs were found to be statistically significant for Chitipa-Mzuzu, Muloza-Mzuzu and Lilongwe-Muloza at 5 percent for the first two and 10 percent for the last market pair. Estimating the same equations without transaction costs, a few changes are noted. The speed of adjustment for Chitipa in the Chitipa-Mzuzu equation drops from 46 to 31 percent and is no longer significant. The one lag price for Chitipa no longer affects current price for Mzuzu at 5 percent level. Secondly, the adjustment speed of Lilongwe to disequilibrium in the Lilongwe-Limbe equation declines from 33 percent to 29 percent and is still significant. Similarly, if transaction costs are not considered 1 lag price for Limbe does not affect current prices at Mzuzu. Thus, with no transaction costs, the price transmission process seems to be delayed.

An unexpected change is noted on results for Chitipa-Lilongwe equation. Without transaction costs, the ECT's for both equations are now significant at 5 percent level. Lilongwe corrects 22 percent of the disequilibrium every month while Chitipa corrects 23 percent of the disequilibrium every month. For Muloza-Mzuzu, without transaction costs the speed of adjustment for Muloza jumps from 13 percent to 33 percent and is statistically significant at 5 percent. Similarly, the speed of adjustment for Mzuzu jumps from 10 percent to 25 percent. These markets are connected by a paved road but are at a distance of 725 km away from each other. Finally, the speed of adjustment for Lilongwe in the Lilongwe-Muloza equation drops from 36 to 28 percent. This is also the case with Muloza-Ntchisi where the speed of adjustment for Ntchisi drops from 72 percent to 66 percent if transaction costs are not considered.

These results indicate that equations with border markets are more likely to be affected by transaction costs. A unique feature for Chitipa is the poor road network connecting it to Karonga and other markets in Malawi. If we consider transaction costs in our analysis, the speed of adjustment for Chitipa improves and becomes significant. This concurs with findings by Van Campenhout (2005) who found transaction costs to improve speed of adjustment in Tanzania. On the other hand the response of the equations involving Muloza is mixed. When paired with Muloza, the speed of adjustment for Mzuzu decreases while for Ntchisi it increases if transaction costs are considered. We can therefore conclude that transaction costs have a significant impact on market integration, especially on equations involving the border markets and those markets with poor road network.

In the study, the short-run speed of adjustment between market pairs ranges from 10 percent to 72 percent if transaction costs are considered and 21 percent to 66 percent when transaction costs are not considered. The speed of adjustment for Ntchisi in the Ntchisi-Muloza equation is very high and differs from the rest. The short-run speed of adjustment ranges from 10 to 46 percent and 21 to 30 percent with and without transaction costs, respectively. This implies that in general, transaction costs are revealing the volatility of market adjustment and should, therefore, be considered when analyzing spatial market integration. Apart from Ntchisi, none of the other markets have an adjustment speed of above 50 percent. The low speed of short run adjustment is an indication of the existence of policy and structural problems which hinder efficient private maize trade in the country. Government intervention in the maize market through the Agricultural Development and Marketing Corporation (ADMARC), National Food Reserve Agency (NFRA) and bans on private maize trade during lean seasons also slows down the short run response of markets to shocks in the country.

In addition to that, in all the equations with transaction costs, only three had statistically significant transaction cost coefficients. This suggests the need to include other components of transactions costs in the study. Such components include; government policies on movement of maize, licensing procedures, delays in accessing price information and capacity constraints pertaining to storage.

4.5 Granger Causality Tests

One of the specific objectives of this study was to establish the existence of central maize markets in Malawi. From the Granger causality test, none of the markets qualifies to be a central market. No market is causing all other markets without being caused by any of them. However, Muloza and Limbe seem to granger cause 5 and 4 other markets, respectively and, therefore, can be good markets for policy intervention. The interesting finding is that Lilongwe Granger causes Chitipa and is Granger caused by Mzuzu both of which are in the northern region. This is in contrast with Goletti and Babu (1994) who found Lilongwe not to be well integrated with the northern region. Lilongwe seems to be a major supplier of maize to all three regions because it is Granger caused by Mzuzu, Ntchisi, Limbe and Muloza. This supports Myres (2008) assertion that major interregional maize flows are from the center to the south, with irregular flows in both directions between the center and the north, depending on the season.

5. Conclusion and policy implications

An assessment of the long run equilibrium relations among selected maize markets in Malawi shows the existence of market integration. However, short run integration is very low implying that it takes a longer period for maize markets to respond to localized shocks. Therefore, it is essential that policy makers should consider market infrastructure development as key priorities to ensure linkages of isolated maize markets.

It is also important to note that maize marketing in Malawi is complex and dynamic. It is, therefore, important to continuously study this market and see how the markets relate. Unless we have knowledge on maize market dynamics, achievement of food security in a liberalized economy will remain a farfetched dream.

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Endnotes

1 58.1 percent of the CPI is from food items and maize is the major contributor.

2 Transaction costs are the product of average fuel price (petrol and diesel) at time t and distance between markets to be analyzed.

3 A time series is stationary if the mean, variance, and covariance of the series are not dependent on time.

4 Ntchisi had no paved road until December 2007 when Ntchisi-Mponela road was officially opened.

Time Path of Price Adjustment in Domestic Markets of Non-tradable Staples to Changes in World Market Prices

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Abstract

The paper presents a model to analyze the adjustment of prices of non-traded food staples to changes in global food prices via the response of traded commodities in domestic markets. It shows that the impact on local prices of shocks originating in global markets lasts much longer than suggested by findings in the traditional literature on market integration. Furthermore, unlike the conventional analysis which focuses on estimating a single parameter indicating the degree of market interconnectedness, the model used here allows us to trace the future impact of shocks on local prices over time and thus helps policy makers to anticipate changes and better plan response strategies. It combines the methodology developed by Gonzales-Rivera and Helfand (2001) and Granger and Gonzalo (1995) on market cointegration with the model developed by Badiane and Shively (1998) for the estimation of the time path of price adjustments to market shocks. It is then applied to monthly price data over a 12-year period from all major regions of Niger, a landlocked country that is extremely vulnerable to volatility in staple foods markets. The results suggests that it takes much longer for the impact of shocks on local prices to stabilize. They also show that the impact of shocks originating from global markets can be more pronounced across markets for non-traded staples, such as local maize and sorghum, compared to traded food commodities such as rice. Furthermore, it appears from the findings that prices the two non-traded staples tend to be "stickier" as their rate of increase decelerates much more slowly than for rice.

Keywords: prices; markets; Niger.

1. Introduction

Anticipating the extent and speed to which domestic commodity prices will adjust to shocks can give policymakers enough time to respond to price spikes and mitigate their impact on consumer purchasing power. Although some important food staples consumed in Africa are not internationally traded, they are affected by changes in global prices via the response in domestic markets for tradable foods. For example, Minot (2011) found that during the 2007-08 food price crisis, the rise in staple prices in 11 African countries was about 75% of the proportional rise in world prices; however, his analysis of longer-term trends showed that only 13 of the 62 African food prices examined exhibited a long-term relationship with world prices. There is clearly a need to better understand how tradable international commodity price spikes are transmitted not only to domestic tradable commodity markets but also to non-tradable ones. The latter link seems to be ignored in the literature, although non-tradable commodities can be far more important for the food security of the poor and vulnerable.

This paper develops a tool to analyze the impact of price shocks originating in global markets on prices for non-tradable staples and to trace the time path of price adjustment beyond the initial shock. This approach combines techniques and concepts from Gonzales-Rivera and Helfand (2001), Granger and Gonzalo (1995) and Badiane and Shively (1998). Two main advantages over traditional price transmission analysis should be highlighted. First, this method allows ex ante examination of the trajectory of the impact of global price shocks, and thus gives policy planners more time to prepare response strategies. Second, it can be applied to examine the response of prices for local food staples to changes in the prices of traded commodities.

The model is applied to data from Niger, a Sahelian country with recurring food insecurity issues. Niger has undergone recurrent food crises in the last decade, and was ranked last of the 186 ranked countries in the United Nations Development Programme 2012 Human Development Index

(UNDP, 2013). Shin (2010) showed that the spatial autocorrelation of millet prices in Niger varied over time, decreasing markedly at the height of the 2005 food crisis but recovering quickly thereafter. Aker (2010) also analyzed changes over time in Niger's grain markets, and found that price dispersion declined by 10 to 16% due to the introduction of mobile phone service in the early 2000s. Our study will add to the understanding of the opertation of staple foods markets in Niger.

2. Background and Methodology

The recent wave of high international commodity prices has increased interest in understanding how prices in domestic food markets react to changes in global food markets, despite the fact that the issue of spatial market integration has been extensively studied in the literature (see for example Ravallion, 1986; Alexander and Wyeth, 1994; Badiane and Shively, 1998; Rashid, 2004; Van Campenhout, 2007). Most of those studies have focused on individual tradable commodities. A smaller number of studies examine intercommodity price transmission across separate market locations (Alderman, 1993; Rashid, 2011). The traditional market integration analysis estimates ex-post a single parameter as a measure of price interconnectedness. It does not address the time path adjustment of local prices. Policymakers need to understand both the extent and the trajectory of adjustment to shocks in order to design effective response strategies; for example, very different interventions would be needed if an entire price shock were transmitted within a month versus 12 months. To the best of our knowledge, no previous studies have tried simultaneously to capture the impact of a given international commodity price change on local prices and to trace their dynamic paths. The aim of this study is to fill this gap. A second contribution of this analysis is to add to knowledge on market integration in Niger, an often food-insecure country whose agricultural markets have not been extensively studied.

The model developed here combines the methodology proposed by Gonzales-Rivera and Helfand (2001) and Granger and Gonzalo (1995) for analyzing the cointegration of markets with that developed by Badiane and Shively (1998) for estimating the time path of price adjustments from central to peripheral markets. First, we define the "market" for a given product as a set of locations where the prices for this commodity share a unique common factor. We identify this common factor and determine which location serves as the central market for each product (maize, millet, rice and sorghum), based on the relative importance of each location in determining the common factor. Price series between the central markets of each commodity are used to assess cross-commodity price transmission between tradable and non-tradable products. Badiane and Shively's approach is then used for each staple food to quantify the trajectory of horizontal price transmission between the central and peripheral markets. The inter- and intra-commodity price response models are then combined to project the future trajectory of the adjustment of prices in local markets for non-traded staples (millet, sorghum, and local maize) to a price shock in rice markets, the main tradable food commodity.

2.1 Identification of markets and central market locations

Following Gonzalez-Rivera and Helfand (2001), a number of n locations can be considered as a market for one commodity if the price series in those locations are integrated, I(1), and cointegrated with (n-1) rank of cointegration. To identify the group of locations that comprises the market for each commodity, we determine the rank of cointegration for different combinations of market locations using the test proposed by Johansen (1992), and select the set of locations for which the (n-1) rank of cointegration condition is met (see Rashid (2011) for more details). The corresponding vector error correction model can be written as follows:

$$\Delta P_t = \gamma\alpha' P_{t-1} + \sum_{i=1}^{q-1} \Gamma_i \Delta P_{t-i} + \epsilon_t \quad (1)$$

Where Δ denotes the differential operator, P_t is the price vector and ϵ the error term.

Since the rank of cointegration equals (n-1), the theory of the common factor (Gonzalo & Granger, 1995) argues that one and only one common factor exists for P_t. This common factor, denoted f_t, is a linear combination of the price series in the considered locations. It is expressed as:

$$f_t = \gamma'_{\perp} P_t \quad (2)$$

Where is obtained from equation (1) such that .

The estimation of the common factor shows the importance of each location, through , in shaping the long-run behavior of the product's price (Gonzalez-Rivera & Helfand, 2001). The higher the coefficient

for a location in (2), the more powerful we expect its impact to be on the product's price in all locations. For each product, we will consider the location with the highest estimated coefficient to be the central market for that product.

2.2 Response of prices for non-tradable staples to changes in prices of tradable foods

After identifying the central market for each product, we use this information to evaluate cross-product price transmission between rice, the tradable commodity, and the other, non-tradable products via a bivariate analysis. To test whether a change in the price of rice in the international market affects the prices of local staples, we use an autoregressive distributed lag (ADL) between the central market for a selected product (maize, millet or sorghum) and the central market for rice.

$$P_t^l = \sum_{i=1}^{p} \alpha_i P_{t-i}^l + \sum_{k=0}^{q} \beta_k P_{t-k}^r + \gamma X_t + \varepsilon_t \qquad (3)$$

Where P_t^l denotes the price for commodity l (maize, millet or sorghum), P_t^r is the price of rice, i and k denote lags, and X is a matrix of deterministic variables that includes an intercept and a time trend. The lag selections are made using the information criteria (AIC, BIC). If all coefficients of P_t^r are null, we conclude that a change in the price of rice has no impact on the price P_t^l. To assess how a change in the price of rice affects the price of maize, millet or sorghum, we derive the intercommodity long-run multiplier from (3). We first compute the intermediate multiplier after j periods:

$$\mu^j = \sum_{h=0}^{j} \frac{\partial E(P_{t+h}^l)}{\partial P_t^r} \qquad (4)$$

The intermediate multiplier converges to the intercommodity long-run multiplier, which can be used to calculate the total effect of a price change in the rice central market on commodity l in its central market after the adjustment process is completed:

$$\mu = \lim_{j \to \infty} \mu^j \qquad (5)$$

2.3. The time path of price adjustment across locations for non-traded food staples and its determinants

Once we have determined the effect of a price shock in the rice central market on the prices of staples in their central markets, we analyze how the change in price for each staple is transmitted from its central market to peripheral markets. We do this by applying equation (3) to prices in the central market P^{lA} and prices in each of the peripheral markets P^{lB} (in the places of rice prices and other staple prices). We obtain an intra-commodity long-run multiplier expressed as in equation (4).

In reality, the ripple effects of price shocks in local markets extends much beyond the period of time it takes for the long-run multiplier to converge. As we will see later, future local prices are affected by the magnitude of the shock itself, that is, the difference between the price prior to the shock and the price after the shock has been transmitted (see equation 9). To show the relationship, first rewrite equation (4), approximating derivatives by first differences and defining as one period the time it takes for the multiplier to converge, as:

$$\Delta P_{t+1}^{lA} = \mu \Delta P_t^{lB} \qquad (6)$$

Next, for each staple food, express the concurrent relationship between the price in the central market and the price in any peripheral market, at any given time, as:

$$P_t^{lA} = P_t^{lB} - T_t \qquad (7)$$

Then inserting the values for P^{lB} from (7) into equation (6) yields:

$$P_{t+2}^{lA} = (1+\mu) P_{t+1}^{lA} - \mu P_t^{lA} + \mu \Delta T_t \qquad (8)$$

Assuming ΔT_t to be constant, equation (8) can be solved as[1]:

$$P_t^{lA} = \varsigma_t P_{(t=0)}^{lA} + \varrho_t P_{(t=1)}^{lA} + \varphi_t \Delta T_t \qquad (9)$$

Where $\varsigma_t = \frac{\mu - \mu^t}{\mu - 1}$; $\varrho_t = \frac{\mu^t - 1}{\mu - 1}$ and $\varphi_t = \left(\frac{\mu}{\mu - 1}\right) t$

Equation (9) can be used to project the time path of price adjustment in local staple markets. It also shows the variables that determine the pace and trajectory of price adjustment. Besides the intra-commodity long-run multiplier, which affects the time path of price adjustment through the parameters ς_t, ϱ_t and φ_t, the other variables that determine the adjustment trajectory are the level of the price before the shock $P_{(t=0)}^{lA}$, the price immediately after the shock ($P_{(t=1)}^{lA}$), and the changes in the cost of transport or arbitrage (ΔT_t). Government policies can thus influence the intensity of the price response in two ways: (i) through measures that limit the initial change in local prices from $P_{(t=0)}^{lA}$ to $P_{(t=1)}^{lA}$, such as subsidies, or (ii) measures that affect the cost of arbitrage. These may include restrictions of commodity flows and fees, legal and illegal, that are levied on such flows, both of which raise arbitrage cost ΔT_t, or measures to lower the cost of transport, which have the opposite effect on ΔT_t. In the long run, measures that affect the degree of market integration and thus the long-run multiplier μ also have an impact on the trajectory of price adjustment.

3. Data and estimation results

Monthly price data from January 2000 to December 2012 on rice, millet, sorghum and maize from the country's seven regions and the capital district, Niamey, are used. Because we choose to include only series which have a unit root, we consider six of the eight locations in our analysis: Agadez, Dosso, Maradi, Niamey, Tahoua and Tillaberi.

A central point in our approach is the determination of a market area for each commodity. We start with a group of six locations (Agadez, Dosso, Maradi, Niamey, Tahoua, Tillaberi) for each of our four considered commodities (maize, millet, rice and sorghum), and define the market by selecting the set of n locations such that the rank of cointegration between their price series is (n-1). We identify a different market area for each commodity. For maize, all six locations are selected. The market for millet includes Agadez, Dosso, Maradi, Tahoua and Tillaberi and that for rice Agadez, Maradi, Niamey and Tahoua. The market for sorghum includes Dosso, Maradi, Tahoua and Tillaberi. Since the selected locations for each commodity hold (*n-1*) rank of cointegration, they share a unique common factor. The estimation of that common factor (equation 2) gives:

$$ft\_Maize = 0.24*Aga+0.517*Dos-0.291*Mar-0.375*Nia+0.67*Tah+0.044*Til$$

$$ft\_Millet = -0.203*Aga+0.672*Dos+0.300*Mar-0.554*Tah+0.332*Til$$

$$ft\_Rice = 0.467*Aga+0.729*Mar+0.146*Nia+0.477*Tah$$

$$ft\_Sorghum = 0.090*Dos+0.943*Mar+0.001*Tah+0.319*Til$$

These estimations show the role of each location in shaping the common factor for a specific product. The most influential locations, as shown by the largest coefficients, are Tahoua for maize, Dosso for Millet, and Maradi for rice and sorghum. Therefore, those cities are considered to be the central market for the corresponding commodity.

As indicated above, we first calculate the connectedness between prices in the leading rice market and prices in each of the leading markets for staple food commodities (equations 4 and 5). The results show no relationship between rice and millet prices. In contrast, long-run multipliers of 0.354 and 0.359 are estimated between rice and maize prices, and rice and sorghum prices, respectively. The next step is the estimation of the same long-run multipliers and speed of convergence between prices in the central and the peripheral markets for each of the staple foods. We find that most of the peripheral markets are highly integrated with their respective central market, with long-run multipliers around than 0.7 or higher (see Table 1). The speed of convergence is the period of time it takes for the transmission of the price shock to peripheral markets to reach the magnitude indicated by the estimated long-run multiplier. Estimates presented in parentheses in the table suggest convergence speeds of around 6 months for most markets.

Finally, we estimate the time path of price adjustment across local markets for non-traded food staples to changes in the price of the traded commodity, rice, beyond the initial shock (equation 9). In addition to the long-run multipliers in the table below, we also need the prices prior to the shock and after the shock has been transmitted, that is, $P^{lA}_{(t=0)}$ and $P^{lA}_{(t=1)}$. For that purpose, we assume a rise of 48.625 FCFA in the price of rice, which corresponds to the variation observed in Maradi during the global food price crisis between July and October 2007. Based on the estimated long-run multipliers, this increase in the rice price raises prices in the central market of maize (Tahoua) and sorghum (Maradi) by 17.21 FCFA and 17.45 FCFA respectively, that is, from 132.357 FCFA and 67.069 FCFA prior to the shock ($P^{lA}_{(t=0)}$) to 149.567 FCFA and 84.519 after the shock ($P^{lA}_{(t=1)}$).

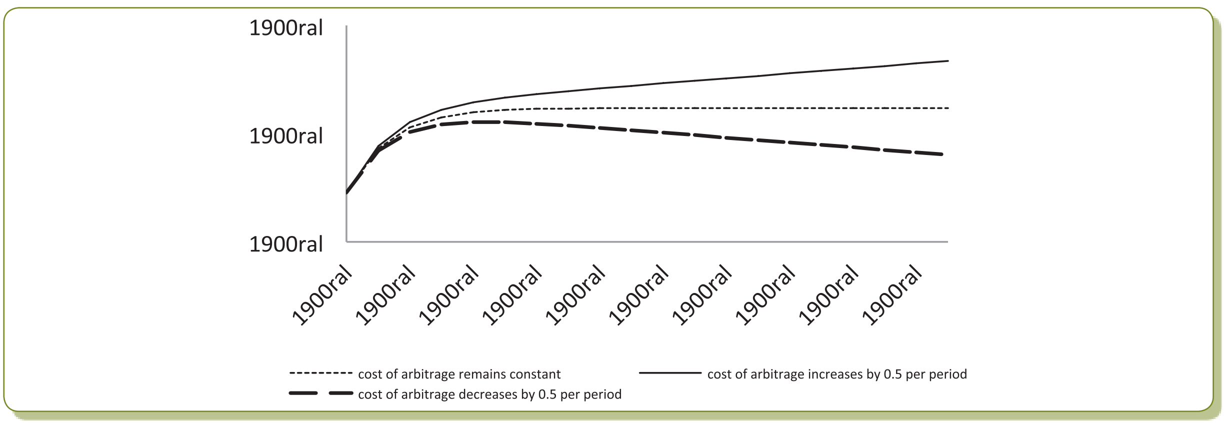
Table 1: Intra-commodity long-run multiplier and speed of convergence (in parentheses).

Products	Central markets	Agadez	Dosso	Maradi	Tahoua	Tillaberi	Niamey
Maize	Tahoua	0.967 (9)	0.916 (6)	0.976 (6)		0.477 (12)	0.939 (5)
Rice	Maradi	0.688 (6)			0.768 (6)		0.972 (13)
Sorghum	Maradi		0.825 (3)		0.850 (9)	0.936 (9)	

The final parameter that we need to compute the time path of the price adjustment in local staple food markets is the change in arbitrage costs (ΔT_t). We first estimate Equation (9) assuming that the cost of arbitrage is constant, $\Delta T_t = 0$. We next run two scenarios assuming alternatively a rise in arbitrage costs of 0.5 FCFA and a decrease of 0.5 FCFA per period. The purpose here is to illustrate the impact of government interventions that may exacerbate or mitigate the magnitude of shocks by raising costs of arbitrage in local markets. A good example of an intervention that may increase arbitrage costs is the decision to restrict operations by private traders or restrict the movement of food staples in the wake of crises.

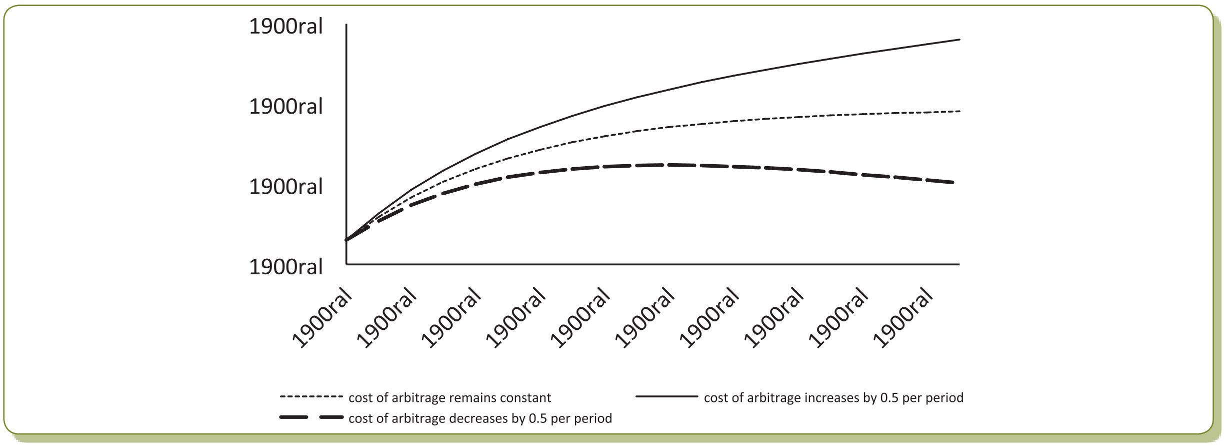
Figures 1-3 show the simulated time path of adjustment in prices for maize and sorghum in local markets across Niger resulting from changes in the global price for rice, transmitted via price changes in the Maradi rice market. As can be seen from all three graphs, the effect of the shock resulting from global rice prices on the prices of local non-traded staples such as maize and sorghum extend beyond the first period, which corresponds to the time it takes for the long-run multiplier that is estimated in the conventional market integration analysis to converge. Without changes in arbitrage costs (the middle line), it takes 2 to 3 periods for the impact on prices to stabilize. The tables in the annex show the evolution of price changes through the first three periods for various markets. It is interesting to observe from the figures that, with the exception of the capital city area of Niamey, the rise in prices for the two non-traded staples (sorghum and local maize) exceeds in all markets the increase in the price of rice, the traded commodity. More importantly, these prices tend to be "stickier," as the increase in the price of rice decelerates much faster. For example, the rate of increase in the price of sorghum in Tahoua of 14% in the first period falls to 10% and 8% in the second and third period. In the case of rice, the rates of price increase in the same market are 11%, 8%, and 6% for the three periods.

Figure 1: Time path of maize prices in FCFA per Kg for Tillabery.



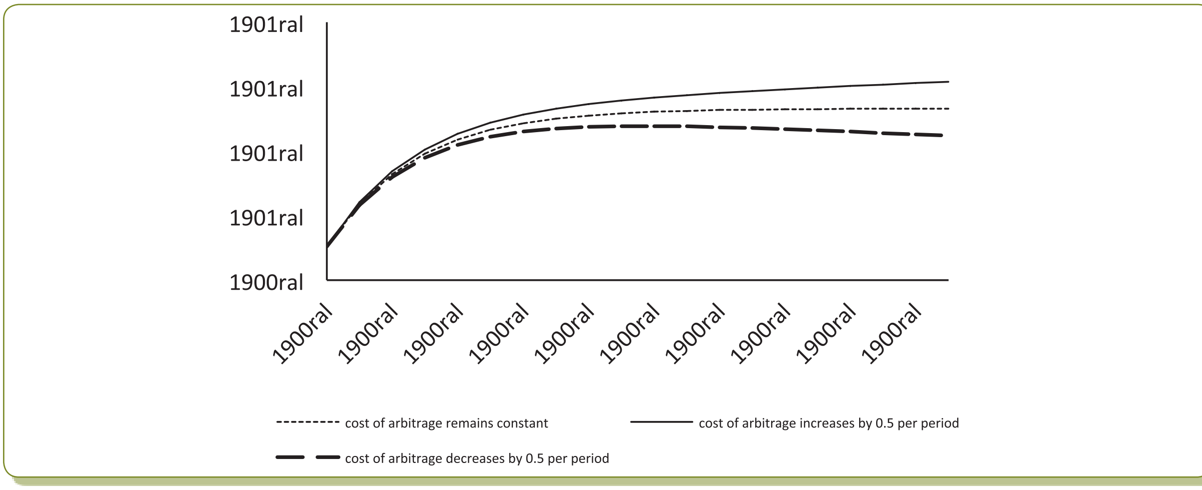
Source: Author's simulations.

Figure 2: Time path of sorghum prices in FCFA per Kg for Dosso.



Source: Author's simulations.

Figure 3: Time path of rice prices in FCFA per Kg for Agadez.



Source: Author's simulations.

4. Conclusion

As indicated by the results discussed above, the model presented here makes three contributions. First, it analyses the impact of changes in global food prices on the prices of non-traded food staples. Second, it shows that the response of local prices to shocks originating in other markets lasts longer than suggested by findings from the traditional market integration analysis. Rather than simply analyzing the mechanism of correction after a shock, the model captures the changes in prices when the effect of the shock is completely absorbed. Thirdly, it provides a base for simulating not just the extent of price adjustment in local markets but also the time path of adjustment. While the simulation cannot predict the exact value of future prices, it can provide a general indication about the evolution of prices. This is by far more valuable information for policymakers than just a parameter quantifying the degree of market interconnectedness. The simulated trajectory of future price adjustment can be used by policymakers to better anticipate the behavior of commodity prices across locations and through time. This in turn allows them to prepare more effective response strategies to global price shocks.

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Endnotes

1 See Badiane & Shively, 1998.

Annexes

Annex 1: Simulated prices changes for maize.

	AGADEZ	DOSSO	MARADI	TILLABRI	NIAMEY
Period 1	10%	14%	15%	6%	14%
Period 2	8%	12%	13%	3%	11%
Period 3	8%	9%	11%	1%	10%

Annex 2: Simulated prices changes for sorghum.

	DOSSO	TAHOUA	TILLABRI
Period 1	13%	14%	13%
Period 2	9%	10%	11%
Period 3	7%	8%	9%

Annex 3: Simulated prices changes for rice.

	AGADEZ	TAHOUA	NIAMEY
Period 1	10%	11%	16%
Period 2	6%	8%	13%
Period 3	4%	6%	11%

Management of Market Risk for Fruits: propositions, analyses and reflections on Juazeiro Producer Market, Bahia, Brazil

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Abstract

The aim of this paper is to demonstrate that the Brazilian fruits, especially whose traded at Juazeiro Producer Market (JPM), have the potential to use financial tools, in a view to minimizing their risk of price, given that they still cannot be classified as a commodity, and therefore do not enjoy the hedging mechanisms available in the futures or options markets. On the other hand, a recent study has indicated the feasibility to implement future market for fruits, given that the characteristics of volatility and market size were considered positive for the success of future contracts (FERREIRA; SAMPAIO, 2009). The results of this paper showed that regarding the use of time series for forecasting future prices, the ARIMA method proved effective, since most fruits showed correlation between the price series current and forecasted above 0.70 and the Theil's U coefficients below 0.10. Regarding the use of VaR to indicate the level of risk in the returns of fruits prices, the Historical Simulation proved the most effective technique, followed by Monte Carlo Simulation, the Autoregressive Conditional Volatility and Exponentially Weighted Moving Average. Moreover, it was also possible to identify the probability distribution functions and λ factors decay, as well as three risk groups among fruits (low, intermediate and high), statistically different. What about the use of hedging, the simulations showed its applicability, since it found optimal hedge ratios between 73% and 98%, with effectiveness ranging between 13% and 80%. Theoretically, it was possible to show a quadratic relationship (with downward concavity) between the maturity of hypothetical futures contract (or lag) and the optimal ratio/hedge effectiveness.

Keywords: Price Risk Management; time series; Value-at-Risk; hedging strategies; fruits.

1. Introduction

Agribusiness is one of the economic activities in Brazil that has received increased attention in the media, as well as the attention of researchers, scholars and investors even in times of economic crises. This is because, at least in the last decade, its participation in the Brazilian economy: an average of 24% in GDP (CEPEA, 2012), achieved 189% growth in exports (BARROS; ADAMI, 2013) and had a 47% growth in generation jobs, an average of 29,769 jobs/year (BRASIL, 2013). Furthermore, agribusiness can be considered an activity that plays better internal policies of development, because it contributes significantly to the reduction of migration and reducing population pressure in the capitals and metropolitan areas (NEVES; CONEJERO, 2007; MACEDO; LIMA Jr.; MORAIS, 2012).

The various reasons for such a significant share of agribusiness in the national and worldwide trade can be grouped into three levels (NEVES; CONEJERO, 2007): (1) Expressive increase of global demand and prices of some commodities, resulting in augmented consumption for food and energy (BRANDÃO; ALVES, 2007; BRANDÃO, 2011, 2012), (2) the improvements in productivity, which technology is the main determinant of the growth of Brazilian agricultural production with temporal effect lasting, explaining about 67% of production (ALVES et al., 2012), (3) the magnitude of exports of multinational companies with own markets or national agribusinesses in the process of internationalization, which transaction is carried out by international trading companies responsible for this in its various segments, targeting a vertical international production chain of agribusiness (BENETTI, 2004, 2006).

Although the results still indicate a promising prospect of expanding agribusiness, it is important to note that the performance of certain products that the Brazil trades depends not only on the direct application of technological advancements in the production area or governance structures for trading, but it is also influenced by external factors to some extent difficult to predict or control, such

as past volatility of prices, price trends, inventory levels, production levels, price transmission between products, exchange rate volatility, volatility fuel prices, the degree of export concentration and volatility of interest rates (BALCOMBE, 2010), as well as climate (MURPHY et al., 2012). The listed factors have great influence on the final price of the agricultural product for the consumer market (both on level and volatility), and most of the producers may feel difficult to plan production and establish a suitable final price (ROACHE, 2010), which makes it necessary for organizations agribusiness greater attention to these topics.

In case of fruits, although they may be standardized for the markets, with the attestation of certificates and seals, their units may be sold in standardized packets and their delivery dates established in agreements between buyers and sellers, these goods are perishable, which undertakes the long-term storage, which fact in the current paradigm that rules the futures markets, precludes its classification as a commodity, and therefore does not enjoy the hedging mechanisms available in the futures or options markets. That it said, these products are sold on the spot market, and even if your purchase will be repeated, there is no guarantee of future purchase (AZEVEDO, 2007). Therefore, in addition to external factors cited, such characteristics also contribute to increase the dose of uncertainty in the behavior of prices of some agricultural products, which is the case of Brazilian fruits traded in wholesale.

Thus, understanding how is the behavior of prices becomes important for domestic fruit growers because this variable attempts to summarize, in a single value, all relevant information for effective trading, as explained by Elder (1993, p.46): *"Each price represents a momentary consensus of value between buyers, sellers, and undecided traders at the moment of transaction. There is a crowd of traders behind every pattern in the chartbook"*. Moreover, Murphy et al. (2012) suggest that the use of financial tools in the management of price and production risks can help to mitigate financial losses across the agribusiness system. However, in the literature, is perceived the tiny and little empirical disclosure of its effectiveness when the research focuses are fruits.

In this sense, the aim of this paper is to demonstrate that the Brazilian fruits, especially whose traded at Juazeiro Producer Market (JPM), have the potential to use financial tools in a view to minimizing the risk of price, considering that it has defining characteristics for their use (particularly price volatility), which would contribute to the emergence of a more stable economic environment for growth and investment in the sector, as it is seen for agricultural commodities traded on futures and commodities markets, and may even materialize in its future the recommendation suggested by Gilbert and Morgan (2010, p.3032): *"Futures and options markets instead provide a means to hedge price risk that is far cheaper than the alternative use of forward contracts and major exchanges"*.

2. Theoretical support

The first evidence for using financial tools for fruits can be seen in Ferreira and Sampaio (2009) work, which they developed an exploratory study for verifying the feasibility of implementation of futures markets for fruits, especially for the grape and mango produced and exported from São Francisco Valley (located at Northeast Region in Brazil), as an alternative to the spot market, presenting so a solution that would contribute in leveraging its exports. Its advantage is that it would allow the transfer of price risk from the growers to market operators that would be likely to accept it, seeking potential future gains. Moreover, this fact would contribute in the process of price discovery by economic agents, which would improve efficiency, competitiveness and price negotiations between producers/exporters and fruits consumers, in this new paradigm.

Thus, Ferreira and Sampaio (2009, p. 94), in their initial findings, found that it would be feasible to implement future market for fruits, given that the characteristics of volatility and market size were considered positive for the success of future contract for fruits (with different weights for grape or mango). However, the authors suggest conducting further studies on this subject, because the decision model that they used to reach these conclusions was deterministic, which dismissed the uncertainty on the evaluation results, this being its main limitation.

On the other hand, since it was identified positive intentions regarding implementation of futures market for Brazilian fruits exported (FERREIRA; SAMPAIO, 2009), is important for the maintenance of this discussion, the definition of methodologies for measuring and managing the degree of volatility that fruit prices have, in order to verify the effectiveness of current available financial tools to manage its price risk. One of the most common mechanisms

that offer a protection against price volatility in the spot market and the consequent connection with the futures market is hedging. In fact, its operation depends on the positive and perfect correlation between the projected prices for the futures market and the price actually charged by the spot market (AZEVEDO, 2007; HULL, 2012). Once there are no futures markets for fruits, it is necessary to build forecasting models in order to estimate the correlation between futures and spot prices.

To do so, it is proposed the use of time series analysis to estimate future prices for fruits, since the econometric model constructed to perform the prediction allows the analyzed data “speak for themselves”, without recourse to a specific underlying theory to enable their interpretation (BOX; JENKINS; REINSEL, 1994). In fact, the idea of using prediction models of time series as a decision making tool in operations with agricultural futures contracts in Brazil was first presented by Bressan (2004), who produced forecasts of spot market prices to signal positions of purchase and selling in the futures market. His results showed that the ARIMA and Linear Dynamical Models (LDM) are best suited for signaling market trend with a view to transactions in futures contracts.

However, the correlation between spot and future prices by time series tends to not be perfect, making residual risk persists in potential hedging operations. This fact happens because hedging strategies have difficulties to capture price risk. To measure and understand it better, it is used Value-at-Risk (VaR), which result is a monetary value that shows the price risk of cash flows and financial position taken. In other words, its concept determines the maximum that an asset (financial or otherwise) can lose in a given period of time, with a certain degree of confidence predetermined (RISKMETRICS GROUP, 1996; JORION, 2007). Regarding to fruits, Wang, Zhao and Huang (2010) were pioneers in applying VaR methodology in China to calculate their probability distribution functions and the price risk associated with them, which results point to the effectiveness of VaR of its requirements. In fact, the main characteristic of VaR is the facility of understanding of those involved in the decision process, which are not always familiar with certain financial and economics concepts and complex formulas.

Once better understood price risk present in fruits, the next step is to identify the optimal ratio of the quantity traded that should be protected through hedging. In this regard, Azevedo (2007) shows that between two extreme options of (a) allowing operations on the spot market without any hedging (100% risk of price and 0% baseline risk - 0) and (b) to hedge the entire production (0% risk of price and 100% of baseline risk - 1), there are strategies for partial hedging (hedging in only part of production), which are less costly than the full hedging and offer less risk to the producer. This is because the baseline risk hasn’t a strictly positive linear relationship of trade-off risk/return: there are situations that increasing the level of hedging implies an increased risk of operation. Assuming that H is the percentage of production that will be object of hedging, ranging from 0 to 1, there will be a point H^* whose optimal trade-off cease to exist, in which an increase in the level of hedging beyond that point would imply an increase in the baseline risk.

In Brazil, Oliveira Neto, Figueiredo and Machado (2009) found that the hedging of corn for the State of Goiás allowed reduction of about 70% of its price risk, with optimal hedge ratios of 85.10% for the season and 80.98% for the offseason. For soybeans produced in the states of Goiás and Mato Grosso, Medeiros, Wande and Cunha (2013) found, respectively, optimal hedge ratios of 53.88% and 69.44%, and effectiveness in the order of 42% and 53%. These results illustrate the level of risk exposure that these products are, demonstrating evidences for the importance of the use of hedging to manage price risk in agricultural commodities, which also could be extended to fruits.

3. Methodology

The locus of the study was the Juazeiro Producer Market (JPM), located in Juazeiro city, state of Bahia, which is the fourth largest warehouse of horticultural products in Brazil and the largest in the Northeast region, working as a gravitational centre of regional trading for surrounding cities. Regarding data collection, these happened with the Administration of JPM, where it sought the fruits average prices in R$ traded between January/2001 and December/2011, totalling 132 monthly observations for fruit. It is important to say that JPM, although has such data, it doesn’t make any statistical or econometric analysis. The selection criterion chosen for the sample was continuity, i.e., it was listed only the fruits that were sold in each month of the period Jan/2001-Dec/2011. In this scope, 21 fruits were selected from among 45 alternatives, representing an average of 84% of the total value traded, presented in Table 1.

Table 1: Fruits selected for analysis.

Acerola	Coconut	Mango
Avocado	Domestic Apple	Orange
Casaba Melon	Dried coconut	Papaya
Chunkey Banana	Guava	Passion Fruit
Pacovan Banana	Italian Grape	Pear
Pineapple	Lemon	Tommy Mango
Cavendish Banana	Lime	Watermelon

Source: JPM (2012).

Regarding the construction of time series of each fruit, it was used ARIMA method proposed by Box, Jenkins and Reinsel (1994), which consists of three stages: identification, estimation and diagnosis of the chosen model. To use this method, it is necessary that the time series be stationary, whose verification is given by the Augmented Dickey-Fuller test (ADF). In case of non-stationarity, it was calculated the first difference of the time series and applied again the ADF test. The estimation and diagnosis occurred concomitantly. After observing the correlogram and autocorrelation and partial autocorrelation functions, it was tried to build a model AR (p), MA (q) or ARMA (p, q) which had the lowest Bayesian Information Criterion (BIC). In this same field, may also be considered using multiplicative seasonal models [SARIMA (p,d,q)x$(P,D,Q)_s$] in case they were needed. Then it was verified the absence of serial autocorrelation on residuals by Ljung-Box test, and the presence of heteroskedasticity on squared residuals of models built, by Lagrange Multiplier proposed by Engle (1982). Once identified, it was applied ARCH(r) (ENGLE, 1982) or GARCH(r,s) (BOLLERSLEV, 1986) models, whose choice also was by the lowest BIC found. Table 2 summarizes the equations used for time series analysis.

For the calculation of VaR, it used the methods of Historical Simulation, Monte Carlo Simulation, Exponentially Weighted Moving Average (EWMA) and Autoregressive Conditional Volatility (HENDRICKS, 1996; RISKMETRICS GROUP, 1996; JORION, 2007; HULL, 2012), with a monthly time and 95% confidence, to calculate the risk associated with continuously compounded returns (or the natural logarithm of simple returns: r) found in the fruits prices series, with 131 observations. In Historical Simulation, VaR is the eighth return ordered increasingly; in Monte Carlo Simulation, VaR is the value corresponding to 5% of the probability distribution function that best fit the returns series, chosen by the Anderson-Darling goodness-of-fit test: Beta, BetaPERT, Exponential, Extreme Maximum, Extreme Minimum, Gamma, Logistic, Lognormal, Normal, Pareto, Student's t, Triangular, Uniform and Weibull; in EWMA, it calculated the coefficient lambda (λ) that minimizes the mean square error (MSE) between actual and fitted variance returns of series; in Autoregressive Conditional Volatility, it used ARCH/GARCH models that best predict conditional variances of series. In all cases it used the backtesting to gauge the effectiveness of the method, with the expectation that only seven observations exceed the calculated VaR (≅ 0.05*131). Table 3 shows the EWMA and MSE equations used in this study.

Table 2: Equations for time series analysis.

Model	Equation
AR(p)	$Y_t^* = \varphi_1 Y_{t-1}^* + \varphi_2 Y_{t-2}^* + \cdots + \varphi_p Y_{t-p}^* + \epsilon_t$
MA(q)	$Y_t^* = \mu - \theta_1\epsilon_{t-1} - \theta_2\epsilon_{t-2} - \cdots - \theta_q\epsilon_{t-q} + \epsilon_t$
ARMA (p,q)	$Y_t^* = \varphi_1 Y_{t-1}^* + \varphi_2 Y_{t-2}^* + \cdots + \varphi_p Y_{t-p}^* - \theta_1\epsilon_{t-1} - \theta_2\epsilon_{t-2} - \cdots - \theta_q\epsilon_{t-q} + \epsilon_t$
SARIMA (p,d,q)x$(P,D,Q)_s$	$\varphi_p(B)\Phi_P(B^s)\nabla^d\nabla_s^D Y_t^* = \theta_q(B)\Theta_Q(B^s)\epsilon_t$
ARCH(r)	$h_t = \alpha_0 + \alpha_1 X_{t-1}^2 + \cdots + \alpha_r X_{t-r}^2$
GARCH (r,s)	$h_t = \alpha_0 + \sum_{i=1}^{r}\alpha_i X_{t-i}^2 + \sum_{j=1}^{s}\beta_j h_{t-j}$

Source: Box, Jenkins and Reinsel (1994); Engle (1982); Bollerslev (1986).

Table 3: Equations for VaR calculated by EWMA.

Model	Equation
EWMAa	$\sigma_t^2 = \lambda\sigma_{t-1}^2 + (1-\lambda)r_{t-1}^2 = (1-\lambda)\sum_{i=1}^{m}\lambda^{i-1} r_{t-i}^2 + \lambda^m\sigma_0^2$
MSE	$MSE = \frac{1}{T}\sum_{t=1}^{T}(r_t^2 - \sigma_t^2)^2$

Source: Riskmetrics Group (1996); Jorion (2007); Hull (2012).

Finally, the optimal hedge ratio that could be employed in case of hedging existence for fruits was calculated by the method of Minimum Variance (MV) proposed by Johnson (1960):

$$H^* = \frac{Cov(\Delta S, \Delta F)}{Var(\Delta F)} = \rho \frac{\sigma_s}{\sigma_f}$$

Where ΔS is the variation of spot prices; ΔF is the variation of predicted prices by time series; ρ is the correlation coefficient between ΔS and ΔF; σ_s e σ_f are, respectively, the standard deviation of ΔS and ΔF. The measurement of hedge effectiveness considered in the study is ρ^2, which means that the larger the square of correlation ΔS and ΔF, the greater the percentage reduction of the variance of change in prices from decision hedging, which shows a greater reduction of risk. For the Δ price variation, they were considered lags 1-12 months, in order to also verify if the optimal hedge ratio approaches the naïve hedge when the hedging horizon increases, as hypothesized by Chen, Lee and Shrestha (2003).

4. Data Analysis

Table 4 shows the results of equations for the time series of fruits prices, which are shown in its reduced format, with C indicating the presence of a constant. All coefficients have shown statistical significance of, at least, 10%. With the exception of Tommy Mango, all other price series are non-stationary, which required the calculation of its first difference to become stationary. In all equations was eliminated the effect of serial autocorrelation of residues, whose final shape has the lowest Bayesian Information Criterion (BIC) found. Regarding heteroskedasticity, it was identified in six fruits, in which the ARCH/GARCH models were applied as the case. On the stochastic multiplicative seasonality (SARIMA), it was identified in seven fruits, being mostly an annual seasonality.

Also on Table 4, it can be seen that 17 fruits showed correlations between actual and expected series of prices above 0.70, which can be considered high, while for the other four fruits, their correlations are between 0.63 and 0.68, and may be classified as moderate, according to Hair et al. (2005, p.312). As for the Theil's U coefficient, this measure indicates the predictive accuracy of the time series equation: the closer to zero, the better. In this sense, it is observed that 13 fruits have values below 0.10, indicating a significant predictive capability of models. Furthermore, although eight fruits have surpassed 0.10, none of them exceeds the value 0.17, which may also be classified with good predictive power of the series of prices, considering this study as exploratory. In general, it was possible to certify the applicability of ARIMA method for the construction of the series of expected fruits prices, which are understood from now as their future prices.

Table 4: Results of time series equations for fruits.

Fruit	Equation	Theil's U	Correlation
Acerola+	AR(1) AR(2) AR(3) AR(4) MA(5) *GARCH (1,1)*	0.1386	0.6314
Avocado*	C AR(1) AR(3) SAR(12) MA(1) SMA(12)	0.0934	0.9153
Casaba Melon	C AR(1) AR(2) MA(1)	0.1651	0.6431
Cavendish Banana	AR(1) AR(2) AR(4) AR(8)	0.0581	0.8786
Chunkey Banana	C AR(1) AR(3) MA(1)	0.0795	0.8882
Coconut	C AR(1) AR(3) AR(4) AR(5) MA(1) MA(2) MA(3)	0.0699	0.9315
Domestic Apple*+	MA(1) MA(3) MA(5) SMA(12) *ARCH(1)*	0.0734	0.7744
Dried coconut	C AR(1) AR(2) AR(3) MA(1) MA(2) MA(3)	0.0747	0.8884
Guava	C MA(1) MA(3) MA(4)	0.0659	0.9490
Italian Grape	C AR(1) MA(1)	0.0652	0.8824
Lemon*	AR(1) AR(2) SAR(12) MA(1) SMA(12)	0.1185	0.8258
Lime*	AR(1) AR(2) SAR(12) MA(1) SMA(12)	0.0883	0.8912
Mango*	C AR(1) AR(2) SAR(6) MA(1) MA(2) MA(3) MA(4) MA(5) SMA(6)	0.1247	0.7810
Orange+	C AR(1) AR(2) MA(1) *ARCH(1)*	0.0763	0.8670
Pacovan Banana*	AR(3) AR(6) AR(7) SAR(12) MA(4) MA(8) MA(9) SMA(12)	0.0472	0.9260
Papaya+	MA(1) MA(2) ARCH(3)	0.1085	0.6798
Passion Fruit	C AR(1) MA(1)	0.1112	0.7830
Pear	AR(1) AR(2) AR(3) MA(1) MA(2) MA(3)	0.0595	0.8221
Pineapple+	C AR(1) MA(1) ARCH(2)	0.0687	0.8762
Tommy Mango*	C AR(1) SAR(12) MA(4) SMA(12)	0.1591	0.7537
Watermelon+	C MA(1) MA(2) ARCH(1)	0.1454	0.6773

Note: * has seasonality; + has heteroskedasticity.

Table 5 shows the results of VaR for the fruits prices series. Regarding Historical Simulation (HS), Monte Carlo Simulation (MS), Exponentially Weighted Moving Average (ES) and Autoregressive Conditional Volatility (GS) methods, it is shown the number of times that returns exceed calculated VaR in each case, whose expected value is seven observations. Importantly, the HS and MS methods consider a single VaR for the entire price series (also shown in Table 5), whereas the ES and GS methods recalculate VaR for each new data inserted in the fruit price series.

When applying backtesting, it was found that HS was the method that best met the expectation of seven observations, showing VaRs that meet the condition of 95% confidence for one month. Moreover, it is possible to divide the fruits into three risk groups, which are statistically different from each other: the first, lower risk, has values between -12.28% and -20.36%; the second, intermediate risk, contains values between -21.77% and -31.82%; and the third, highest risk, has values between -33.96% and -50.99%. Pineapple is the fruit with the lowest risk, Chunkey Banana is the median and Tommy Mango presents the greatest risk to returns of fruit price series.

Regarding VaR obtained by MS, it was underestimated in nine cases [see values above seven], overestimated in nine cases [see values below seven] and met expectations in three cases. However, an important information achieved by this method were the probability distribution functions of returns found, in which the logistic distribution was predominant (12 times), followed by Student's t (5 times), the Lognormal (3 times) and the Weibull (once). Since the Normal distribution has not been identified, it is important to say that the initial proposal of VaR presented by RiskMetrics Group (1996) should be adjusted for data probability distribution functions, as observed in the Wang, Zhao and Huang (2010) paper. And since the decision makers tend to be averse to losses, the VaR overestimation reveals its positive side, indicating that adjusted Monte Carlo simulation showed results more pros (12) than cons (9).

Considering VaR obtained by ES, it was 17 times underestimated, overestimated three times and met expectations once. Such adverse outcome may have

Table 5: Results of VaR for fruits (converted to simple returns).

Fruit	HS	MS	ES	GS	λ	VaR HS	VaR MS	DPF
Pineapple	7	4	5	5	0,971	-12,28%	-17,36%	Logistic
Italian Grape	7	4	10	-	0,976	-15,45%	-19,84%	Student's t
Orange	7	6	8	6	0,966	-16,67%	-19,11%	Logistic
Pacovan Banana	7	8	9	-	0,952	-17,31%	-17,15%	Lognormal
Cavendish Banana	7	8	8	-	0,940	-18,42%	-18,25%	Logistic
Guava	7	6	11	-	0,921	-20,24%	-22,64%	Weibull
Pear	7	9	9	-	0,893	-20,36%	-18,72%	Logistic
Domestic Apple	7	8	9	8	0,768	-21,77%	-21,50%	Logistic
Dried coconut	7	4	6	-	0,967	-21,79%	-30,31%	Student's t
Coconut	7	7	11	-	0,958	-23,08%	-23,12%	Logistic
Chunkey Banana	7	5	9	-	0,854	-24,12%	-21,81%	Lognormal
Papaya	7	6	12	8	0,943	-26,67%	-27,45%	Logistic
Avocado	7	12	5	-	0,558	-29,67%	-27,89%	Logistic
Watermelon	7	6	14	8	0,505	-31,82%	-38,00%	Logistic
Lime	7	8	8	-	0,949	-33,96%	-33,56%	Lognormal
Passion Fruit	7	10	13	-	0,952	-37,50%	-33,56%	Logistic
Mango	7	8	15	-	0,958	-40,98%	-40,05%	Student's t
Lemon	7	7	9	-	0,941	-43,18%	-43,68%	Logistic
Casaba Melon	7	7	13	-	0,919	-44,44%	-44,63%	Logistic
Acerola	7	9	13	9	0,850	-48,60%	-37,61%	Student's t
Tommy Mango	7	5	7	-	0,948	-50,99%	-55,37%	Student's t

been caused by the use of Normal distribution in VaR calculation, since EWMA provides one of its parameters, which is the estimated standard deviation. Moreover, the use of ES allowed the calculation of λ coefficient that minimizes the Mean Square Error (MSE), in which one can check if the previous estimate σ^2_{t-1} or the most recent observation of variation r^2_{t-1} receives the highest weighting. The results show that 15 fruits had λ coefficients above 0.90 and four obtained λ values between 0.76 and 0.90, indicating that the previous estimate σ^2_{t-1} has greater importance in predicting the σ^2_t current estimate. However, in the case of avocado and watermelon, λ values are close to 0.50, showing that both previous estimate r^2_{t-1} as the most recent observation of r^2_{t-1} variation are prevalent in σ^2_t current estimate.

As for VaR obtained by GS, it was underestimated in four cases, in two cases overestimated and met expectations in any case, which use has happened only in case of heteroskedasticity detected in the fruits prices series. Interestingly, in which of the six cases identified, five were ARCH(r) models, showing the prevalence of the most recent r^2_{t-1} observation in σ^2_t prediction, whereas in single valid GARCH(r,s), the previous estimate σ^2_{t-1} has greater importance in predicting the σ^2_t current estimate. In all cases, their results were equal or better than showed by ES.

Tables 6 and 7 show, respectively, the results of the optimal ratio and hedging effectiveness for fruit sold monthly in JPM, if the equations found in Table 4 reflect the prices of futures contracts hypothetically traded, since they do not currently exist. To further explore the issue, it is admitted the use of futures contracts with maturities (or lags) between 01 and 12 months, monthly marketed and without the option of early maturity. It was not considered the transaction costs involved. The acerola was not considered in this stage because their correlation coefficients, at all lags, were negative, precluding the use of hedging in its context.

Table 6: Results of optimal hedge ratio for fruits (%).

Fruit/Lag	1	2	3	4	5	6	7	8	9	10	11	12	R^2
Acerola	-	-	-	-	-	-	-	-	-	-	-	-	-
Avocado	41	97	112	124	122	124	123	121	112	100	96	88	80
Casaba Melon	-	109	114	142	116	141	132	124	110	100	97	87	77
Cavendish Banana	-	38	52	75	63	61	75	77	73	69	77	64	71
Chunkey Banana	-	69	89	108	113	112	110	112	100	91	75	60	97
Coconut	35	72	94	103	109	110	113	108	103	104	99	102	86
Domestic Apple	-	48	87	83	94	97	95	90	81	71	73	40	85
Dried coconut	-	72	82	88	91	101	104	104	111	110	113	109	98
Guava	06	58	83	97	103	107	108	109	103	103	113	110	86
Italian Grape	-	50	64	79	79	87	83	80	80	75	66	66	87
Lemon	73	108	112	114	113	113	112	111	113	112	100	65	75
Lime	71	97	106	109	107	109	108	107	105	104	98	81	83
Mango	29	88	106	110	103	107	108	109	100	90	89	64	77
Orange	09	88	95	105	111	114	115	108	111	100	107	100	73
Pacovan Banana	38	72	88	94	93	98	101	97	96	89	80	70	90
Papaya	-	26	32	44	56	58	52	75	58	74	69	74	87
Passion Fruit	-	41	74	80	97	92	83	102	77	84	88	96	57
Pear	06	65	81	94	88	92	80	86	71	72	66	66	66
Pineapple	-	39	59	69	75	76	80	77	78	77	74	72	91
Tommy Mango	35	77	91	100	100	101	101	104	103	101	111	113	78
Watermelon	-	92	58	84	74	71	56	67	55	60	69	57	44

Table 7: Results of hedge effectiveness for fruits (%).

Fruit/Lag	1	2	3	4	5	6	7	8	9	10	11	12	R^2
Acerola	-	-	-	-	-	-	-	-	-	-	-	-	-
Avocado	09	46	60	70	68	68	69	66	54	45	48	35	81
Casaba Melon	-	24	24	31	23	31	28	25	21	17	18	14	76
Cavendish Banana	-	08	18	29	25	26	36	36	32	31	37	30	82
Chunkey Banana	-	26	37	52	54	53	51	53	43	37	25	16	96
Coconut	11	44	63	70	77	75	78	74	68	68	62	65	83
Domestic Apple	-	14	38	37	45	47	46	41	35	26	24	10	91
Dried coconut	-	22	32	42	46	54	54	55	60	60	64	59	97
Guava	0	19	36	42	46	48	47	51	45	46	54	48	88
Italian Grape	-	10	17	26	26	32	30	28	29	26	21	22	88
Lemon	33	69	75	76	73	72	73	73	76	68	39	12	83
Lime	37	68	79	84	82	85	83	82	79	72	51	30	93
Mango	04	39	49	55	58	66	59	53	48	38	28	13	93
Orange	01	38	43	51	54	55	56	51	50	45	50	44	76
Pacovan Banana	16	50	68	75	75	80	81	76	71	61	49	39	93
Papaya	-	01	03	05	09	10	08	20	12	20	18	22	86
Passion Fruit	-	04	14	17	24	22	17	26	15	17	21	25	47
Pear	0	20	33	41	40	43	37	44	34	37	36	36	78
Pineapple	-	10	23	31	37	38	42	39	39	39	36	34	94
Tommy Mango	06	36	54	63	67	68	65	64	58	51	52	43	87
Watermelon	-	13	06	12	09	08	06	08	05	06	08	06	44

In practical terms, all optimal hedge ratios that exceeded 100% were excluded at this time, precisely because they contradict the theoretical assumptions that guide the hedging. That said, it tried to identify the maturities on these futures contracts that had the largest hedge effectiveness possible, as well as their percentage of the amount transacted that should be used of these contracts (the optimal ratio), whose results are highlighted by fruit tables above. Under these conditions, it was possible to note that the optimal hedge ratios ranged from 73% (lemon) to 98% (pacovan banana), accompanied by a range between 13% (watermelon) and 80% (pacovan banana) observed in the effectiveness of hedge. Moreover, it was also found that there was no indication for the use of futures contracts maturing in nine months, as described above.

In theoretical terms, it was tested the hypothesis formulated by Chen, Lee and Shrestha (2003), which says that as the hedging horizon increases (i.e., the maturity of futures contracts), the optimal hedge ratio approaches to the naïve hedge. At this stage, all the results in Tables 6 and 7 were considered in the analysis. Therefore, it was observed that as the maturity of futures contracts increased, the optimal hedge ratio increased to some extent, often reaching their maximum above the naïve hedge, and then begin to decrease, suggesting the existence of a quadratic relationship between variables, such as: $H^* = -a(Lag)^2 + b(Lag) + c$. It is also important to say that the same phenomenon was observed between the maturity of the futures contracts and hedging effectiveness. To confirm this observation, the equation was tested by the Ordinary Least Squares (OLS), which coefficient of determination R^2 is the last column of Tables 6 and 7, being statistically significant at the 5% confidence level, in all cases. Since the coefficient of determination R^2 was above 0.70 in 17 fruits regarding the optimal ratio, and 18 fruits regarding the effectiveness, it was possible to confirm the existence

of a quadratic relationship (with downward concavity) between the maturity of the contract (or lag) and the optimal ratio/hedge effectiveness for the fruits here investigated. The only exception is watermelon, which result indicated an upward concavity, indicating an opposite effect to the mentioned above.

5. Conclusion

The aim of this paper was to demonstrate that the Brazilian fruits, especially whose traded at Juazeiro Producer Market (JPM), had the potential to use financial tools in a view to minimizing their risk of price.

Regarding the use of time series for forecasting future prices, the ARIMA method proved effective, since most fruits showed correlation between the price series current and forecasted above 0.70 and the Theil's U coefficients below 0.10. Regarding the use of VaR to indicate the level of risk in the returns of fruits prices, the Historical Simulation proved the most effective technique, followed by Monte Carlo Simulation, the Autoregressive Conditional Volatility and Exponentially Weighted Moving Average. Moreover, it was also possible to identify the probability distribution functions and λ factors decay, as well as three risk groups among fruits (low, intermediate and high), statistically different. What about the use of hedging, the simulations showed its applicability, since it found optimal hedge ratios between 73% and 98%, with effectiveness ranging between 13% and 80%. Theoretically, it was possible to show a quadratic relationship (with downward concavity) between the maturity of hypothetical futures contract (or lag) and the optimal ratio/hedge effectiveness.

Finally, the expectation of this study is that its results would stimulate discussion on the use of financial tools in agricultural products that are not yet formally classified as commodities, in order to extend the theoretical and practical on Futures Markets, and also contribute to the mitigating monetary losses that happen in these markets, providing perhaps a more stable economic environment for growth and investment to these sectors.

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APN 7
Food Security

Organizer and chair: Cheryl Christensen, USDA/ERS

Food security is a growing global concern, reflected in newinternationalinstitutionalarrangements,increased investment in food security at the national level, and a growing awareness of the interconnections with nutrition and sustainability. The challenges involved in developing statistical and information systems to support these efforts are of increasing salience to a wide audience—as evidenced by the development of the Global Strategy, significant investments in metrics on the part of USAID and other donors, innovation data collection and analysis programs in the World Bank, programs and conferences in FAO and data initiatives private voluntary organizations such as WFP. In addition, new national programs developed to improve food security based on cash transfers create new data challenges for developing countries. This session seeks to bring together a range of practitioners working on food security from a range of perspectives to assess the "state of the art" in their community of practice and facilitate discussion of ways to improve the development, sharing and analysis of high quality food security information. Topics to be explored could include innovations in the use of household level information measure food security and support food security programs and evaluation; contributions of national agricultural statistical systems to food security, data and information bases for food security monitoring systems, and evaluations of key differences across methods and levels of food security analysis.

Papers:

- Erdgin Mane, José VallsBedeau, Gary Jones (FAO), "The Evolving FAO Investment Dataset: statistics on resource flows to agriculture"
- Ankush Agrawal, Nilabja Ghosh, Badri S Bhandari (India), "Availability of Food and Nutrients in India: the food balance sheet approach"
- Elisabetta Aurino (United Kingdom), "Measuring Food Security: a structural equation approach"
- Sarah Andrade, Mônica Pires, Valéria, Santos et al. (Brazil), "Food Security: analysis on basic basket's items prices in the Northeast region of Brazil"
- Juliane Perini, Carmem Bocchi, Marconi Sousa et al. (Brazil), "Data SAN - multidimensional data and indicators for food and nutrition security in Brazil"

The Evolving FAO Investment Dataset: statistics on resource flows to agriculture

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Abstract

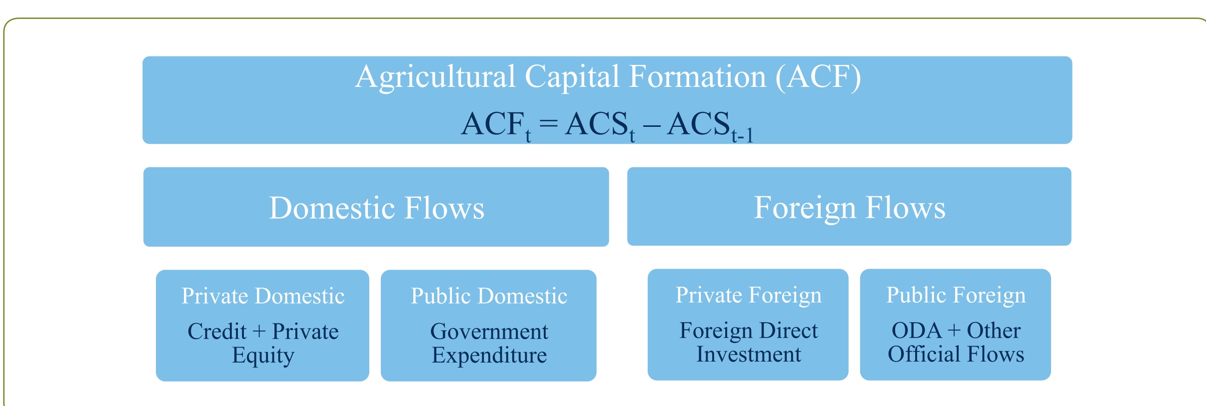
Creating a climate conducive to investments that both raise productivity levels and realise structural changes for generating additional food supplies and the incomes necessary for access to food continues to be a principal policy challenge. To support analysis of the related resource flows, FAO Statistics Division is developing a global Investment Dataset comprised of four main elements (Credit to Agriculture, Government Expenditure on Agriculture and Rural Development, Official Development Assistance to Agriculture, Foreign Direct Investment in Agriculture). Taken together, these resource flows and the overall manner in which they are mobilized directly impact inter-alia investment in the accumulation of agricultural capital stocks — as estimated by FAO — and the effectiveness of public or private and external or internal sector-based agricultural development activities, as reflected in the evolving FAO Score Cards initiative. This paper reviews strengthened efforts to monitor resource requirements for — and commitments to — agriculture at the global level. A key feature of this initiative is the harmonization of FAO work with that of other international organizations that are compiling relevant datasets.

Keywords: agriculture; investment; capital stock; credit; government expenditure; official development assistance; foreign direct investment.

Introduction: why monitor investment flows to agriculture?

Creating a climate conducive to investments that both raise productivity levels and realise structural changes for generating additional food supplies and the incomes necessary for access to food continues to be a principal policy challenge.[1] To support analysis of the related resource flows, FAO Statistics Division is developing a global Investment Dataset comprised of four main elements (Credit to Agriculture, Government Expenditure on Agriculture and Rural Development, Official Development Assistance to Agriculture, Foreign Direct Investment in Agriculture). Taken together, these resource flows and the overall manner in which they are mobilized directly impact *inter-alia* investment in the accumulation of agricultural capital stocks — as estimated by FAO — and the effectiveness of public or private and external or internal sector-based agricultural development activities, as reflected in the evolving FAO Score Cards initiative. This paper reviews strengthened efforts to monitor resource requirements for — and commitments to — agriculture at the global level. A key feature of this initiative is the harmonization of FAO work with that of other international organizations that are compiling relevant datasets, as presented in the following sections. The FAOSTAT's framework of agricultural investment flows is illustrated in the following hierarchical chart.

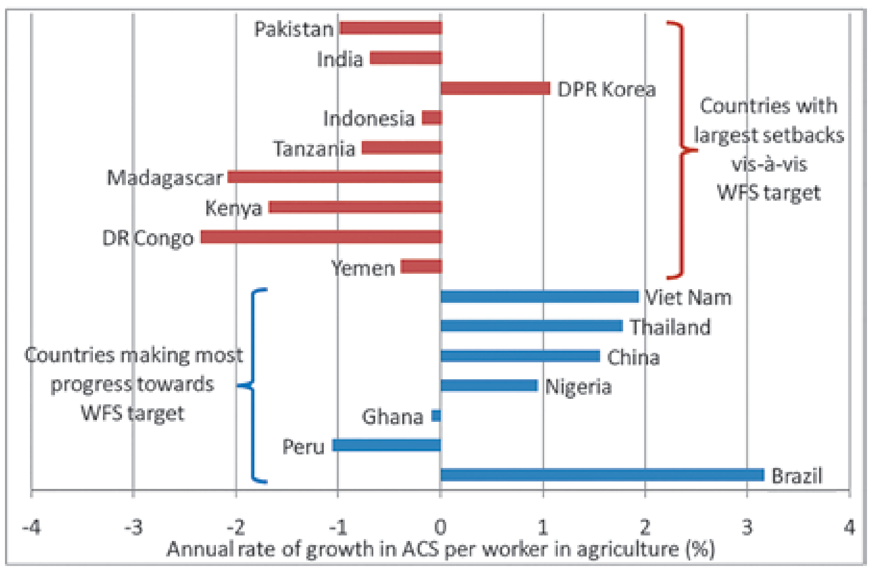
Figure 1: FAOSTAT's Agricultural Investment Data Framework.



1. Agricultural capital stock (acs)

Low capital stock per worker is reflected in low productivity per agricultural worker in agriculture, a defining characteristic of low-income countries. For agricultural labour productivity to grow, the amount of capital available for each worker (the capital-labour ratio) must grow. In many instances the gaps between high-income and low-income countries are widening as a result of low investment rates and/or growing labour forces in countries with low levels of agricultural capital per worker. As shown in Figure 2, there exists a strong correlation between investment, i.e. capital accumulation, in agriculture and hunger reduction in developing countries.

Figure 2: Annual rates of ACS growth (1990-2005): best and worst performing countries.



Source: Von Cramon-Taubadel et al. (2009).

The graph shows that all countries with the largest setback vis-à-vis the WFS goal (except DPR Korea) have a negative annual growth rate in **Agricultural Capital Stock (ACS)** per worker in agriculture for the period 1990-2005, while, an opposite patterns is shown for the countries with the highest progress.[2]

BOX 1: FAO ACS Methodological Enhancements.

FAO ACS data are constructed using several sources of information and their quality is only as good as the underlying data. FAO Statistics Division is therefore undertaking several actions to improve the quality of ACS data. The most important are:

- Extending, when possible, the use of national accounts data in the estimation of fixed capital.
- A revised and more detailed questionnaire on Agricultural Machinery and Equipment based on HS 2012 was sent to countries.
- Use, in future, of the Cost of Production questionnaire being implemented by FAO for improving the input data.
- Develop a methodology for obtaining the aging profile of machinery.
- Improve the estimation methodology for the present value of future revenues from permanent crops.
- Obtain country-level information on the price of arable and irrigated land.

In order to take into account the varying capital intensity and technology levels of the agricultural sectors in the different countries, data on capital stock per agricultural worker are essential. FAO has developed a comprehensive database on ACS, based on FAOSTAT's physical inventories. For the FAO approach to measuring ACS data, the concept of agriculture refers specifically to the activity of crop and animal husbandry for primary agriculture and includes the following components: land development, plantation crops, machinery and equipment, livestock, and structures for livestock. These data notably exclude the forestry and fishery subsectors as well as greenhouse production structures, mainly due to lack of information, which the Investment Dataset initiative will seek to address. As a result, current global FAO ACS estimates (Annex II) may under represent actual capital intensity when compared with the investments which encompass agriculture, forestry, and fishing activities more broadly.[3] FAO Statistics Division staff is investigating the availability and relevance of existing series that could support establishing linkages with the other data sets as highlighted in Annex I and discussed — with reference to only the agriculture component for Dominican Republic in 2007 — in Section VII, Building Country Profiles.

2. Credit to agriculture

Agriculture sector growth through credit (investment oriented loans provided by the banking sector) directly relate to the rate at which at which ACS is being accumulated and food security is enhanced over time. There is a diversity of areas of credit flows to agriculture. Inclusive credit flows aimed at improving the productivity of land, water, livestock and labour owning families as well as those aimed at enhancing the skills of agricultural workers on marginal holdings have been shown to support income generation. While in some countries many farmer households may be outside the formal financial system, data on credit extended to agriculture — including finance to corporations and firms for onward financing to farmers under agriculture (emerging farmers, commercial farmers as well as to agricultural cooperatives and agri-related businesses) — is generally available through monetary and financial statistics and can often serve as a benchmark indicator of private sector (primarily domestic) investment activity. FAO Statistics Division is developing a comprehensive credit to agriculture dataset that supports analysis of the destination (working or investment credit) of these flows worldwide. This dataset is constructed by harvesting official data from the Central Banks websites. While better data is needed in order to show whether its distribution is aligned with need, the amount of credit extended may also be influenced by flows pertaining to Government Expenditure on Agriculture and Rural Development, Official Development Assistance to Agriculture, and Foreign Direct Investment in Agriculture, each of which are discussed below.

3. Government expenditures on agriculture

Although most investments may be primarily mobilised by the farmers themselves, the public sector — general government units and public (financial and nonfinancial) corporations — has a critical role. The efficiency of these expenditures, whether measured in relation to agricultural GDP, to total government outlays, or the agricultural labour force, remains a key element of the overall policy mix. Well targeted government expenditures can create a conducive environment for private investment (economic incentives) and can ensure sufficient availability of public goods (basic rural infrastructure and market openness). This is particularly important because the role of government in economic activity may be scaled down in some countries over the coming decade owing to structural and fiscal reforms.

The share of **government expenditures on agriculture (GEA)** is not related in any simple way to the size of the agricultural sector, and depends *inter alia* on the overall importance given to economic functions in governments' budgets. By bringing together the data on agriculture's shares in GDP and overall government expenditure we can construct an ***"agricultural orientation index"*** which reflects the extent to which government expenditures on agriculture reflect (or not) the importance of agriculture in the overall economy. To construct the index, the share of agricultural expenditure in total government expenditure is divided by the share of agriculture in GDP. For these and other reasons, monitoring government outlays on agriculture and rural development remains important. Despite the clear need for comprehensive time series, data on government expenditures on agriculture and rural development remain scarce, making addressing key public policy issues a challenge.

To address the paucity of observations for developing and emerging market countries and to ensure comparable data that are aligned with international standards, the FAO Statistics Division in collaboration with the IMF Statistics Department has developed a questionnaire based on the *Government Finance Statistics Manual, 2001 (GFSM 2001)* methodology, in particular Table 7: Outlays by Function of Government from the IMF's annual questionnaire on fiscal statistics. FAO Statistics Division launched the questionnaire in 2012, designed to collect key data series for tracking the allocation of government expenditures to agriculture and rural development and related metadata, requesting a General Government (and its subsectors) time series for the period 2001 to 2011. These data will support better analysis of governments' policy toward agriculture, forestry, fisheries, and environmental protection. Annex I — with reference to only budget execution data for Dominican Republic in 2007 — presents the FAO GEA template and its potential for establishing linkages with the other Investment Datasets, as discussed in Section VII, Building Country Profiles.

4. External official flows to agriculture

Governments can often raise additional domestic resources through fiscal reforms, including reforms in the tax systems geared toward ensuring a friendly investment environment for both foreign and domestic private investors. However, a number of low-income, food deficit countries will still have to rely on external transfers and drawing on some measure of official finance resources to generate funds for agriculture.

Official Development Assistance to Agriculture (ODA-Agri) by the major bilateral and multilateral donors is an important complement to domestic resources. Among countries with the highest prevalence of undernourishment, external assistance to agriculture may account for much of gross domestic investment and government expenditures. Developing countries that are particularly in need ODA may particularly benefit when an increasing share is directed towards the agricultural sector and other related areas, in particular rural development and infrastructure, research, extension and training, and environmental protection. These flows could be either official or private — comprised of loans (financial transactions) and/or grants (concessional transfers) — and, over time, there can be dramatic change in the composition of these resources. Understanding the dynamics underlying the share of Agricultural and Rural Development (both the broad and the narrow definitions) in total ODA therefore requires a dataset that captures all contributions made by bilateral donors as well as multilateral assistance, where the share and geographic distribution of flows of concessional assistance in total commitments and disbursement for agriculture and the share of grants in total commitments may be compared/analysed.

The OECD Creditor Reporting System (CRS), which records ODA and Other Official Flows (OOF) at the project level, is currently the most comprehensive when considering the allocation of assistance to agriculture as well as other relevant sectors by recipient country and region. FAO Statistics Division, in consultation with OECD, is developing a comprehensive CRS-based dataset that supports analysis of the destination of these flows world-wide in order to show whether its distribution is aligned with need or concentrated in a small number of countries. The existing FAO database on External Assistance to Agriculture (EAA) includes all CRS donors and gathers information on some additional relevant multilateral donors using annual reports or official websites. The EAA classification system is more detailed than OECD CRS on some agricultural activities/purposes and it refers to both narrow and broad definitions of agriculture.

Given that most of the donors report their aid activities to the OECD, FAO has decided to abandon its existing EAA classification and to adopt the CRS list of purposes. However, FAO will augment the CRS data by continuing to collect and maintain data for the activities related to agriculture provided by non-CRS reporters included in the FAO broad definition of agriculture. Annex I — with reference to data for Dominican Republic in 2007 — presents the new FAO EAA template and its potential for establishing linkages with the other Investment Datasets, as discussed in Section VII.

5. Foreign direct investment resources

In the poorest countries, where financial markets are underdeveloped, external aid still accounts for much of gross domestic investment (and for government expenditures). Nonetheless, a host of factors — spikes in food and fuel prices, a desire by countries dependent on food imports to secure food supplies in

the face of uncertainty, and speculation on land and commodity price increases — has recently prompted a sharp increase in investment involving significant use of agricultural land, water, and forested areas in developing and transition countries. While **Foreign Direct Investment in Agriculture (FDI-Agri)**, may bring tax income, new technologies, higher land productivity as well as foreign currency, the allocation of FDI, particularly in primary agriculture and related secondary activities may not be distributed according to where needs arise or where opportunities exist and investors may refuse to honour investment commitments and exploit weak domestic legal infrastructure. Recognizing that FDI-Agri by private and public sector agents may become an increasingly important source of finance for agricultural development, FAO, IFAD, the UNCTAD Secretariat and the World Bank Group have developed a set of Principles for Responsible Agricultural Investment that Respects Rights, Livelihoods and Resources.[4] Agreement was also reached that a consultative approach be developed for monitoring that encompasses all countries from which investment initiatives are emanating and towards which such investments are directed.

FAO and UNCTAD are collaborating to strengthen data on FDI-Agri, elaborating a questionnaire that would disaggregate the sector/industry series currently collected by UNCTAD, based on ISIC Revision 4, as indicated in Annex I (with reference to data for Dominican Republic in 2007). This will improve data that support analysis aimed at maximizing the economic value-added and job creation potential of agriculture arising from external private sector investment in primary and secondary sector value chains. The disaggregation also strengthens the potential for establishing linkages with the other Investment Datasets, as discussed in the next section. In combination, the information may help inform policy aimed at avoiding asymmetric rights in favour of the investor to the detriment of the host state's food security. To better inform the feasibility of the FAO / UNCTAD questionnaire, which would be formally launched in 2013, FAO Statistics Division will survey to selected member countries requesting their views on the feasibility of providing the proposed data in time series format.

6. Building country investment profiles — dominican republic 2007

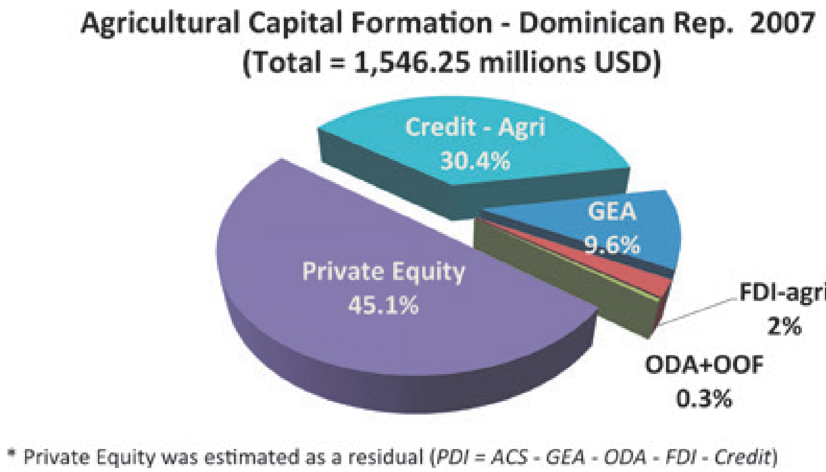
An example of preliminary work on collecting and combining the five datasets described above is illustrated in the Investment Dataset for Dominican Republic (2007) presented in Annex I. As shown in Table 1[5], Dominican Republic was chosen because it had the more complete time-series on investment flows among the countries considered for the analysis.

This example illustrates both the strengths and the challenges of obtaining a comprehensive and internationally comparable Investment dataset. In 2007, the FAOSTAT database would indicate that Agricultural Capital Formation[6] (ACF) (excluding forestry and fisheries), when measured in nominal terms, increased in Dominican Republic by 1,546 millions USD. This was achieved through a combination of agriculture investment oriented loans provided by the banking sector (516 million USD), a portion of the GEA for only agriculture (totalling 297 million USD, of which the capital component is estimated at 149 million USD)[7], a portion of the ODA-Agri (totalling 5 million USD for the agriculture specific component), and a portion of the total amount (30 million USD) from FDI-Agri inflows. As shown in Figure 3 below, we estimate Private Equities (697 millions USD) in agriculture as a residual by subtracting the total of the four above mentioned flows to agriculture from the FAOSTAT ACF. The example illustrates that if national authorities provide the desired disaggregation of agriculture, forestry, and fisheries data, including current and capital figures (or proxies) where relevant, a robust analysis of the dynamics of capital stock accumulation could be achieved for a majority of countries.

Table 1: Data availability in LAC Countries.

Countries	WB_c	FAO_id	ACS	ODA	FDI	GEA	CRED
Barbados	BRB	14	75-07	78-80	-	01-07	89-11
Chile	CHL	40	75-07	91-11	06-11	01-11	-
Dominican R.	DOM	56	75-07	73-11	93-11	01-10	01-10
Ecuador	ECU	58	75-07	74-11	86-11	08-11	08-12
Jamaica	JAM	109	75-07	74-11	98-10	01-11	01-11
St. Kitts	KNA	188	75-07	spotty	-	03-10	02-12

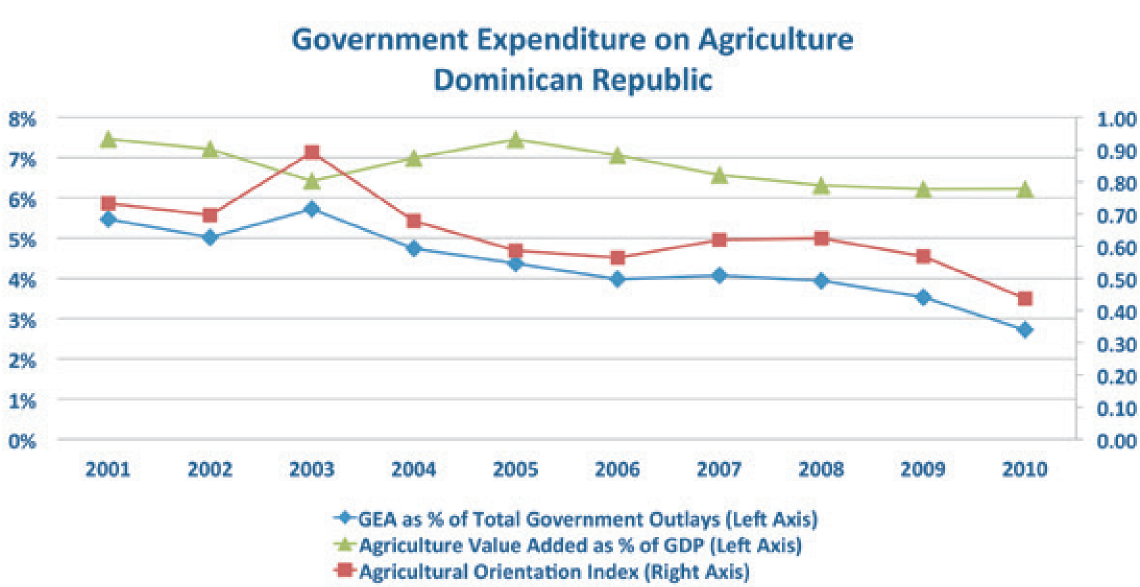
Figure 3: Components of Agricultural Investment Flows in Dominican Republic (2007).



Going forward, FAO Statistics Division will work with countries to ensure that data needed to complete the Template in Annex I become available according the FAO broad definition of agriculture. In the short to medium-term, this will entail FAO staff compiling time series from data (and metadata) made available by national authorities on national websites (ministries of finance, central banks, and national statistical offices, among others). Modalities will need to be found for engaging in dialogue to address data gaps and ensure a timely flow of annual data series that support this initiative.

BOX 2: Analysis of Government's Orientation towards Agriculture in the Dominican Republic.

The Agricultural Orientation Index shows the extent to which government expenditures on agriculture reflect (or not) the importance of agriculture in the overall economy. It is defined as the ratio between the share of GEA over Total Government Outlays (source: FAOSTAT) and the share of Agricultural Value Added over GDP (source: World Bank's World Development Indicators). The graph shows that the share of governments spending in agriculture has declined from 5.5% in 2001 to 2.7% in 2010, while the agricultural orientation index has declined from 0.73 to 0.44 for the same years.



7. Conclusions and points for discussion

Well channelled investment has individual and collective economic rewards as it enables the rural population to better contribute, in the short and long-term, to economic growth and the prosperity of the national and global community. In this respect, the information and analyses supported by the evolving Investment Dataset will help to ensure that policies followed create favourable incentive environments supporting effective investment by farmers and other stakeholders.

Participants are asked to express their views regarding the Investment Dataset initiative and FAO activities pertaining to, ***inter alia:***

- **Suitability of the proposed dataset to monitor and enhance investment in member countries** through advocacy, capacity development, the promotion of multi-stakeholder dialogue, etc.
- **ACS estimates disseminated on FAOSTAT** would be improved by the incorporation of data on private investment, where available, and data on capital stocks for forestry and fisheries, where relevant. How could such data be made more widely available and provided to FAO?
- **The availability of national and/or international guidelines pertaining to allocations of ODA and FDI to Agriculture** in terms of recurrent (wages and salaries, use of goods and services, etc) and capital (acquisition of nonfinancial assets) purposes?
- **Relevance and analytical interpretation of these data** for the Food Security Commitment and Capacity Scorecard initiative.
- **Scope of guidelines to be developed for the analytical interpretation of these data** for review and endorsement by the regional meetings

Endnotes

1 For a review of the magnitude of, trends in, and data gaps pertaining to investment in agriculture, see ESA Working Paper No.11-19 Financial Resource Flows to Agriculture (http://www.fao.org/docrep/015/an108e/an108e00.pdf) and the 2012 State of Food and Agriculture (http://www.fao.org/publications/sofa/en/).

2 International data on Private Domestic Investment (PDI) are not available. Therefore, the Agricultural Capital Stock data are crucial to estimate PDI as a residual after accounting for government and foreign investment flows (including both ODA and FDI).

3 In Annex II we show the evolution of gross capital stock in the various regions from 1975 to 2007 and the differences between developing and developed countries in the composition of capital stock.

4 See http://archive.unctad.org/Templates/Page.asp?intItemID=6123&lang=1.

5 Table 1 includes only the list of LAC countries with better investment data in FAOSTAT.

6 ACF in 2007 is measured as ACS_{2007} - ACS_{2006}.

7 As in SOFA 2012, we assume that 50% of government spending can be considered capital accumulation.

Annex 1: Interrelationships among FAO Investment Datasets: Dominican Republic 2007

FAO - ACS	ΔACS = ACS2007 - ACS2006	
	Agricultural Capital Stock	millions USD
	Agriculture (crops and animal husbandry)	1546.25
	Machinery and Equipment	3.11
	Land Development	163.51
	Livestock	1209.03
	Structures for Livestock	60.32
	Plantation Crops	110.28
	Forestry	
	Machinery and Equipment	
	Forest reserves	
	Fisheries	
	Machinery and Equipment	
	Acquaculture Development	
	Fish stocks	
	Hatcheries for fishstocks	

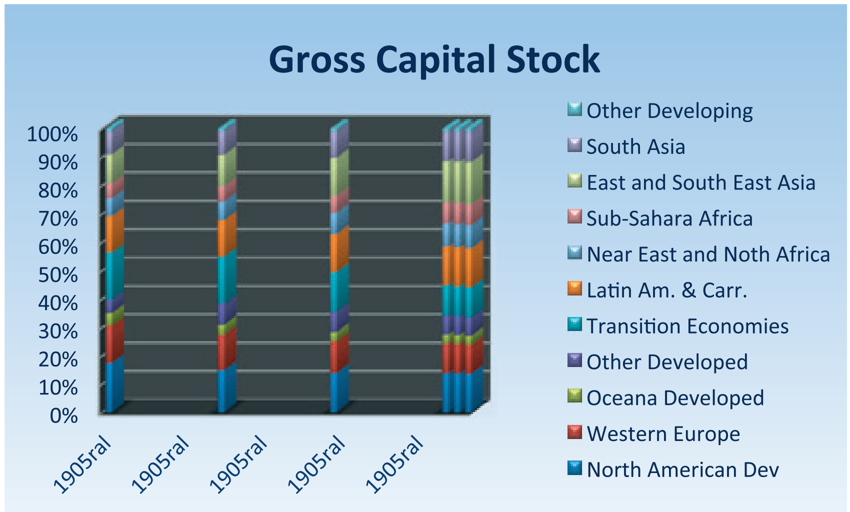
FAO - GEA	Government Expenditure on Agriculture	millions USD
7	TOTAL OUTLAYS	7311.12
704	**Economic affairs**	
7042	Agriculture, forestry, fishing, and hunting	297.47
70421	Agriculture (and livestock)	
704211	Agriculture (and livestock) - Current	
704212	Agriculture (and livestock - Capital	
70422	Forestry	
704221	Forestry - Current	
704222	Forestry - Capital	
70423	Fishing and hunting	
704231	Fishing and hunting - Current	
704232	Fishing anf hunting - Capital	
7048	R&D Economic Affairs	
70482	R&D Agriculture, forestry, fiscjing and hunting (CS)	
705	**Environmental protection**	31.58
7054	Protection of biodiversity and landscape	
70541	Protection of biodiversity and landscape - Current	
70542	Protection of biodiversity and landscape - Capital	
7055	R&D Environmental protection	
70551	R&D Environmental protection - Current	
70552	R&D Environmental protection - Capital	
7056	Environmental protection n.e.c. (CS)	

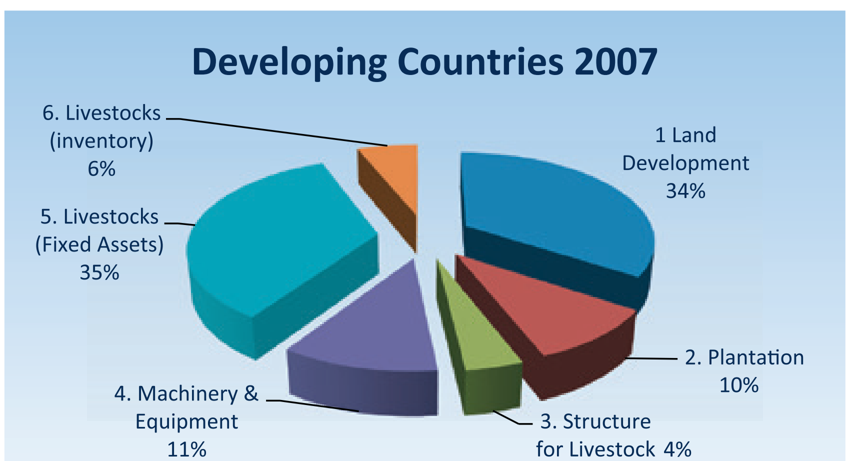
FAO - FDI	Foreign Direct Investment Inflows to Agriculture	millions USD
	Total	1,667.40
	Primary	
	Agriculture, hunting, forestry and fishing	30.4
	of which: Crop and animal production, hunting and related service activities	
	of which: Forestry and logging	
	of which: Fishing and aquaculture	
	Secondary	
	Food, beverages and tobacco	70.4
	of which: Manufacture of food products	
	of which: Manufacture of beverages	
	Tertiary	1,566.60

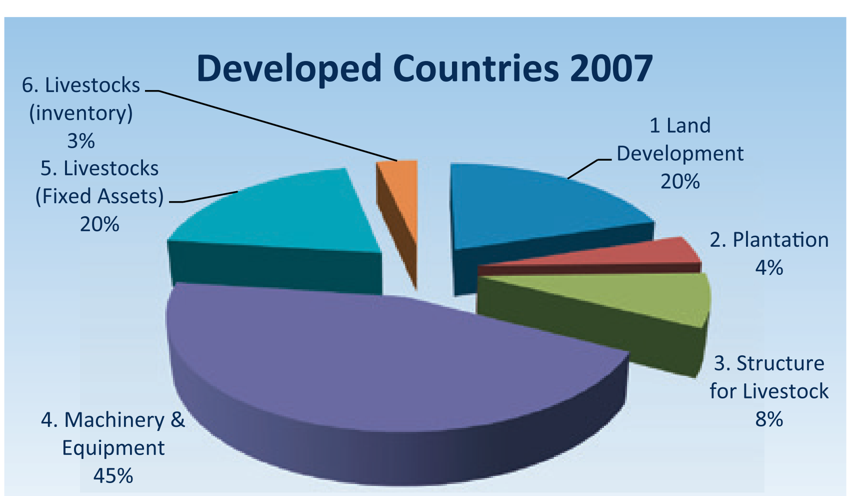
FAO - CRS	Disbursements	
	Official Flows for Agrivulture (ODA+OOF)	millions USD
310	**AGRICULTURE, FORESTRY, FISHING, TOTAL**	
311	**AGRICULTURE**	5.303
31110	Agricultural policy and administrative management	
31120	Agricultural development	
31130	Agricultural land resources	1.109
31140	Agricultural water resources	
31150	Agricultural inputs	
31161	Food crop production	2.502
31162	Industrial crops/export crops	
31163	Livestock	
31164	Agrarian reform	
31165	Agricultural alternative development	
31166	Agricultural extension	
31181	Agricultural education/training	0.734
31182	Agricultural research	
31191	Agricultural services	
31192	Plant and post-harvest protection and pest control	
31193	Agricultural financial services	0.107
31194	Agricultural co-operatives	
31195	Livestock/veterinary services	0.851
312	**FORESTRY**	
31210	Forestry policy and administrative management	
31220	Forestry development	
31261	Fuelwood/charcoal	
31281	Forestry education/training	
31282	Forestry research	
31291	Forestry services	
313	**FISHING**	
31310	Fishing policy and administrative management	
31320	Fishery development	
31381	Fishery education/training	
31382	Fishery research	
31391	Fishery services	

Credit - Agi	Commercial bank Credit to Agriculture	millions USD
	Total	18387.041
	Agriculture, hunting, forestry and fishing	743.853
	of which: Working capital credit	
	of which: Investment capital credit	

Annex 2: Global Agricultural Capital Stocks







Availability of Food and Nutrients in India: the food balance sheet approach

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Abstract

This study provides estimates of physical and nutrient availability from crop and animal based food products in India. The study finds that the availability of dietary energy remained nearly unchanged but that of protein increased marginally. While cereals continue to be the major source of different nutrients, pulses waned in importance. There is a need to conduct systematic studies in order to have reliable information on the extent of post-harvest losses and the stocks held with non-government agencies.

Keywords: agriculture; food; Food Balance Sheets; India; nutrients.

1. Introduction

This paper discusses trends in production and availability of crop- and animal-based foods in India. The paper provides estimates of availability of nutrients in India. In light of the ongoing nutrition transition in the country (Ramchandran 2007), the composition of supply of nutrients is discussed. We ask whether the trends in the availability of nutrients corroborate those observed in food availability and also check consistency of the nutrient availability worked out in this paper with that from the other sources.

At the outset, it may be noted that FAO Food Balance Sheets (FAO 2008 and FAOSTAT) too provide information on nutrients availability. However, the alternative estimates that are provided in this paper are likely to differ from those available in the Food Balance Sheets on the account of the differences in methodology.

The next section discusses the methodology and data. Section 3 is an overview of trends in physical production and per capita availability of food items and Section 4 deals with the availability of nutrients from food items. Composition of nutrients is examined in the fifth section. Section 6 compares food availability within the BRICS and SAARC countries.[1] The final section summarizes the findings and concludes the paper.

2. Data and Methodology

We compute production and availability in physical and nutrient terms for the following three food item groups:

1. Field crops: foodgrains (cereals, *viz.*, rice, wheat and coarse cereals, and pulses), nine oilseeds and sugarcane.
2. Animal and dairy foods: egg, fish and meat (EFM), and milk.
3. Horticultural crops: fruits, vegetables, and nuts.

Daily per capita physical production (PP) and physical availability (PA) for each food item, *i*, are computed as follows:

$$PP_i = \frac{Q_i}{N * 365} \quad (1)$$

$$PA_i = \frac{(Q_i - \Delta S_i + NI_i)}{N * 365} * (1 - w_i) \quad (2)$$

Where for the *i*th item Q denotes gross production, ΔS, change in stocks (stocks at the end of the year less that at the beginning of the year), NI, net imports, and w, allowance for seed, feed and wastage. N is the population.

Similarly daily per capita nutrient production (NP) and nutrient availability (NA) of the *j*th nutrient can be specified as follows where e_i denotes the portion (share) of the *i*th item that is edible and v_{ij}, the quantity of the *j*th nutrient present per 100 grams in the *i*th item:

$$NP_j = \sum_i \frac{Q_i}{N * 365} * e_i * v_{ij} \quad (3)$$

$$NA_j = \sum_i \frac{(Q_i - \Delta S_i + NI_i)}{N * 365} * e_i * (1 - w_i) * v_{ij} \quad (4)$$

Data on production of the food items has been compiled from Govt of India (2000, 2011a, 2011b and nd). We compared the two sources of data on production–FAOSTAT and the Govt of India–and found that though there is discrepancy for some food items, it is only marginal. Information on exports and imports has been obtained from Govt of India (2002, 2007a and 2011a). As regards the nutrient intake, the NSSO reports (Govt of India 1996, 2001, 2007b, 2012) provide information on the average per capita intake of energy and protein. The information on the population for census years is obtained from Govt of India (2011c). The population for inter-censual years has been worked out using the growth rates available there.

Nutritive values: Table 1 compiles the information on nutritive values of the food items (v_{ij}) from Gopalan *et al*. (1984).

Seed, feed and wastage: The Directorate of Economics and Statistics, Ministry of Agriculture uses 7.6 per cent for rice, 12.1 for wheat, 22.1 for coarse cereals and pulses towards seed, feed and wastages while computing the per capita availability of foodgrains and we have used the same proportions in this study. For oilseeds, egg, meat, and milk, we use an allowance of 12.5 per cent, which is the production share-weighted average value of the allowance for cereals. Allowance for fish is the average of the wastage figures for the period 1991-1999.

Edible portion: The information on edible portion for the most of food items is available in Gopalan *et al*. (1984). The Table 1 summarizes information on nutritive value, seed, feed and wastage, and edible portion of different food items that have been used in the paper.

Study period: The study covers the period 1990-91 to 2010-11 for all the food items owing to our inability to trace comparable and reliable information on all the production of horticultural crops prior to 1990-91. Unless mentioned, all the estimates in this study are based on three year (central) average figures on production.

3. Production and Availability

The daily average per capita physical production (PP) of the foodgrains declined from 576 grams in 1993-94 to 544 by 2009-10 (Table 2). The decline is mostly on the account of rice which is the single largest contributor to the foodgrains. The decline in the physical production is also observed for pulses and coarse cereals, each of which declined by about 10 per cent during the above period.

The daily per capita physical availability (PA) of foodgrains declined from 490 grams in 1993-94 to 457 in 2009-10. The item wise trends in availability are in keeping with the production despite the presence of trade. Pulses, whose availability stands nearly at 34 grams after dipping in between, are an exception.

The growth in production of egg, fish, meat and milk during the last two decades has been higher than that of population leading to an increase in per capita production of all the items (Table 2). In fact the growth of egg, fish and milk has been higher than that of population since 1950s. The production of animal and dairy foods increased steadily from 209 grams per capita in 1993-94 to 286 in 2004-05.

4. Nutrient Production and Availability

This section discusses estimates of nutrient production (NP) and availability (NA). The Tables 3 and 4 provide estimates of the production and availability of the nutrients from the above food items for selected time periods during the last two decades.

The production of dietary energy in the country was around 2800 Kcal per capita during the last two decades whereas the net availability for most of the period varied between 2400 and 2500 Kcal (Tables 3 and 4). The amount of dietary energy available from cereals has declined between 1993-94 and 2009-10 though the same has been compensated by the remaining two groups, namely, animal and dairy foods and horticultural crops.

The physical production of protein between 1993-94 and 2009-10 increased marginally from 86 grams per capita to 89 and the availability, from 73 to 76 owing largely to increase in protein from animal and dairy foods (Tables 3 and 4).

5. Composition of Nutrients

In 1993-94, rice and wheat together contributed about half to the availability of dietary energy; oilseeds, 12 per cent; sugarcane, 10 per cent; coarse cereals and pulses together about 10 per cent; and milk six per cent (Figure 1). The share of the horticultural crops was seven per cent. The composition of net availability of dietary energy did not change substantially by 2009-10 except

that shares of oilseeds, milk and the horticultural crops increased. The share of milk and horticultural crops combined increased from 13.6 to 17.6 per cent between 1993-94 and 2009-10 and that of oilseeds, from 12 to 17 thanks to imports of edible oil.

Wheat, sugarcane and rice are the three most important sources which together contribute two-third in the availability of protein (Figure 2). The share of rice has declined from about 20 per cent to 17 between 1993-94 and 2009-10. Milk and Pulses are other important sources, the contribution of each has ranged between 8-11 per cent. The increase in milk production has led to gradual rise in share of milk from 8 to 11 per cent. The share of pulses which was nine per cent in 1993-94 declined afterwards before reverting back towards the same figure.

6. Other Estimates of Nutrients

Compared to the FAO, our estimates are higher by about 5-10 per cent for energy (Table 5). An item wise comparison of FAO and our estimates indicates only minor difference in availability of energy from foodgrains, oilseeds (excluding edible oil imports) and sugarcane and the animal and dairy foods. But, in the case of horticultural crops, especially, vegetables, the difference was substantial. The difference between the FAO and our estimates is much larger for protein, where ours exceed the FAO estimates by about one-third.

According to the FAO estimates (FAO 2009 and FAOSTAT), the daily per capita availability of dietary energy as well as protein falls short of the BRICS countries (Table 6). Among the BRICS countries barring India, the availability of dietary energy is higher and that of protein is at least as much as the world average. India's position is relatively better among the SAARC countries with regard to availability of dietary energy.

The NSSO estimates of both dietary energy and protein intake are about 15 percent lower than the availability worked out by us. However, the data from the two sources need not exactly match at least for various reasons.

7. Conclusion

The study finds that the availability of nutrients during the last two decades merely kept pace with the population growth. While the availability of dietary energy remained nearly unchanged, that of protein increased marginally. Even though cereals continue to be the dominant source of nutrients, its share has gradually declined and the share of animal and dairy foods and horticultural crops has increased. Compared to the estimates available in the FAO Food Balance Sheets for India, our estimates are slightly higher.

Figure 1: Composition of Energy Availability.

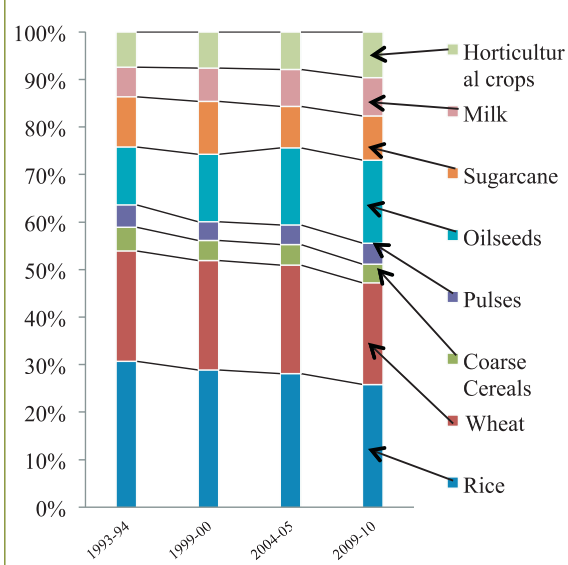

Figure 2: Composition of Protein Availability.

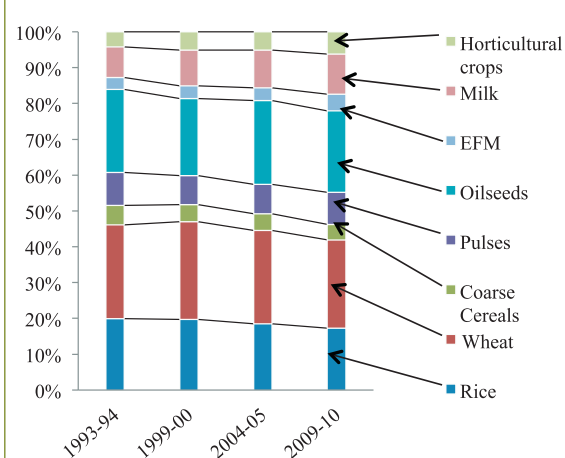

Table 1: Nutritive Values; Edible Portion; and Seed, Feed and Wastage.

Food Items	Nutritive value (per 100 grams)		Seed, Feed and Wastage	Edible Portion
	Protein	Energy		
Rice	6.80	345.00	7.60	1.00
Wheat	11.80	346.00	12.10	1.00
Coarse Cereals	7.86	239.78	22.10	1.00
Pulses	20.03	339.63	22.10	1.00
Oilseeds	30.15	512.41	12.50	1.00
Edible oil		900	0.00	1.00
Sugarcane	0.40	383.00	12.50	1.00
Eggs	5.90	76.99	12.50	1.00
Fish (all)	17.98	136.67	6.50	0.60
Meat	22.82	104.91	12.50	1.00
Milk	3.75	92.00	12.50	1.00
Apple	0.20	59.00	18.00	0.90
Banana	1.20	116.00	13.00	0.71
Citrus	0.70	48.00	20.00	0.67
Grapes	0.50	71.00	27.00	1.00
Guava	0.90	51.00	9.00	1.00
Mango	0.60	74.00	27.00	0.74
Papaya	0.60	32.00	12.50	0.75
Pineapple	0.40	46.00	13.00	0.60
Pomegranate	1.60	65.00	12.50	0.68
Sapota	0.70	98.00	12.50	0.83
Brinjal	1.40	24.00	12.00	0.91
Cabbage	1.80	27.00	11.00	0.88
Cauliflower	5.90	66.00	13.00	1.00
Onion	1.50	54.50	23.00	0.95
Potato	1.60	97.00	18.00	0.85
Peas	7.20	93.00	10.00	0.53
Sweet Potato	1.20	120.00	12.50	0.97
Tapioca	0.70	157.00	12.50	1.00
Tomato	0.90	20.00	12.50	1.00
Almond/ Walnut	20.80	655.00	0.00	0.15
Cashew nut	21.20	596.00	0.00	0.72
Coconut	4.50	444.00	0.00	0.33

Table 2: Production and Availability (grams per capita per day).

Food Item	Physical Production (PP)				Physical Availability (PA)			
	1993-94	1999-2000	2004-05	2009-10	1993-94	1999-2000	2004-05	2009-10
Rice	243.85	240.71	222.77	221.60	216.60	206.19	195.60	185.61
Wheat	189.73	200.64	177.70	193.61	161.59	169.31	157.52	172.29
Coarse cereals	100.97	85.62	88.90	91.41	78.38	66.66	66.52	64.86
Pulses	41.68	36.38	35.03	37.00	33.63	28.79	29.85	33.77
Oilseeds	65.33	59.00	65.55	66.36	56.22	50.87	56.49	57.11
Sugarcane	760.95	816.08	635.98	709.19	665.83	714.07	556.48	620.54
Egg	0.08	0.09	0.11	0.14	0.07	0.08	0.10	0.12
Fish	14.32	15.35	16.30	18.09	12.65	13.42	14.14	15.98
Meat		5.26	5.58	9.12		4.60	4.88	7.98
Milk	189.50	216.30	234.82	258.43	165.83	189.28	205.48	226.13

Table 3: Production of Energy and Protein.

Food Item	Energy (Kcal per capita per day)				Protein (grams per capita per day)			
	1993-94	1999-00	2004-05	2009-10	1993-94	1999-00	2004-05	2009-10
Cereals	1652.90	1656.22	1519.99	1574.84	44.06	44.36	40.59	42.52
Pulses	141.55	123.56	118.98	125.68	8.35	7.29	7.02	7.41
Oilseeds	334.76	302.32	335.88	340.05	19.69	17.79	19.76	20.01
Sugarcane	291.44	312.56	243.58	271.62	0.30	0.33	0.25	0.28
EFM	17.44	18.07	19.19	24.38	2.78	2.85	3.02	4.02
Milk	174.34	198.99	216.03	237.75	7.11	8.11	8.81	9.69
Fruits	60.70	58.17	68.45	91.55	0.62	0.60	0.70	0.95
Vegetables	107.67	126.21	120.26	162.91	2.48	3.16	3.01	4.04
Nuts	43.18	40.73	40.32	43.27	0.56	0.57	0.57	0.61
All	**2823.98**	**2836.84**	**2682.68**	**2872.05**	**85.95**	**85.05**	**83.74**	**89.54**

Table 4: Availability of Energy and Protein.

Food Item	Energy (Kcal per capita per day)				Protein (grams per capita per day)			
	1993-94	1999-00	2004-05	2009-10	1993-94	1999-00	2004-05	2009-10
Cereals	1421.39	1384.82	1348.52	1311.59	37.66	36.83	35.97	35.05
Pulses	114.21	97.78	101.38	114.68	6.74	5.77	5.98	6.76
Oilseeds	293.29	352.01	396.92	448.41	16.95	15.34	17.03	17.22
Sugarcane	255.01	273.49	213.13	237.67	0.27	0.29	0.22	0.25
EFM	15.36	15.80	16.70	21.46	2.45	2.49	2.63	3.54
Milk	152.56	174.14	189.04	208.04	6.22	7.10	7.71	8.48
Fruits	49.87	47.80	56.42	76.01	0.51	0.50	0.58	0.80
Vegetables	84.07	97.80	93.06	124.70	1.99	2.54	2.42	3.21
Nuts	44.07	41.53	43.3	45.81	0.59	0.59	0.68	0.71
All	**2429.82**	**2485.16**	**2458.48**	**2588.37**	**73.37**	**71.44**	**73.22**	**76.02**

Table 5: Various Estimates of Energy and Protein.

Year/ period	Energy (Kcal/person/day)			Protein (g/person/day)		
	FAO	NSSO	This study	FAO	NSSO	This study
1992-1994	2338.3	2132.7	2432.66	55.3	59.3	73.4
1998-2000	2270.0	2150.8	2481.56	55.8	59.0	71.4
2003-2005	2264.7	2040.2	2457.23	55.0	57.0	73.2

Table 6: Nutrient Availability in BRICS and SAARC Countries.

Country/ World	Energy (Kcal/person/day)			Protein (g/person/day)		
	1994-1996	1999-2001	2003-2005	1994-1996	1999-2001	2003-2005
Brazil	2,872	2,875	3,094	77	79	84
Russia	2,862	2,905	3,100	88	86	92
China	2,811	2,899	2,940	79	85	88
South Africa	2,753	2,792	2,900	72	73	76
India (FAO)	2,343	2,352	2,358	57	56	56
India (this study)	**2,500**	**2,436**	**2,457**	**74**	**69**	**72**
Bangladesh	1,927	2,159	2,233	42	47	48
Nepal	2,208	2,287	2,425	56	58	61
Pakistan	2,375	2,376	2,338	61	61	59
Sri Lanka	2,268	2,373	2,361	50	53	54
World	**2,688**	**2,730**	**2,768**	**73**	**75**	**76**

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Endnote

1 BRICS is a group of five emerging economies, viz., Brazil, Russia, India, China and South Africa. SAARC stands for 'South Asian Association for Regional Cooperation' and is a group of eight south Asian nations, viz., Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka aimed at promoting mutual co-operation in various areas for the welfare of the people.

Measuring Food Security: a structural equation approach

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Abstract

Food security (FS) is a fundamental component of human well-being, and, as well-being, it is also multidimensional. In order to be policy-relevant, FS metrics should be multidimensional, as no single indicator can adequately capture its complexity. The recognition of the multidimensionality of food security, while being a theoretical advancement, poses substantial theoretical and methodological challenges for the development of food security metrics. The paper presents an original theoretical and methodological framework for the measurement of FS. In particular, it argues that Structural Equation Modelling (SEM) is particularly appropriate for this purpose, as SEM models have features that can suitably tackle the multiple weaknesses of available multidimensional indicators: (i) feeble theoretical foundations; (ii) measurement error; and (iii) lack of a natural aggregator function to synthetize different indicators into a composite index. In this setup, FS is conceptualised as a latent (multidimensional) phenomenon proxied by a number of observed indicators. Additionally, the use of these models also allows for the inclusion of those institutional, economic, and social factors that have been identified in the literature as key determinants of FS outcomes and to estimate their associations with estimated FS in a sample of low- and middle-income countries.

The empirical analysis shows that the estimated Multidimensional Index of Food Insecurity (MIFI) is able to offer a more balanced view regarding FS than single indicators and to capture more effectively cross-country variation. Coherently with the proposed theoretical framework, the empirical results show that countries' FS results from the complex interaction between key human development dimensions such as health and education, and environmental, institutional and economic factors.

Keywords: food security; measurement; cross-country; multidimensional; structural equation models.

1. Introduction

The 1996 World Food Summit (WFS) definition of food security (FS) emphasised the inherent complexity of the concept by pointing to the four pillars of availability, access, utilisation, and stability[1]. While the explicit recognition of the multidimensionality of FS represented a ground-breaking advancement from previous conceptual frameworks that identified FS with food availability (UN 1975), it also brought with it a number of additional theoretical and methodological difficulties, especially in relation to the measurement of FS. Developing sound and comprehensive metrics of FS is a difficult task for various reasons related to (i) the complexity and elusiveness of the concept; (ii) the lack of an operational definition; (iii) the absence of 'gold standard' metrics; (iv) the poor availability of data across countries and over time; and finally, (v) discontent/disagreement regarding the methodological soundness of available indicators. Given the critical role that measures play in evidence-based policy-making, the debate on how to adequately measure countries' FS is, unsurprisingly, as heated as ever (Mason 2002; Barrett 2010; Masset 2011; De Haen *et al.* 2011; CFS 2011).

This paper argues that Structural Equation Modelling (SEM) offers a suitable methodological framework for measuring FS. In this framework, FS can be conceptualised as a latent (multidimensional) phenomenon that is measured through a number of observable indicators describing different facets of such a latent construct. Additionally, the latent variable methodology is also able to simultaneously test the empirical association of the estimated FS measure with a set of economic, institutional, and environmental factors that have been postulated to be associated to FS outcomes. By applying the proposed methodology to a set of low- and middle-income countries, the paper goes beyond the *measurement* of multidimensional FS, by also *modelling* its main covariates at the cross-country level.

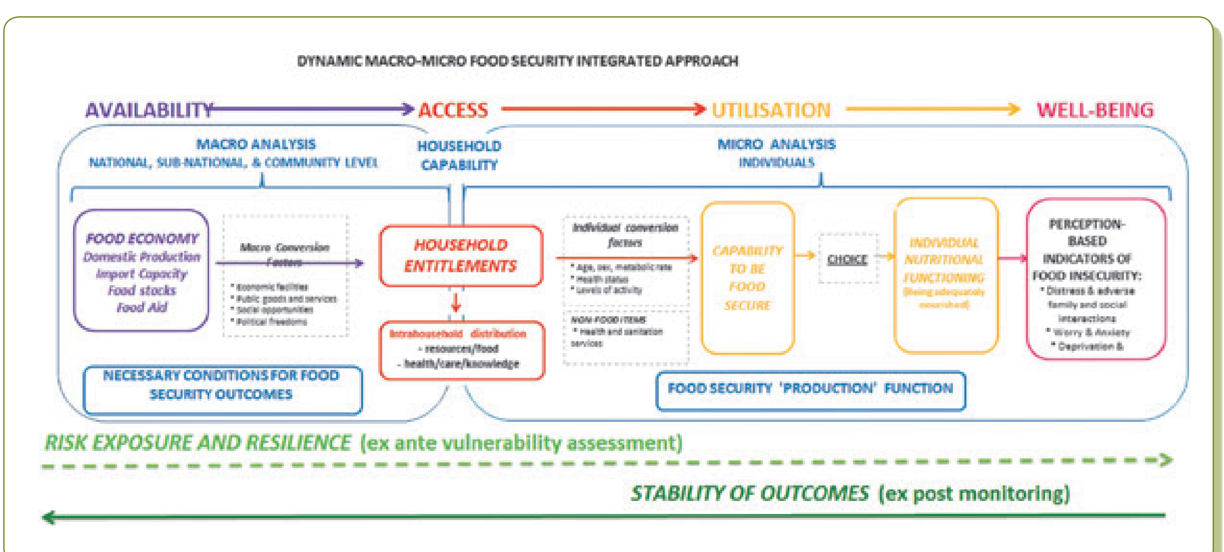
The paper proceeds in the following way: while Section 2 and 3 respectively introduce the theoretical and methodological frameworks, Section 4 presents the empirical application. Finally, Section 5 concludes.

2. Theoretical framework

The aim of this Section is to present an original conceptual framework for the analysis of FS. FS is a complex phenomenon: not only is it multidimensional, but it is also the outcome of a *process* of achievement, in which the dimensions of FS are interdependent rather than merely additive. This paper re-elaborates the UNICEF framework (UNICEF 1990) by building on Sen's Capability Approach[2] (CA, Drèze & Sen 1989, Sen 1999) and the integrated micro-macro framework of Chiappero Martinetti & Pareglio (2009). Figure 1 shows that *'the capability to be food secure'* is the result of the joint and complex action of macroeconomic and social constraints, functional limitations and other contextual characteristics of the household environment, as well as of individual factors (Drèze & Sen 1989; Burchi & De Muro 2012). While availability is typically a macroeconomic concept, access and utilisation are intrinsically microeconomic (i.e. household and individual). Additionally, availability is a necessary, yet insufficient, condition for access, which in turn is a necessary, but still insufficient, condition to use the food in a nutritious way. Finally, the dimension of 'stability' emphasises the intrinsic dynamics of the concept, as the term *security* points to "safety from chronic threats" (UNDP 1994, p.1).

This framework is innovative in many respects: first, by incorporating the subjective consequences of the lack of FS, such as psychological distress and alienation from the community (Wunderlich & Norwood 2006), FS is expressly conceptualised as a fundamental component of the broader concept of human well-being. Second, it emphasises the interdependencies that exist between the macroeconomic and microeconomic levels of analysis and explores which are the drivers of FS outcomes at each level. At the macroeconomic level, Figure 1 stresses the relevance of economic, institutional, social and environmental factors in providing an 'enabling environment' for FS outcomes to occur and to be sustained over time. At the microeconomic level, Figure 1 shows that the complex 'capability to be food secure' depends on a series of other basic capabilities (i.e. health, education, care, *etc.*), the intrahousehold distribution of resources, and the individual conversion factors that allow people to convert food access into nutritional outcomes (Drèze & Sen 1989). These factors, as it will be shown in the empirical application, are fundamental in the process of determination of food security outcomes. Finally, the framework emphasizes the dynamic nature of FS, by highlighting the elements of *ex ante* assessments of risk and vulnerability, as well as those of *ex post* evaluation of past outcomes.

Figure 1: An integrated macro-micro and dynamic framework for the analysis of food security.



3. Methodological Framework

Under the general tag of SEM there is a variety of distinct methodologies that differ on the basis of both statistical tools and on the assumptions they make regarding the nature of the associations between the variables. Nonetheless, different methods share the assumption that a latent construct can be estimated through a set of observable indicators, which represent linear and noisy representations of the phenomenon itself (Bollen 1989; Kline 2011). SEM is appealing for measuring multifaceted phenomena as it addresses the two most prominent difficulties in multidimensional measurement: (i) lack of a natural aggregation function for combining multiple indicators into a single metrics; and (ii) measurement error (Kuklys 2005). Also, a fundamental prerogative of SEM is to build on strong theoretical foundations before the model is specified. Unlike other data-driven techniques, it is up to the researcher to put forward hypotheses on the number of latent factors and how they are associated with the observed indicators, and later to check the consistency of the theory with sample data. In this way, the key issue of "measuring without theory" (Koopmans 1947) is avoided. Additionally, *SEM models* aim at testing the association between the latent constructs and some exogenous variables[3] that are hypothesised as influencing the latent factors.

This paper adopts a Multiple Indicators Multiple Causes model (MIMIC, Jöreskog 1973; Jöreskog & Goldberger 1975) to measure FS. MIMIC models are characterized by two types of equations: a "measurement equation", which models the relationship between the latent phenomenon and its observed indicators, and a "structural equation", which links the latent variable to a set of exogenous indicators. This general theoretical model can be characterised in the following way:

1. FS or countries' "capability to be food secure" is considered as a latent and endogenous factor in the structural model.

2. Observable outcome indicators of FS are modelled as noisy manifestations of the latent construct in the set of measurement equations.

3. The latent "capability to be food secure", and in turn, the measurement indicators, are influenced by a set of social, institutional, and economic elements. These are linked to the endogenous construct through a structural equation.

To introduce some basic notation:

y^* a scalar of latent country 's FS, or 'capability to be food secure';

y a (p x 1) vector of observed indicators representing the manifested functionings associated with the latent construct;

$\boldsymbol{\lambda}$ a (p x 1) vector of factor loadings. These estimate the direct effects of the latent construct on the indicators and are interpreted as regression coefficients. In the case of standardised factor loadings, these represent the estimated correlation between the indicators and the underlying factor;

x a (k x 1) vector of exogenous causes of y^*;

$\boldsymbol{\beta}'$ a (1 x p) vector of path coefficients. These can be interpreted as regression coefficients.

On this basis of the conceptual framework sketched above, we can introduce the following MIMIC model (Jöreskog and Goldberger 1975):

$$y = \lambda\, y^* + \varepsilon \tag{1}$$

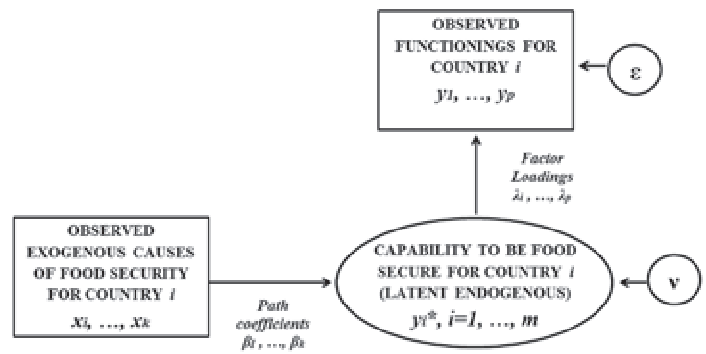
$$y^* = \beta' \mathrm{x} + \nu \tag{2}$$

The first set of equations represents the measurement model, which specifies how the observed indicators are manifestations of the latent construct, the 'capability to be food secure', plus an error term. The second equation specifies the structural model, which explains the latent construct as a function of a set of observed exogenous variables. Vectors ε and ν are the respective error terms in the measurement and structural equations, with zero expectations and uncorrelated between the two parts. In particular, ε captures uncertainty in the relationship between true FS and the observed indicators. Note that in MIMIC the exogenous covariates are modelled as error-free (Bollen 1989). The above relations are specified in Figure 2 below. Jöreskog and Goldberg (1975) showed that the latent factor scores can be estimated by:

$$\hat{y}^* = (1 - \lambda'\Omega^{-1}\lambda)^{-1}(\alpha' x + \lambda'\Psi^{-1} y) \tag{3}$$

With $\mathbf{V}(\varepsilon) = \boldsymbol{\Psi}$, $\mathbf{V}(\nu) = \sigma^2 \boldsymbol{I}$, and $\boldsymbol{\Omega} = \lambda\lambda' + \boldsymbol{\Psi}$. In general $\boldsymbol{\Psi}$ is assumed to be diagonal in the literature on latent variable models (Khrishnakumar 2007).

Figure 2: A MIMIC model for measuring country food security.



Source: Author.

4. Empirical Application

a. Sample

The sample relates to a cross-section of 57 middle- and low-income countries for the year 2008 or the closest point available, with data from the World Bank *World Development Indicators.* Although this is a quite limited sample for SEM, it is akin to the ones of analogous literature that uses the same data for cross-country comparisons[4]. Descriptive statistics are reported in Appendix 1.

b. Indicators

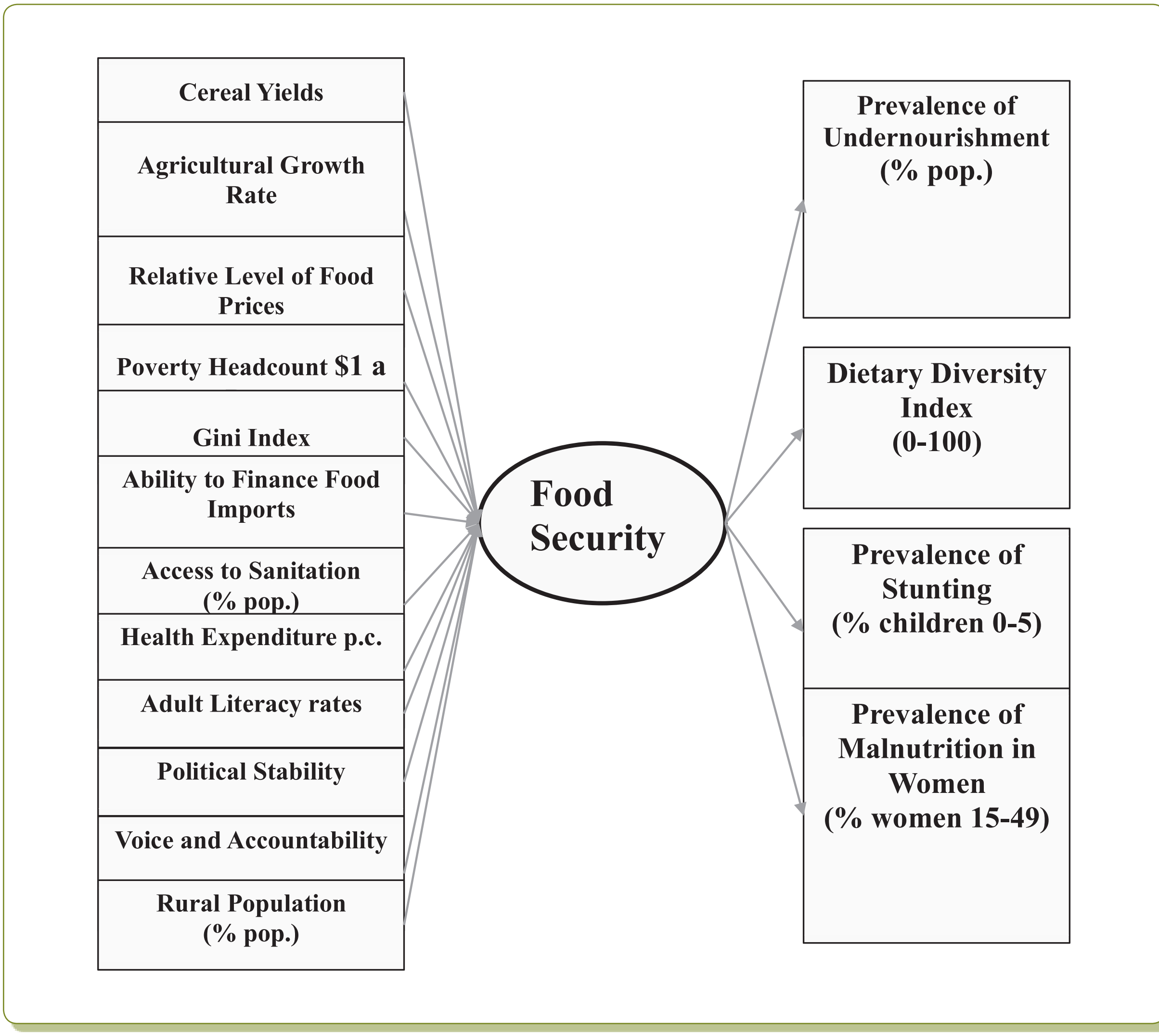
The indicators in the measurement part, which aim to capture the latent 'capability to be food secure', are outcome indicators of distinct dimensions of FS. These are: (i) FAO's Prevalence of Undernourishment (PoU); (ii) dietary diversity index; (iii) prevalence of malnutrition (height for age) in children aged 0-5 years; and (iv) prevalence of malnutrition in women. FAO PoU estimates the proportion of the population in conditions of chronic undernourishment and is a measure of both the availability and access dimensions of FS. It is used to monitor global hunger trends in the MDGs (UN 2003). The 'dietary diversity index' has been constructed from FAO FAOSTAT data as the ratio of aggregate dietary energy supply (kilocalories/per day/per person) provided by staple foods (cereals and starchy roots). A high value indicates a low diet diversification. It is one of the core Committee for Global FS indicators to monitor global progress towards the WFS goals (FIVIMS 2003). The other two indicators provide information about the nutritional status of two of the most vulnerable population groups and are outcome variables of the utilisation dimension. The prevalence of stunting measures the proportion of children aged 0-59 months whose height-for-age is more than two standard deviations below the median for the international reference population aged 0-59 months, as defined by WHO child growth standards[5]. (WHO Multicentre Growth Reference Study Group 2006). It is an indicator of chronic child malnutrition, manifested in retarded height growth (stunting). The prevalence of being underweight in women measures the per cent of non-pregnant women aged 15-49 years who have a Body Mass Index (BMI) below the international reference standard of 18.5 (extreme thinness). Although malnutrition in women is a problem insufficiently recognized, the gender dimension is food security is not only intrinsically but also instrumentally relevant, as women's malnutrition is likely to be transmitted to children, perpetuating growth and development failure through generations (Walker *et al.* 2011).

As argued earlier, the level of achievement in the capability to be food secure is undoubtedly influenced by the presence of a congenial environment for the flourishing of FS (Drèze & Sen 1989; Khrishnakumar 2007). The indicators included in the structural part of the model relate to country-level economic, social, institutional and technological factors and are strongly linked to possible areas of policy interventions. Appendix 2 provides a list of the indicators and the rationale for their inclusion.

c. Identification and model fit

This section presents and analyses estimates of the MIMIC model specified according to the path diagram in Figure 3 below.

Figure 3: Path Diagram.



Source: Author.

The identifying condition of the model is met (Kaplan 2009). The estimation, implemented using Stata Version 12, confirmed identification. Table 1, following Kline's recommendations (2011), provides a selection of goodness-of-fit statistics, which seem to point to an overall good model fit to sample data.

Table 1: Data availability in LAC Countries.

Fit statistic	Value	Description
Likelihood ratio Chi2_ms(32)	35.8	model vs. saturated
p > chi2	0.295	
RMSEA	0.046	Root mean squared error of approximation
90% CI, lower bound	0	
upper bound	0.113	
CFI	0.976	Comparative fit index
TLI	0.965	Tucker-Lewis index
SRMR	0.041	Standardized root mean squared residual

Table 2: Parameter estimates for the Measurement Model.

	Coefficient	Standardised coefficient	
Prev. of Stunting	1.000	0.9	***
Prev. of Undernourishment	0.71***	0.62	***
Prev. of Malnutrition in Women	0.67***	0.58	***
Dietary Diversity Index	0.88***	0.74	***

*** denotes significance at 1%.

d. Estimation results

A "robust" maximum likelihood method was used to derive estimates on standardized data (Satorra & Bentler 1994). Table 2 shows the estimation results for the measurement part of the MIMIC model, reporting both normal and standardised coefficients. The latter can also be interpreted as z-scores (Brown 2009). For instance, an increase of one unit in the latent construct "food insecurity" will result in an increase in 0.59 standardised units of female malnutrition and 0.9 of stunting. Although model fit has been found to be unaffected by the choice of the variable for scaling the latent factor, stunting was chosen as the reference variable because it is the most reliable indicator (Kline 2011).

The estimated coefficients in the structural part of the model can be interpreted as in multivariate regression analysis (Kline 2011). In this case, the structural part of the MIMIC provides estimates of the associations between the process indicators and countries' "capability to be food secure". Table 3 shows estimation results with different model specifications. The specification that is linked to the parameter estimates for the measurement model in Table 2 can be found in the first column.

With respect to the availability dimension, the yield of cereals, a key measure of agricultural productivity, and the rate of growth in the agricultural sector (col. 7) are not found to be significantly associated to FS at a cross-country level. Given the theoretical framework outlined in Section 2, this result is not surprising: although food availability is a basic prerequisite for FS, it is not a sufficient condition to ensure that FS outcomes will follow. Similarly, the rate of food imports to total merchandise exports were not found to be statistically significant: a high dependence on food imports is not *per se* a cause of food insecurity. The latter will depend on the country's inability to finance its food imports through commodities exports, and as such, to be resilient to abrupt fluctuations in world food prices.

Regarding the access dimension, the empirical analysis unsurprisingly shows that income poverty, which can be seen as households' lack of entitlements to food and basic non-food commodities (Sen 1981), is a key factor affecting food insecurity. In contrast, no significant effects are found for economic growth. Although the empirical evidence on the impact of growth on FS is mixed[6] (Harttgen *et al.* 2012; UNDP 2012; Headey 2013), this finding points to the heterogeneity of countries' pathways to FS, which could either be promoted by rapid economic growth ("growth-mediated"), or through the provision of public goods without sustained economic expansion ("support-led")[7] (Drèze & Sen 1989; Sen 1999). Finally, coherently with other empirical contributions (Osmani 1997; Heltberg 2009), the Gini index of income distribution is not statistically associated to FS (col. 6). This result is robust to various model specifications[8].

At a cross-country level, higher food prices (relative to general consumer prices) are positively and significantly associated with higher levels of FS. Although this result may seem puzzling at first, it is nonetheless coherent with a well-established strand of literature that argues that the aggregate effect of food prices on FS is uncertain, and that it ultimately depends on the relative terms of trade of food commodities with respect to the goods and services people produce and sell (Sen 1981; Deaton 1989; Barrett & Dorosh 1996; Barrett 2002; Swinnen & Squicciarini 2012). Additionally, this result could also be driven by the way food and consumer prices indexes are constructed, which may not reflect the patterns of consumption of the poorest households, which are more at risk of food insecurity.

With regards to the utilisation dimension, the ratio of female to male adult literacy and the rate of adult female literacy, two common proxies for the status of women in society (UNDP 1997; Haddad 1999; Smith *et al.* 2003), are strongly and negatively associated to food insecurity outcomes in all the

specifications. It is interesting to stress that the same does not apply to men's education (col. 3), which is not statistically significant. These results corroborate a well-acknowledged result in the literature on the link between women's education (and empowerment) and FS (Osmani 1997; Smith & Haddad 2000; Smith *et al.* 2003; Harttgen *et al.* 2012; Headey 2013). Consistent with our conceptual framework, another key capability, health, is found to play a leading role in the promotion of FS. This is shown by the strong and significant coefficient of the share of public health expenditure per capita, an indicator that is usually used as a proxy for the public provision of social services and public goods (Anand & Ravallion 1993). It is hence not surprising that the coefficient related to rurality is strong and significant. Rural populations, which typically enjoy less access to critical services such as health and education, seem to be less likely to be food secure. This result, together with the one related to statistical insignificance of factors related to food availability, points to the need to overcoming an exclusive focus on agricultural productivity as a *panacea* for FS (World Bank 2008; Hoddinnott *et al.* 2012) in order to devise a comprehensive strategy of broader rural and human development that includes policies for rural non-farm employment, education, health and infrastructure, in which agriculture is only one, albeit relevant, component. With respect to the latter, rather interestingly, neither the prevalence of population with access to clean water nor the one with access to improved sanitation facilities turns out to be statistically significant in our model. The way in which these indicators are measured for cross-country comparisons (especially in the MDG context) could probably explain this rather counter-intuitive result, which is nonetheless consistent with recent research (Lechtenfeld 2012; Headey 2013). Finally, the lack of statistical association between the governance indicators and FS is coherent with Sen's theory and empirical evidence (Sen, 1999; Burchi 2011): while there is robust evidence of the positive effect of democracy on famine prevention, the effect of governance factors on FS is still overall uncertain.

5. A multidimensional index of countries FS

Based on the results of the model presented in previous sections, the latent 'capability to be food secure' was estimated. A Multidimensional Index of Food Insecurity (MIFI) was in turn obtained by normalizing the scores of the capability to be food secure on a scale from 0 to 1, where 0 indicates a situation of maximum FS and 1 of complete food insecurity. This paper argues that MIFI has three features that render it appealing for measuring FS: first, by including outcome indicators on different dimensions of the concept, MIFI is more able to capture the complexity of FS than single indicators alone. This first feature is well shown in Figure 4 and 5,which provide a scatterplot of MIFI against the two leading indicators of food insecurity in the MDG

Figure 4: Relationship between MIFI and Prevalence of Undernourishment.

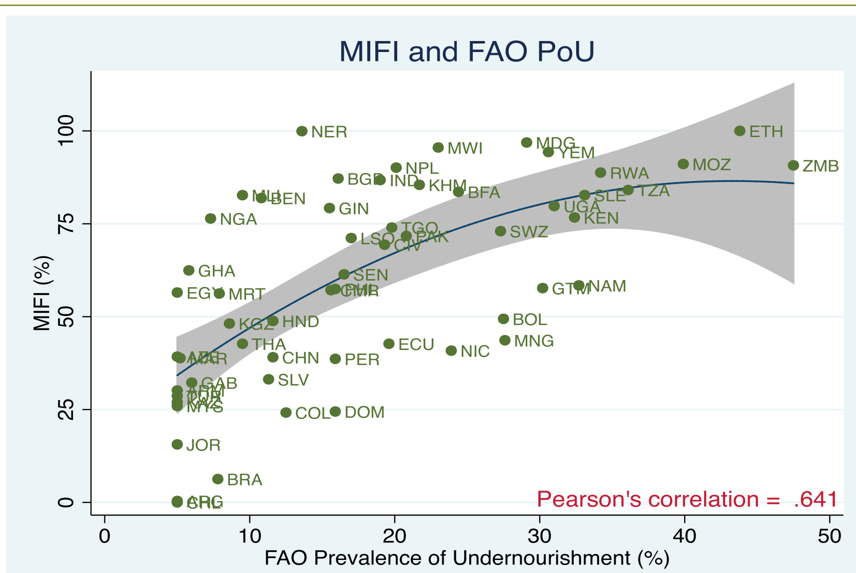
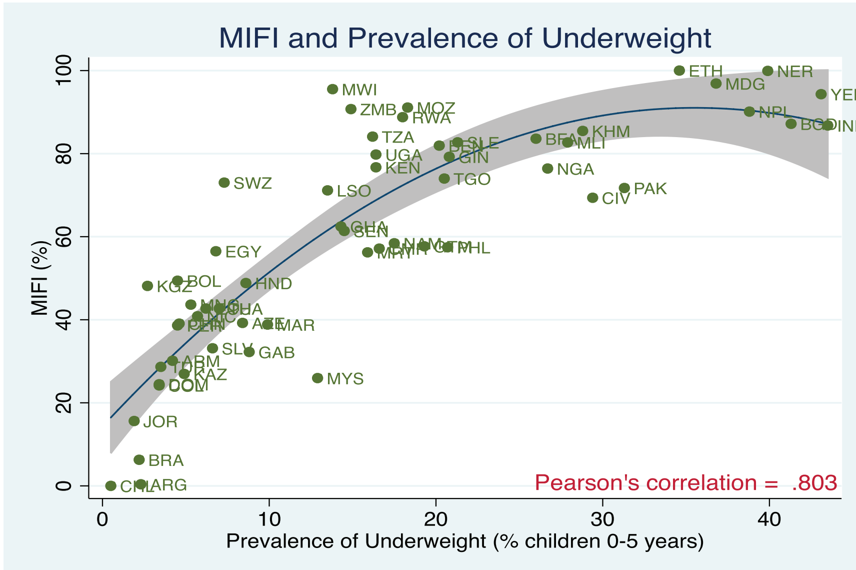


Figure 5: Relationship between MIFI and Prevalence of Underweight.



context, FAO PoU and the prevalence of underweight in children less than 5 years.

Figure 4 is also a measure of internal validity of MIFI, as PoU is one of its measurement indicators used in the analysis. The figure clearly shows that the inclusion of a multidimensional measure of FS such as MIFI is able to capture more cross-country variation in FS performances than of single indicators. When the PoU is around a level of 5%, performances in terms of MIFI are extremely varied: the analysis of MIFI shows the very low levels of food insecurity in Argentina, the relatively poor performances of Azerbaijan, Egypt and Ghana, and the worrisome case of Nigeria. Although the latter country is classified by FAO as characterized by low undernourishment rates (with a PoU of just 7%), a MIFI of 76% provides a very different picture, due to the high rates of malnutrition among children and women (at 41% and 12.3% respectively), and low dietary diversification (with two thirds of overall food consumption based on staple foods). In contrast to the PoU, which provides information only on availability and access, MIFI is also able to shed light on the utilization dimension through the two malnutrition indicators and the one on diet diversification. As such, MIFI seems to be able to provide a more nuanced picture of FS than the FAO indicator. The same conclusion applies when the relationship between MIFI and the prevalence of underweight is analysed. Secondly, through the combination of indicators independently measured, MIFI reduces the impact of random measurement error in single indicators. Moreover, as opposed to other types of composite indexes, such as the Global Hunger Index (Wiesmann 2006), the SEM methodology explicitly models and controls for measurement error by assuming that the latent construct is only imperfectly proxied by observed indicators. Finally, as shown by Table 3, the strength of association, as measured by rank correlations, of MIFI with other relevant development indicators of health and FS is higher for the composite index than for its components. This feature shows the ability of the MIFI to better capture deprivation in nutrition and health related indicators than its single components, and hence to provide a comprehensive, yet summary, view of overall food insecurity performance. The relatively high correlation with these commonly used measures to assess the health and nutrition dimensions provides an additional measure of MIFI's "external validity" in adequately measuring FS.

6. Conclusions

This paper presented two original theoretical and methodological frameworks for the analysis and measurement of FS. In order to avoid "measuring without theory" (Koopmans 1947), the paper presented an original theoretical framework grounded in Sen's CA that shows the process of achievement of

Table 3: Parameter estimates for the Structural Model (selected specifications).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cereal Yields	0.017	0.01	0.015	0.017	0.005	0.016	0.007
FPI/CPI	-0.157*	-0.171**	-0.178*	-0.157**	-0.158*	-0.158**	-0.170**
Ratio female to male literacy rates	-0.168*			-0.168**	-0.177*	-0.185*	-0.119
Adult literacy, females		-0.171*					
Adult literacy, males			-0.091				
Poverty Headcount $1 a day (% pop.)	0.256**	0.250**	0.222*	0.256**	0.245**	0.243**	0.224
Access to sanitation (% pop.)	-0.079	-0.117	-0.128	-0.079	-0.079	-0.069	-0.103
Health expenditure p.c.	-0.229***	-0.214***	-0.234***	-0.229**	-0.247***	-0.241***	-0.179**
Av. Growth rate (2006-08)	0.017	0.046	0.024		0.013	0.022	-0.002
Growth rate (2008)				0.017			
Av. Agricultural growth rate (2006-08)							0.097
Rural population (% pop.)	0.400***	0.361***	0.420***	0.400***	0.399***	0.404***	0.477***
Voice & Accountability	0.04	0.023	0.03	0.04	0.041	0.035	0.033
Political stability	-0.069	-0.061	-0.064	-0.069	-0.071	-0.059	-0.088
Food imports/merchandise exports					-0.046		
Gini index						0.04	
Chi2	35.8	37.996	38.602	35.8	42.943	51.41	37.705
p > chi2	0.295	0.215	0.196	0.295	0.167	0.036	0.347
RMSEA	0.046	0.057	0.061	0.046	0.064	0.091	0.038

Note: ***, **, * denote significance at 1%, 5%, and 10% levels, respectively. The estimates were carried out with robust standard errors. Coefficients are standardised.

FS at different levels of analysis. Also, the choice of the indicators in the evaluative exercise was based on the role they play in the process of achievement of FS. In particular, coherently with CA's focus on the ultimate ends of development rather than its means (Sen 1999) and with the literature on social indicators, the selected measurement indicators are all outcomes of distinct dimensions of FS. Methodologically, the paper argued that the latent variable methodology can offer an appropriate framework for the measurement of FS, which is modelled as a latent and unobservable phenomenon. The MIMIC setup was shown to be able to: (i) adequately capture the multifaceted nature of food insecurity though a multidimensional evaluative exercise; (ii) minimize the burden of measurement error in single indicators; (iii) shed light on the broadly environmental factors that are associated to FS at the cross-country level. With respect to the first objective, the empirical evidence presented in this paper showed that the resulting MIFI, by including information on the availability, access and utilization dimensions, is able to offer a more balanced view regarding food insecurity than single indicators, which cannot capture the complexity of the concept, and to capture more effectively cross-country variation. Moreover, MIFI is highly correlated to a number of other key health and nutrition indicators, which, while on the one hand supports the external validity of the measure, on the other points to its ability to provide a comprehensive, yet summary, view of overall countries' FS performances. Also, MIFI, by combining indicators that are measured independently from each other and by explicitly modelling the error term, reduces and controls for the impact of random measurement error in each single indicator (Kuklys 2005). Finally, the empirical evidence reported in this paper sheds light on the factors that are associated to FS outcomes at the cross-country level. Consistent with our theoretical framework, empirical results showed that the "capability to be food secure" results from the complex interaction between key human development dimensions such as health and education, and environmental, institutional and economic factors. In particular, the empirical results showed that economic growth alone is not a sufficient condition to ensure FS, while there is extensive space for public action for the promotion of FS through, for instance, expenditure on women's education, health, and expansion of

households' entitlements to food through income poverty reduction. Also, the empirical evidence on prices and agricultural productivity contributes to a more nuanced policy debate on their role in the promotion of FS. Although further research to validate these empirical results is certainly needed, they are nonetheless coherent with our theoretical framework: following the CA, the focus on food availability and prices is not enough to ensure FS to automatically follow, and, as such, a broader approach, combining investments in rural and human development seems to be more promising.

Finally, one of the main limitations of the present analysis relies on being based on a cross-country sample, for three main reasons: first, FS is an inherently dynamic concept, and, by analysing it at a given point in time, the dimension of stability is inevitably left out. Secondly, cross-country estimates suffer from many limitations (Durlauf *et al.* 2005), the most prominent of which relates to some unobserved country-specific factors that may lead to endogeneity in the estimates. By acknowledging these shortcomings, further research using longitudinal data seems a promising way forward.

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Endnotes

1 Availability refers to the "physical supply of food from all possible sources" (e.g. all forms of domestic production, commercial imports, food aid, etc.).). Access represents the "economic, physical, and social ability to acquire adequate amounts of food", while utilisation points to "households' use of the food to which they have access, and to individual efficiency in biologically converting nutrients in order to meet their specific nutritional and health needs" (WFP 2009). Finally, stability emphasises the permanency and sustainability over time of these dimensions.

2 The CA is a theoretical framework for evaluating and assessing well-being and poverty. Critical concepts are the ones of functionings and capabilities. Functionings are being and doing activities that people value or have reason to value and include achievements in different dimensions of life. Capabilities reflect the various functionings available to the person and her real opportunity freedom to achieve those vectors of well-being outcomes that she has reason to value (Sen 1999).

3 Note that the interpretation of causality in SEM using observational data is no less problematic than the one of standard regression models. As such, it is important to stress that the estimated coefficients in the empirical applications are measures of statistical associations and not of causality in the sense of Rubin (1974).

4 For instance, Khrishnakumar (2007) uses data from 56 countries, while Cracolici et al. (2010) have a sample of 64 countries.

5 For further discussion, see Section 4.4.

6 The case of Sub-Saharan Africa is particularly instructive: while having experienced sustained growth during the 2000s, no corresponding progress in nutrition has been achieved, which led some commentators to refer to this phenomenon as the "paradox of food insecure growth" (UNDP 2012).

7 In a recent contribution, Headey (2013) provides tangible examples of "growth-mediated" or "support-led" FS pathways. While the former includes the case of Thailand or Vietnam during the 1980s and 1990s, Brazil, Mexico or Honduras, without experiencing strong rates of GDP growth, could promote FS through the provision socio-economic improvements in various domains.

8 Available upon request to the author.

List of Tables.

Table 4: Rank correlations between MIFI and its components and selected health and nutrition indicators.

	MIFI	POU	Prev. of stunting	Prev. of Malnutrition in women	Dietary Diversity Index
Prev. of Wasting	0.68***	0.34*	0.68***	0.89***	0.58***
Prev. of Underweight	0.86***	0.53***	0.85***	0.89***	0.69***
Infant mortality rate	0.77***	0.63***	0.72***	0.56***	0.66***
Under 5 mortality rate	0.79***	0.67***	0.73***	0.55***	0.67***
Depth of hunger	0.74***	0.80***	0.67***	0.49***	0.51***
Engel coefficient	0.64***	0.41***	0.58***	0.45***	0.63***

* and *** denotes significance at 10% and 1% respectively.

Appendix 1: Descriptive Statistics.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Prev. of stunting (% children 0-5 yrs)	97	28.35	14.00	2.00	57.70
Prev. of malnutrition in adult females	67	10.67	8.91	0.70	39.90
Prev. Of Undernourishment	97	18.54	14.20	5	72.4
Dietary Diversity Index	97	0.56	0.12	0.32	0.82
Cereal Yields	97	2352.64	1535.44	252.20	7894.70
GDP p.c. (PPP)	94	5796.75	6652.37	422.23	49952.16
Gini index	82	43.14	8.33	29.33	63.90
GDP growth rate (2007)	96	6.56	4.37	-3.65	25.05
$1 a day Poverty headcount (% pop.)	88	24.82	23.43	0.00	83.76
Ratio food imports on merchandise exports	90	13.43	6.90	1.86	45.56
Ratio food prices over consumer prices indexes	89	1.05	0.22	0.31	2.18
Road density index	96	28.06	36.62	1.00	201.00
Access to sanitation (% pop.)	96	59.66	30.57	9.00	100.00
Access to water (% pop.)	96	80.32	16.24	42.00	100.00
Health exp. p.c.	95	213.56	236.35	10.66	1116.63
Adult literacy ratio (females)	94	79.24	22.51	17.98	100.00
Female-to-male adult literacy ratio	92	0.86	0.17	0.35	1.15
Rural pop. (%)	97	50.91	22.10	1.78	89.86
Voice & accountability index	97	-0.40	0.86	-2.20	1.56
Political stability index	97	-0.31	0.86	-2.43	1.16

Appendix 2: Indicators, Definition, Sources and Rationale of the indicators in the Structural Part.

Indicator	Definition	Source	Rationale
Cereal yields	Harvested production per unit of harvested area.	FAO, FAOSTAT	Measure of agricultural productivity. It provides a measure of the "health" of the agricultural sector in the country.
Agricultural spending in R&D, % *Agricultural GDP*	Total agricultural R&D expenditures by the government, higher education, and non-profit sectors as % of agriculture GDP.	ASTI	Proxy for the research intensity in the agricultural sector.
GDP per capita (PPP)	Gross domestic product converted to international dollars using Purchasing Power Parity (PPP) rates.	World Bank WDI	Indicator of the general standard of living in the country.
GDP growth rate	Annual percentage *growth rate* of *GDP* per capita based on constant local currency.	World Bank WDI	Indicator of the dynamism of the economy.
Food imports, % merchandise exports	Ratio of total food imports on total merchandise exports.	World Bank WDI	It measures country's ability to finance its food imports.
Relative level of food prices	Ratio of food consumer prices index and the general consumer prices index.	Author's calculations from FAO FAOSTAT data	The ratio provides a measure of the relative food prices with respect to the prices of goods and services in the economy. Consumer price indexes measure the cost of purchasing a fixed basket of consumer goods and services of constant quality and similar characteristics, with the products in the basket being selected to be representative of households' expenditure.
Poverty headcount ratio, $1.25 a day 2005 PPP	Population below $1.25 a day is the percentage of the population living on less than $1.25 a day at 2005 international prices.	World Bank WDI	Poverty boosts food insecurity by affecting households entitlements to food and increasing their vulnerability to disease (Sen 1981; World Bank 1986; Drèze & Sen 1989).
Gini index	Measure of the inequality of the distribution of income or consumption expenditure among individuals or households within an economy.	World Bank WDI	The inequality in the distribution of resources may affect food security outcomes (Sen 1981).
Road density	Ratio of the length of the country's total road network to the country's land area.	Author's calculations from World Bank data	It is a proxy of the infrastructure stock and connectedness to the markets.
Improved water source, % population with access	% of the population with reasonable access to an adequate amount of water from an improved source.	World Bank WDI	Safe water is an essential component of food and nutritional security. The use of unsafe drinking water is directly related to water-related diseases such as diarrhea, cholera and typhoid. These types of diseases are often found to be a cause of malnutrition in developing countries.
Improved sanitation facilities, % population with access	% of population having access to adequate sanitation facilities.	World Bank WDI	Adequate sanitation is an essential component of food and nutrition security, as it lowers the risks of diarrhea and other diseases that hamper the capability of converting food in good nutritional outcomes.
Literacy rate, adult female	% of females aged 15 and above who can, with understanding, read and write a short, simple statement on their everyday life.	World Bank WDI	The positive relationship between education, female in particular, and food security is well documented in the development literature (Behrman & Wolfe 1987; Kassouf & Senauer 1996; Burchi & De Muro 2007). In particular, literate women provide good nutritional outcomes for their families through their capability to use information related to good health and nutritional practices.
Voice and Accountability Index	The index "captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media"(Kauffman *et al.* 2003, p. 3).	World Bank World Governance Indicators	Related to the "governance" aspect of food security: the work of Sen (1981, 1999) and Drèze & Sen (1989) among the others showed that governance, and in particular accountable forms of governments, play an important role in averting famines. The UNDP (2012) has also recently stressed the role of voice and participation in promoting food security.
Political Stability Index	The index " captures perceptions of the likelihood that the government will be destabilised or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism" (Kaufmann *et al.* 2003, p. 3).	World Bank World Governance Indicators	Other index related to the "governance" aspect of- food security:
Rural population (%)	Rural population refers to people living in rural areas as defined by national statistical offices. It is calculated as the difference between total population and urban population over total population.	World Bank WDI	Used as a control variable.

Food Security: analysis on basic basket's items prices in the Northeast region of Brazil

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Abstract

Large amount of the Brazilian population, mostly from the Brazil Northeast region, live on an income below the official minimum wage. This situation considering scenarios of rising food prices and economic uncertainty stemming from financial crises and food supply in the world, implies the searching for studies in order to understand such phenomena and thus anticipate policy strategies that enable such situation threatens food safety of people, especially those who are at minimum income range, since most of the costs of the population corresponds to expenses related with food. In order to understand the behaviour of this phenomenon, food prices that comprise the basic basket´s were analyzed, considering these adverse scenarios, from the price series, applying the analysis of seasonal factors by the method X-12 -ARIMA. The studied area covers the Northeast capitals where the DIEESE performs the collection of basic prices and the cities of Ilhéus and Itabuna, Bahia State, taking in account the Database Project on Basic Basket Cost developed at Santa Cruz State University. The results showed that seasonality in most surveyed cities, increases in the first semester and decreasing in the second; more deterministic seasonality was related to meat and tomato. Regarding to intervention analysis, it was found that variations in tomato prices strongly alter the behaviour of the series. Changes in climate factors, the exchange rate, prices of oil, changes in the political scenario, and reduced supply by producers were factors that resulted in series interventions of total cost. The chosen models for forecasting were close to observed values, demonstrating they are important tools for management and planning by both the producer and structuring public policy.

Keywords: food prices; economic development; food insecurity.

1. Introduction

Studies of the United Nations Food and Agriculture Organization (FAO, 2012) indicate that there has been change in the behavior of food prices worldwide. Until the mid-1970s prices had been decreasing, and at the beginning of when they begin to grow from the 2000s, reaching high levels from 2007/2008 due to the global food crisis.

The possible causes for this world crisis of foods stems of inequality in income distribution among the Northern and Southern countries, of the allocation of part of agricultural production for biofuel production, of the increased consumption in emerging countries, of ethnic and social conflicts, natural factors, among others (FAO, 2009). Moreover, the world financial crisis worsened even more the access to basic foods by the poorer population.

This occurs because in an increasingly globalized world these factors are more easily perceived and disseminated through unemployment, reduced levels of exportation and importation, trade slowdown, oscillations in futures markets and exchange rates. All this causes changes in the demand for food, discourages food production, so that impacts prices in many different markets. In this sense, the current scenario of crisis has caused profound impacts on prices that spread up along the nations.

In this perspective the aim of this paper was to identify and analyze the basic-needs grocery package cost behavior in the Northeast Brazil, taking as reference the collections of the Departamento Intersindical de Estatística e Estudos Socioeconômicos (DIEESE) and the Universidade de Santa Cruz (UESC). For that, it was sought to identify the structural and cyclical factors that affect the behavior of the cost of the official basic-needs grocery package and the seasonality-price of the products that make up the package.

2. Methodology

2.1 Field of study

The field of study of this article has encompassed the Northeastern capitals: Aracaju, Fortaleza, João Pessoa, Natal, Recife and Salvador, beyond the cities of Ilhéus and Itabuna in the Bahia.

2.2 Data source

The data of the cost of the basic-needs grocery for the capitals of the Northeast were obtained from the website of the Departamento Intersindical de Estatística e Estudos Socioeconômicos (DIEESE) and for the cities of Ilhéus and Itabuna, from the database of the project Acompanhamento do Custo da Cesta Básica (ACCB) conducted by the Department of Economics of UESC.

It were analyzed the time series of the total cost of the basic-needs grocery package and the series of official price of the items in that package, taking as reference the period from May 1999 to June 2012.

2.3 Theoretic model

The initial assumption in time series analysis is that the original series can be decomposed into four components deterministic: the seasonal component (S) which is defined as the pattern of variation within a year, the cycle-trend (T) which refers to the long-term trend and to the business cycles; weekdays (TD) which signify the variations according to the calendar effect as Saturdays, Sundays and holidays and the irregular component (I) which are irregular variations due to impacts of political events, strike effects, unseasonal weather conditions, survey sampling errors, etc. (Carvalho et al., 2008). When these components of the time series are independent, they can be defined by the additive model:

$$Zt = St + Tt + TDt + It \quad (1)$$

However, when the seasonal component, weekdays and irregular, is proportional to the trend (trend-cycle) series, which occurs frequently in economic series, this one is expressed by the multiplicative model:

$$Zt = St \times Tt \times TDt \times It \quad (2)$$

Seasonality represents movements in time series throughout the year, which recur with some regularity every year and are mainly related to the periods during and between harvests, to the physical and climatic conditions, to the seasons, the customs population, the religious holidays (Easter, Christmas, etc.) among others. Thus, seasonality results from non-economic forces, exogenous to the economic system that cannot be controlled or modified by decision-makers in a short interval of time. Accordingly, understanding your behavior pattern can guide various forms in decision making by economic agents.

Cazorla (1986) points out that the knowledge of the seasonal component has, among other features, an importance in controlling inventory, or in government guidance in the supply policy formulation. Thus, the seasonal adjustment helps to relate a time series with other series, external events or political variables. According to the referred author, the seasonally adjusting of a time series consists in decomposing the series Z(t) basically in two unobservable components: seasonal S(t) and non-seasonal N(t). Since in general, the non-seasonal component is decomposed into other components, such as trending, cycles, calendar variation, irregular component.

In accordance with the foregoing, it is pointed out that the series in given period of time can make a change in their behavior, which would mean interference of events that have occurred at the same period or at a later time, caused by interdependence, which is a common phenomenon to economic factors. According Morettin and Toloi (2006, p. 301), the intervention can be understood as "the occurrence of some kind of event at any given instant of time T, known a priori."

Through the analysis of intervention it is possible to evaluate the impact of a particular event on the conduct of an analyzed series, and this impact may be temporary, modifying the conduct of the series which, after a short period, can return to the previous path or a permanent change. This analysis tool can be applied in various areas of study, such as economics, health, education, sociology, among others, and may be related to various aspects. In economics, for example, policy measures, tax incentives, subsidies and so on.

In this article the method X-12-ARIMA was used to perform two types of analysis: the seasonal adjustment and then detecting and analyzing the outliers (intervention analysis). It was made a prediction for 12 months to the analyzed cost series. According to Carvalho et al. (2008) the following steps were made:

Step 1:

a) Preliminary analysis of the series through the construction of charts in order to identify abrupt changes in time, and for that it was made a logarithmic transformation and sought to identify the presence of outliers;

b) Seasonality test Application like F and Kruskal-Wallis tests for stable seasonality, moving seasonality test and identifiable seasonality test which is the combination of the other three tests;

c) Determining the type of decomposition in order to identify if the model is additive or multiplicative;

d) Detection of outliers (intervention analysis). If the presence of stable seasonality in the analyzed

series is identified, it moves up to the second stage which consists of applying X-12 ARIMA procedure for obtaining the seasonally adjusted series.

Step 2:

a) Regression factors adjustments concerning to business days, holidays and leap year, besides testing other variables available in the program;

b) Adjustment of SARIMA models of Box and Jenkins1, considering, besides the standard models available on the X-12 ARIMA, other potentially possible models;

c) Estimation of a series for the next 12 months;

d) Application of the X-11 method for the series previously estimated to obtain the seasonal factors and the seasonally adjusted series.

After this step, other procedures are performed. They consists in assess the adjustments made in step 2.

Step 3:

a) Observing the randomness of waste, i.e. the lack of periodicity, the absence of normality 2 and autocorrelation will be evaluated and the FAC analysis (autocorrelation function);

b) Analyzing the M and Q statistics, stand its importance in deciding the type and quality of the seasonal adjustment model. There are 11 M statistics and each one has a specific function. The value of M statistics cannot exceed one unit. However, it is acceptable up to three M statistics with a value greater than 1. By combining the M statistics, without considering the value of M2 statistic, it is obtained the value of the Q statistic, important information for assessing the quality of the model 3.

The last step refers to the correction of problems detected in the models.

Step 4:

a) Revising the model chosen for decomposition and choosing the type of transformation to be adopted;

b) Reviewing the ARIMA model according to the estimation performed;

c) Checking if the models can be better adjusted;

d) Checking whether or not the regression to business days is significant by examining the periodogram to the adjusted series and to the residue and testing the elimination of insignificant coefficients and new combinations of repressor variables;

e) Reviewing the outliers and check if the observations are below the critical value and its magnitude, thus revising the threshold critical value;

f) Final revised model from the completion of the previous steps, setting a new proposed model;

g) Reviewing the options of X-11 by checking the successive filtrations.

To operationalize the X-12-ARIMA it was used DEMETRA+ program which is free software (http://circa.europa.eu/irc/dsis/eurosam/info/data/demetra.htm).

3. Results and discussion

Instability in food prices versus food security

The status or situation of food security depends on several variables involving political, economic and social aspects which may be related to availability of food quality, food production /marketing and purchasing power of wages[1].

The instability of the food prices affects the food security of the population. The high volatility of food prices affects the relationship between supply and demand, and these movements are more abrupt when subjected to fluctuations in the price of oil (SILVA, 2011).

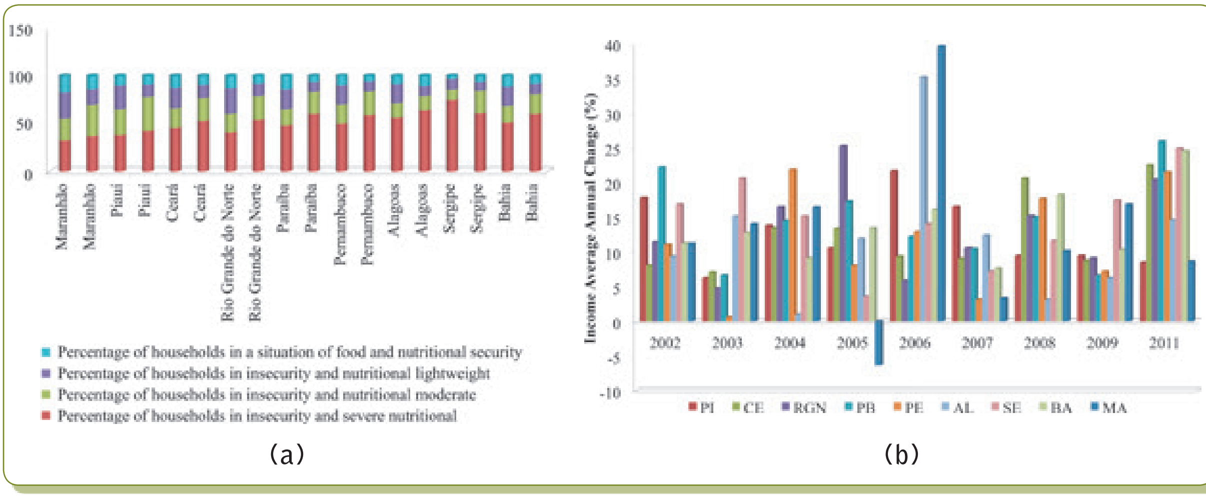
This fact undermines the purchasing power of workers, as their real income decreases, often requiring direct policy measures (income transfer programs) or indirect policy measures (tax reduction, credits to farmers, among others) to mitigate the direct impact of the rising prices.

According to data from the Ministério de Desenvolvimento Social e Combate à Fome (MDS, 2013), the Northeast region has the lowest average per capita income of the country, U.S. $ 474.18 in 2011, a lower percentage of people in food safety (53.79 %) and a higher percentage in food insecurity and nutritional impairment (9.35%), while the South and Southeast regions of the country, have 2.13% and 2.91% respectively for that latter variable.

Although this is a disastrous scenario, the figures noted above, the food security situation in the Northeast has been showing some improvement when comparing the data from 2004 to 2009. This situation has occurred in almost all the states of this region, except for the state of Sergipe (Figure 1).

This improved food security situation is subject to decrease, because the DIEESE data have pointed "accelerated" growth of the cost of food in the capital of the Northeast. From 2004 to 2012, the cost of the basic-needs grocery package in the cities of Salvador,

Figure 1: Evolution of the food security situation % of households from 2004 to 2009 (a) and variation of the average annual income for the states in the Northeast of Brazil, 2002-2011 (b).



Source: Data Social 2.0. (PNAD suplementar).

Fortaleza, João Pessoa, Natal, Recife and Aracaju increased 59.17%, 63.80%, 59.54%, 61.40%, 69.46% and 39.04% respectively (DIEESE, 2013). In order to mitigate the food rising prices to the consumer, the government seeks to adopt pricing policies that can stimulate production and consumption, as highlights the MDS (2011), however, it is not an easy task.

Seasonality

The seasonal tests indicate deterministic seasonality in most capital items for meat and tomato, only in the series of Itabuna the meat was not positive for the combination of tests for mobile and stable seasonality. The fact that these items have made this seasonality does not mean that the other series did not show seasonal effect, since the analysis of the seasonal pattern was performed in all series. However, in the series of these two products, seasonality was deterministic, which may indicates that the supply of these products have well-defined periods throughout the year.

The analysis of the tests also indicated a strong tendency for multiplicative models, inferring that the series of food are heavily influenced by cyclical economic changes.

In the analysis of the seasonal pattern it was observed that in the first half of the year there is greater seasonal effect while in the second half the effect is smaller. Thus, the cost of basic food tends to be higher in the first half of the year, and little by little this cost decreases, leading us to believe that the harvest of most basic food items occurs in the second half of the year. Only in the capitals of Fortaleza and Natal, the observed behavior was the opposite, with decreasing seasonal effect in the first half of the year and ascending in the second half of the year.

Intervention

The intervention analysis sought to identify which factors alter the behavior of the series of total cost. This analysis has highlighted points of intervention in all series in the item “tomato”, this fact is due to the high sensitivity of the product in relation to changes in temperature and perishability, leading to strong price movements over the year and also the weight of such item on the total cost of the package. Many times this item is named as “villain” of the basic-needs grocery increasing prices. However, increases in the price of tomatoes and other horticultural products, are temporary and caused by atypical factors like climate change, as the study points CEPEA (2004). On the other hand, increases in costs arise from other variables such as inflation, tax burden and public tariffs.

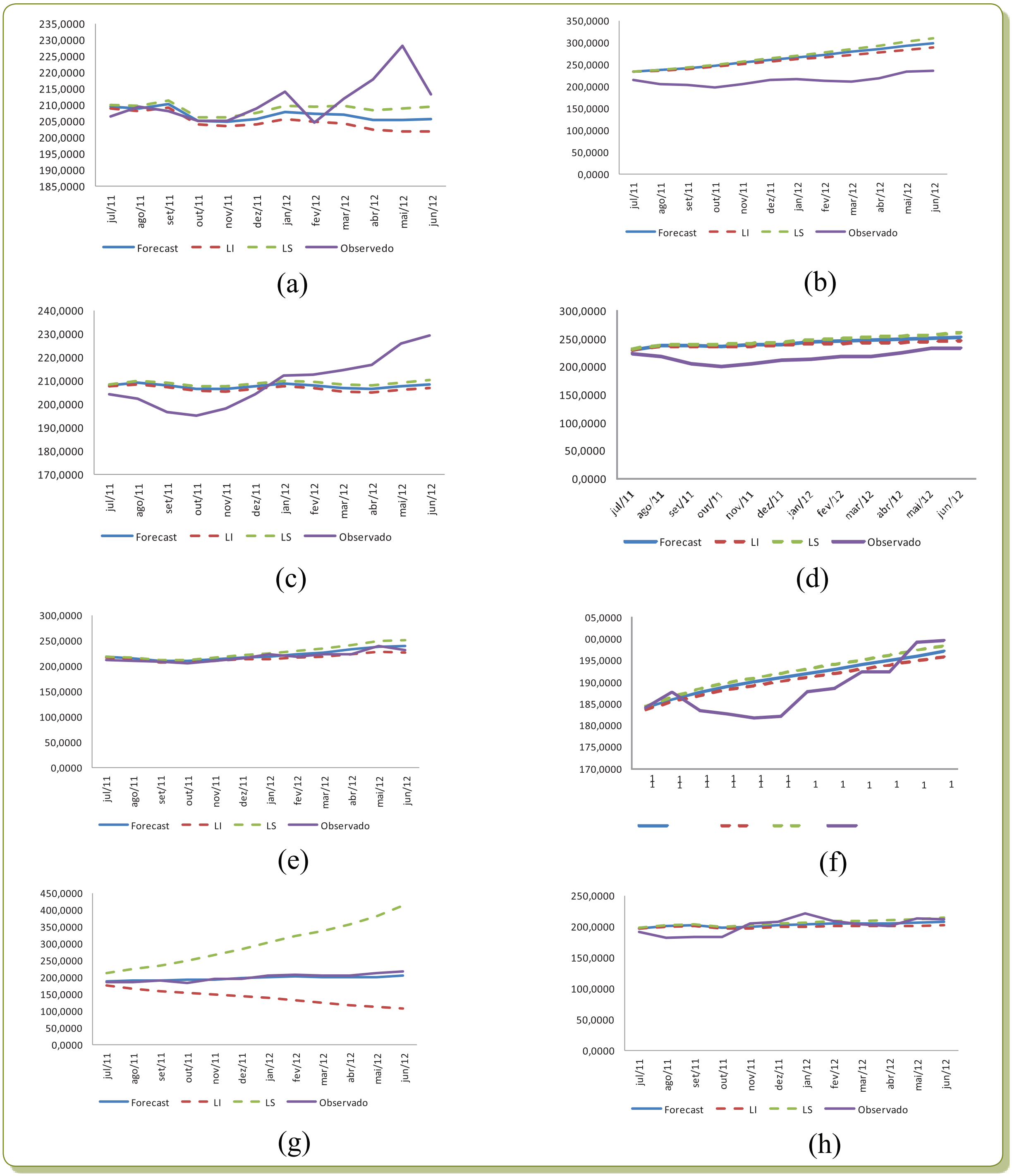
Other basic food products have also suffered the effects of climate change, especially drought Northeast in 2001, besides alternating periods of heavy rainfall and severe drought. These factors have significantly altered the supply of products and prices. Besides the factors associated with climate, the change in the trajectories of the analyzed series have occurred by fluctuations in the exchange rate which have had an important role on the behavior of prices, especially for exportable items such as meat, soy and coffee. They also affected the cost of the package: the changes in the prices of oil and its derivatives, the internal political scene as the election and re-election of President Lula and the trade relations with other countries.

Forecast

Regarding the analysis of the eight series forecasting of total cost of basic-needs grocery, it was observed that the eight series, four of the chosen models were more efficient including the effects of four interventions without these effects.

In general, the predictions that best fit, indicated similar behavior to the actual values observed, being more efficient in early prediction, as expected. This shows that this type of analysis may constitute an important tool for the producer and consumer planning as well as a tool for analysis of pricing policies (Figure 2).

Figure 2: Estimated cost of the basic-needs grocery package of the cities of Salvador (a), Fortaleza (b), João Pessoa (c), Natal (d), Recife (e), Aracaju (f), Itabuna (g) and Ilhéus (h), July 2011 to June 2012.



Source: Research Data.

4. Final considerations

It can be inferred that food prices in the analyzed cities, indirectly or directly, were influenced by the factors that caused the food crisis and still remains, and climate change constitutes the most relevant factor for price movements of basic food products. The financial crisis, despite having influenced the behavior of some of the series, the extent of its influence is not relevant in the overall behavior of the prices of items in that package.

It can be inferred that the upward trend in food prices tends to increase food insecurity and consequently the highest level of malnutrition of the population. Accordingly, it is relevant policy measures that provide greater price stability and "preserve" the purchasing power of the minimum wage.

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Endnotes

1 The population of a given region can produce a lot of food, which is exported to another region in view of the inability of this population to acquire these foods (Sen, 2010, p. 211).

Data SAN – multidimensional data and indicators for food and nutrition security in Brazil

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Abstract

The Right to Food is achieved when everybody has guaranteed a continuing access to adequate and healthy food, in a sufficient quantity and obtained by a sustainable way. To ensure the achievement of this right, it is mandatory the allocation of public funds, from different sources, to the formulation, implementation and monitoring of public policies, mainly aimed for that population that has its rights violated, as well as any other related to them.

Brazil recorded a significant progress in the past few years, however, several surveys - including some National Household Sample Survey (PNAD) of National Statistics Bureau (IBGE) - show that many Brazilian families still live in food and nutrition insecurity.

Data SAN was based on the report "Food Security and the Right to Food in Brazil: indicators and monitoring, the Constitution of 1988 to today," published in 2010 by the National Council of Food and Nutrition Security (CONSEA). It integrates an informational tool called Data Social, developed by the Ministry of Social Development and Fight Against Hunger (MDS).

The Data SAN tool consists of a large data set and indicators to know the overview of the situation of the Food and Nutrition Security (SAN) in Brazil from an intersectoral approach. This approach aims to monitor indicators of production and availability of food, access, income, health and nutrition, education, and the public policies that would be focusing on this set of indicators:

I-Food Production;

II-Availability of food;

III-Income / Access and food expenditure by households;

IV-Access to Adequate Food;

V-Health and Access to Health Services;

VI-Education; and

VII-Public Policies.

The Data SAN tool provides indicators already constructed from different and several public databases, such as the Survey of Local Agricultural Production and Agricultural Census, the National Survey of Household and Expenditure Survey, all from IBGE; availability and storage data form CONAB, IPEA data, DATASUS, ANVISA, among others.

The indicators are updated periodically and it is possible to find data for National, states, Federal District and municipalities, and other breakdowns for each indicator, since available in the bases on which the data were collected. Furthermore, it allows creates graphics, charts and the exportation for a Excel format.

Thus, the innovation of the Data SAN is to organize and deliver a set of sparse information, using a systemic and intersectoral Food Security and Nutrition benchmark, and become it available to researchers, managers, social movements and citizens in general.

Keywords: food security; intersectoral; multidimensional data.

1. Introduction

The Law 11.346 of 15th September 2006, called Organic Law of Food Security and Nutrition (LOSAN) introduced the National System of Food and Nutrition Security (SISAN) in order to ensure the achievement of the right for all to access regular and permanent quality food in a sufficient quantity, without compromising access to other essential needs, based on health promoting food practices that respect cultural diversity and that are environmentally, culturally, economically and socially sustainable (Brazil, 2006).

LOSAN presents the structure of SISAN by which government institutions by the three levels of government and the civil society organizations should work together in the formulation and implementation of policies and actions to fight against hunger and promote food and nutrition security. It also establishes mechanisms for monitoring, tracking and evaluating the nutritional status of the population, defining the rights and duties of government, family, business and society. LOSAN was regulated by the Decree No. 7.272, 25th August, 2010, which established the National Policy for Food and Nutrition Security (PNSAN) and its guidelines. For determination of the mentioned Decree, it was drawn up, in 2011, the first National Food and Nutrition Security Plan - PLANSAN 2012/2015, the main instrument for planning, management and execution of PNSAN at the federal level (Brazil, 2010).

With the inclusion of the right to food in the list of social rights set out in article 6⁰ of the Federal Constitution of Brazil, the government has to adopt policies and actions that are necessary to promote and ensure Food Security and Nutrition (SAN) for population.

In order to achieve this purpose, it is necessary that all entities of the Union, States, Federal District and Municipalities integrate efforts, together with civil society, for tracking, monitoring and evaluation of the SAN and the progressive achievement of right to food.

The SISAN requires a monitoring system to provide, periodically, indicators on the evolution of the right to food and promotion of food and nutrition security. This monitoring has to consider the indivisibility of rights and the intersectoral approach. Therefore should contain indicators that express the multiple dimensions of SAN, with the cultural, territorial and regional dissociation, considers the specific cuts that demonstrate gender inequalities, ethnic and racial breakdowns and focus on vulnerable populations such as indigenous peoples, maroon communities, people of African origin, among others.

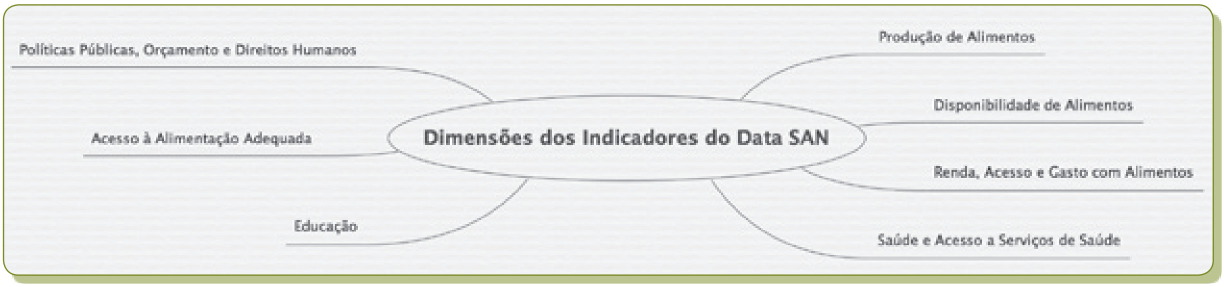
2. Conceptual Framework Monitoring System of Food and Nutrition Security in Brazil

The monitoring system of SAN in Brazil was built from a comprehensive discussion of civil society and government within the National Council for Food and Nutrition Security (Consea). A working group (GT) composed of experts from various agencies that deal with information in the federal government, university researchers and non-governmental organizations and counselors of Consea was established in 2006 to define the theoretical framework of the system and develop a framework of indicators able to account for the determinants of SAN.

The result of this work was the publication of the report “Food Security and the Right to Adequate Food in Brazil: Indicators and monitoring of the Constitution of 1988 to the present day”, published by the National Food and Nutrition Security Council (Consea). The document (Consea, 2010) presented for the first time, an analysis of the evolution of the indicators and policies of SAN in the country since the promulgation of the 1988 Constitution until 2010.

The elaborate framework was divided into seven dimensions of analysis chosen from studies of theoretical determinants of Food and Nutritional Security (Kepple & Segall-Corrêa, 2011), which are: 1.food production 2.availability of food, 3. income/ access and food expenditure by households, 4.acess to adequate food, 5.health and access to health services, 6.education and 7.public policies, according to the scheme below. Each of these ones presents a set of indicators, around 42 in the total.

Figure 1: Dimensions of Food and Nutrition Security.



3. The Monitoring System of Food and Nutrition Security - Data SAN

With the assignment to evaluate and monitor the National Policy for Food and Nutrition Security, since 2011, the Department of Monitoring (DM) of the Secretariat for Evaluation and Information Management (SAGI) of the Ministry of Social Development and Fight Against Hunger (MDS) has produced simple and timely information about the performance and effects of programs, activities and services conducted by the federal government with the aim of supporting the decision-making of managers.

For Data SAN tool, which aims to bring together, in a single instrument, the main indicators and variables of the SAN, we took into account the methodological steps of defining the concept of SAN, specifying operational dimensions, and obtaining government statistics from various sources.

In addition to these indicators, another relevant ones were brought to Data SAN to monitor the National Food and Nutrition Security Plan - 2012/2015, which was prepared by the Interministerial Chamber of Food and Nutrition Security - CAISAN. The plan includes several actions of many federal agencies focused on food production, the strengthening of family farming, food supply and the promotion of adequate and healthy food.

Another innovation from Data SAN tool was the inclusion of specific issues such as those related to price volatility of food and its effects on low-income populations.

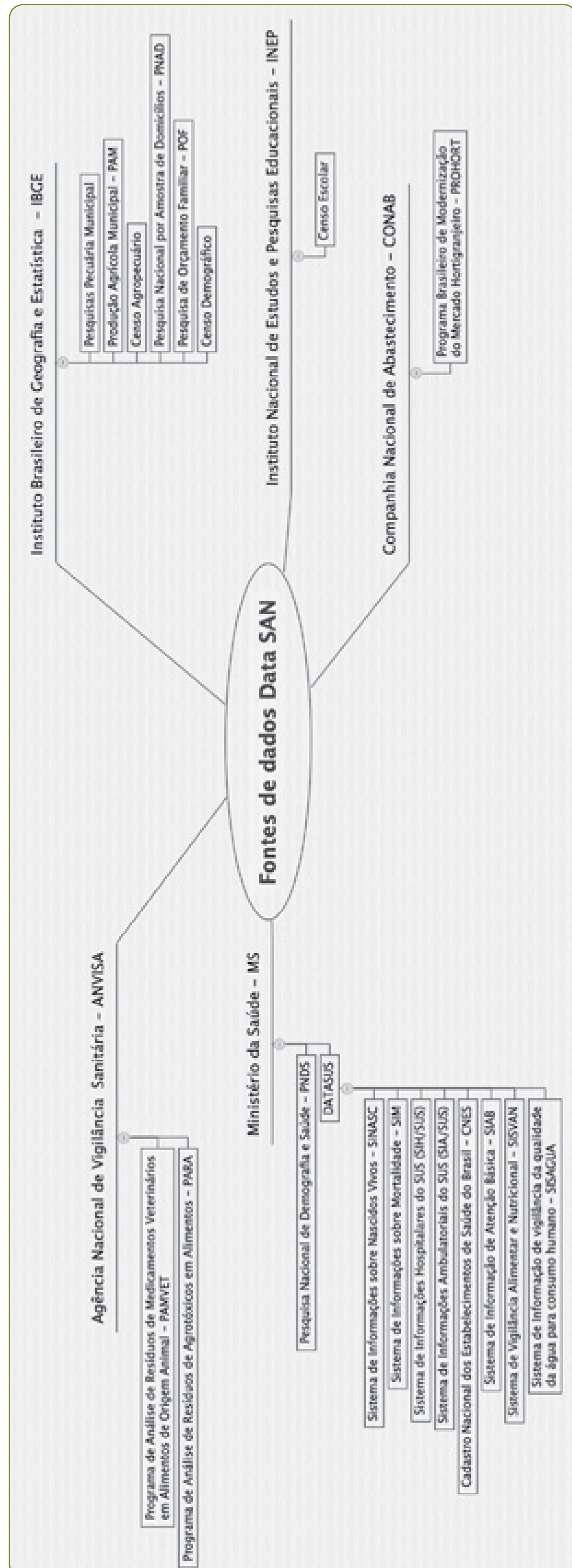
In this new context the Data SAN can be described as a panel of data and indicators of food and nutrition security that allows managers, technicians, users and other citizens to access information about SAN through a single instrument, covering their several dimensions without resorting to various bases. This way, they can build a multi sectoral analysis of relational and inter-related events of SAN. Their indicators compute information from various databases with territorial and temporal granularities.

3.1. Formatting Database

3.1.1. Extraction

The indicators that integrate the Data SAN tool come from various surveys and information systems as shown below.

Figure 2: Sources of the Data SAN.



All indicators included in the Data SAN tool is extracted from data or microdata available through official sites of information available on the Internet. Therefore, from these inputs the indicators are calculated and the charts are formatted to load the data. Extracting data from microdata permits to automate the treatment and the routine of loading data and to facilitate the documentation of the indicators calculation.

3.1.2. Treatment

The treatment of the data is made in individual cases. For the most of the indicators are used the charts extracted from the official websites and is modified only the format of the files according to the metadata of the database. In the case of treatments applied in microdata, they are documented in the routines used syntaxes. Both the base treatment and routine are documented for the purposes of replication. Schedules are made by using the software Excel (VBA Macros) and Statistical Product and Service Solutions (SPSS).

3.1.3. Load Routines

After the extraction from the source charts, the files are transformed into standard format files, according to metadata database. An informational tool is used to execute the data upload. This tool creates the metadata already indicating the frequency, and granularity of the source indicator. Currently the bank that feeds the Data SAN tool has over 1.700 indicators.

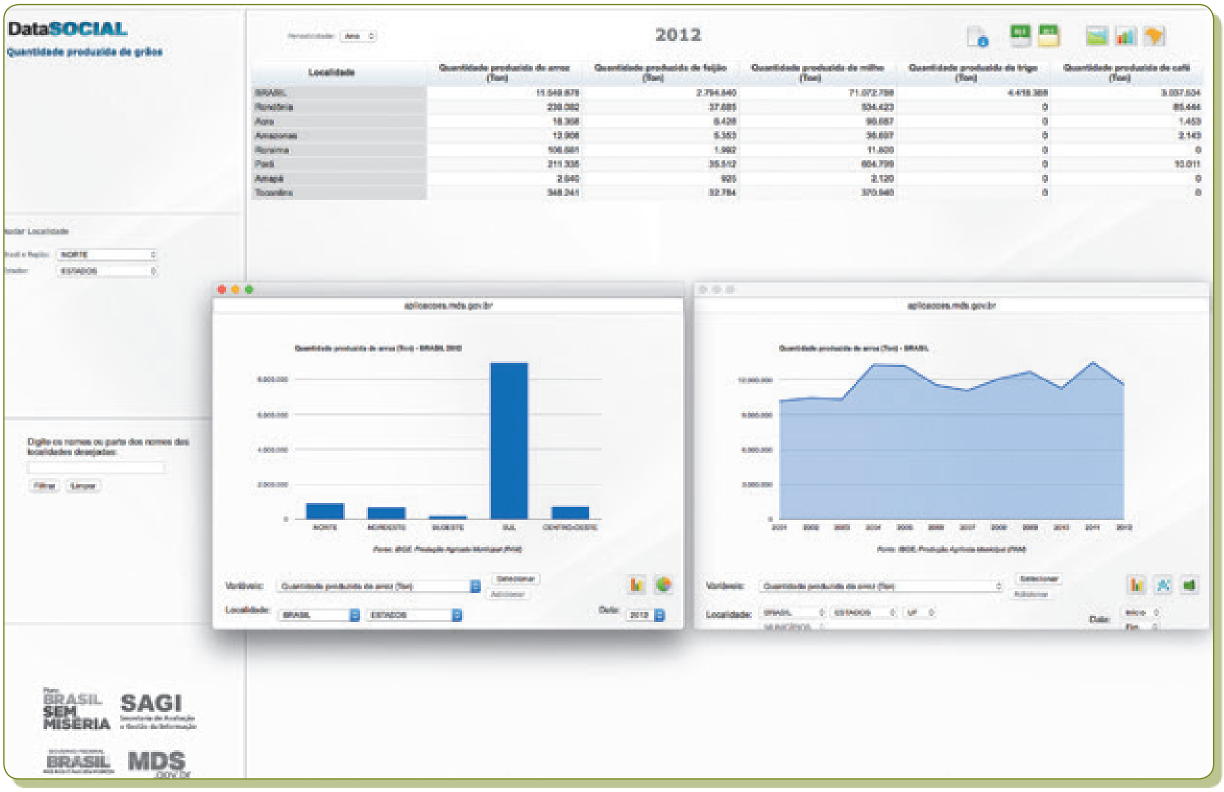
3.2. Accessing the Data SAN

Data SAN is an informational tool that is part of Social Data. It is accessed through the website of SAGI (www.mds.gov.br/sagi).

Figure 3: Portal access to the Data SAN.

The menu allows accessing the indicators by thematic groups. By clicking on a window, the charts and graphical analysis tools are opened.

Figure 4: Graphical analysis of Data SAN tools.



4. Conclusion

The guidelines and strategies that guide the policy of SAN in Brazil have been discussed with civil society since the 1990s, which ensures greater legitimacy and strengthening of the right to food, provided in LOSAN. Also social participation is an essential element in the construction of the monitoring system of the SAN.

The Data SAN can be described as a panel of data and indicators of SAN that allows the knowledge and the analysis of the dimensions related to the SAN in Brazil. Its preparation involved the participation of several actors who act within the SAN, including the participation of civil society. The consolidation of its contents will occur incrementally and with the involvement of these various actors.

Thus, the system design and the development of an informational tool included the principle of participation and social control and intersectionality. The innovation of Data SAN tool consists in organizing and aggregating a set of scattered data, from a systemic and intersectorial reference of Food and Nutrition Security, available to researchers, managers, social movements and citizens in general.

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Poster Session

Organizer: Leonardo Z. Maya (IBGE)

Focus groups: a possible method to improve quantitative agricultural data

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Abstract

Focus group is a method of gathering information through an organized discussion with a group of individuals who are experts in the issue being investigated (Fern, 2001). Originally created for use in marketing research in the 1920s (Marder, 1997), and adopted by social scientists in the early 1990s (Vaughn, Schumm, & Sinagub, 1996), focus groups can also be used to clarify survey data and as primary data gathering method when other forms of research are unavailable (Morgan, 1997). This paper will share the challenges and advantages of using focus groups to gather agricultural data for IBGE's *Systematic Agriculture and Livestock Production Assessment* (LSPA – in Portuguese, Levantamento Sistemático da Produção Agropecuária) research in the state of Sao Paulo. The paper will focus on the LSPA's implementation and establishment effort that is taking place in the state since 2010 through 2013, through 74 IBGE state agencies. LSPA's assessment uses focus group meetings five times a year to update municipal data such as planted, producing, and harvested crop areas, expected and total crop production, and price paid to producers, while registering, in addition, agricultural or market related problems affecting crop production. Participants of such focus groups can be local producers, city hall officials, State agricultural department officials and agronomic engineers, labor union representatives, cooperative delegates and even market representatives, all those in position to provide informed data on municipal or state agriculture.

The authors have found that, in order to be successful, such methodology (focus groups) require state level intensive and extensive planning; engagement of agency managers and community leaders; strong state level support in providing manuals, contact lists, and suggestions of available area institutions of interest in agriculture and livestock matter; and constant follow-up with agency technicians.

Keywords: agricultural data assessment; focus group; research methods.

Research for County-scale estimation on yield of winter wheat based on Spatial Statistic Method

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Abstract

Involved in current institution of agricultural production survey of NBS of China, Acreage and yield is calculated through sampling survey method, acreage times yield give the result of total winter wheat production. The sampling unit is selected through Interval-sampling method, and general average yield is equal to average of all survey result data, which covered the spatial variance.

This research will giving County-scale winter wheat distribution image by remote sensing technology. We work with the distribution image as planting fact. Then we'll estimate the distribution

data of yield per pixel in the whole county through spatial statistic approach with the result data from current sampling survey.

Finally, we will compare the result of traditional County-scale average yield with yield per pixel, analyzing difference between these two methods.

Keywords: spatial statistic method; sampling survey; kriging interpolation; yield estimation.

Use of administrative sources in agricultural statistics – what we gain and what we lose

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Abstract

The development of data sources in the administrative environment since 2000 has led to new approaches in data collection in the field of agriculture statistics as well as in methodological and technical work. The use of administrative data sources in official statistics is multifaceted. Above all, the importance of cooperation between different institutions must be understood, which consequently has positive effects that can be recognized as partial reduction of response burden, reduction of the cost of data collection, ensuring complete capture of certain characteristics, facilitating data collection in the field and substantive harmonization of certain information between different institutions.

At this point it is necessary to point out other direct effects of the use of administrative sources in any survey. What is needed is a different organizational approach in the implementation of such survey. In the process we must count on more time spent on methodological work and in the field of technical integration and adoption of various data sources. More demanding as well are the organization and supervision of the implementation of individual work steps, since it is necessary to coordinate the work in the complex working environment.

In addition to all these effects of the use of administrative data sources, we must be aware of the impact on the professional independence. Principle 1 of the European Statistics Code of Practice notes that institutional and organizational factors have a significant impact on the effectiveness and creditability of a statistical authority developing, producing and disseminating European statistics.

Professional independence of statistical authorities must be ensured in all steps of the survey, which is difficult to provide if administrative data sources are used.

Keywords: administrative data; survey; register; professional independence.

Understanding rural structures from diverse data sets*

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Abstract

The Global Strategy for Improvement of Agriculture and Rural Statistics aims at meeting the contemporary data needs for comprehensive understanding and synthesis of development issues. The Strategy signifies the importance of multifaceted agricultural and rural statistics for convergent scientific studies and systematic policy formulation, more so in view of the persisting concern on the aspects of level of living, prevalence of poverty and hunger, overall well-being of the people and development sustainability. These aspects depend on a combination of factors, such as endowments, options available for pursuing economic activities and correspondingly, the scope and magnitude of income generation. Towards this end, the increasing necessity to study the aspects of efficient use of resources in the domain of agriculture activities with focus on sustainable agriculture and food system are further tuned with the outcomes of Rio 20+ Conference.

Equally important in this direction is to use relevant data for drawing inferences on rural structures.

Notwithstanding the definitional differentiation of rural over the territories, rural is structurally distinct from urban in terms of the resource endowments, factors of production and opportunities and options in economic activities. The synonymous entity of rural and agriculture, particularly in developing agrarian economies, the structural constraints associated with the farm sector and its overriding influence over the rural economy has bearings on the livelihood and well-being of the rural people.

In this background, use of diverse data for coherent inference of agriculture in particular and rural in general is a corollary to the Strategy. Along with the explicit reference of core set of indicators, the Strategy also has implicit reference to structural attributes of entrepreneurs and entrepreneurship. The aggregated response to various institutionalised interventions in agriculture depends upon the entrepreneurial endeavors of farmers, spread over diverse social, economic, geographic and agro-climatic domains with varying endowments and their differentiated capacity and opportunity to adopt technology, access to farm services and integrate with the market. In large number of developing economies, the rural enterprises and employment is informal in nature. This enhances care and concern for the data, dovetailed with the three interwoven social, economic and environmental dimensions in the conceptual framework of the Strategy.

These attributes, both in respect of farm and nonfarm activities are expected to have complimentary and supplementary role in growth and development of agriculture, income generation and overall well-being. The paper explores data aspects of multifaceted farm and nonfarm rural characteristics, and attempting empirical analysis based on available data for understanding rural and agricultural structures. This is in consonance with the third pillar of the Strategy, to develop statistical capabilities in the national system for data generation, standardisation of concepts and definitions and analytical inferences for assisting policy analysis.

Keywords: agriculture statistics; rural development; rural structures.

* Views expressed are of the Author.

Typology of sugarcane production in Brazil: the use of multivariate statistics on municipal data

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Abstract

Given the large territorial extension and the high social and economic diversity, Brazil has a remarkable variability in agricultural cropping systems. The description and the understanding of this variability is fundamental for proposing research gaps, technology transfer and appropriate public policies for the sector. Sugarcane is used for several purposes on farms, such as household consumption, energy and sugar production, and forage production. Data collected during the 2006 agricultural census, accomplished by the Brazilian Institute of Geography and Statistics (IBGE), shows that 192,931 farms (3.7% of Brazilian farms) reported having grown sugarcane in 2006. This paper addresses the classification and characterization of the sugarcane producing municipalities in Brazil, using techniques of multivariate statistical analysis (factor and cluster analysis). The 41 variables used were created from the data collected by the 2006 agricultural census, covering 3,576 municipalities. Data went through a sugarcane filter, and was then regrouped by municipality. Those variables gather socioeconomic and technological information on the farms, such as land usage, harvested area, production goal, productivity, input usage, use of industrial wastes, irrigation, source of producer's income, percentage of the income that comes from sugarcane, family or conventional farming, size of herds, distance from the farms to sugar mills, among the most important. Analyses identified 9 different groups of

sugarcane production in the municipalities, remarking large variability of sugarcane sector in Brazil, and the clear spatial differences of production and technology use in the territory. The results of the statistical analysis and the characteristics of the groups were discussed among scholars specialized in sugarcane research and were considered coherent with Brazilian reality.

Keywords: sugarcane production; typology of municipalities; factor analysis; cluster analysis.

Comparision of estimates of area in production of sugarcane in São Paulo state

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Abstract

Sugarcane (*Saccarum offinarum L.*) is originally from New Guinea, it was introduced in Brazil by Martin Afonso de Souza in the year 1532, and is one of the main products of Brazilian agriculture. Brazil's role in world stage is the largest producer of sugarcane, the amount of the Brazilian, 55% is used to produce ethanol and 45% for sugar production. The state of São Paulo has the largest area under cultivation of this plant with the equivalent of 40% of the total. Given the magnitude of the numbers involved in the production of sugarcane in Brazil and especially in state of São Paulo and its relevance as food and fuel has two relevant surveys production area in state São Paulo. A survey is conducted through remote sensing techniques using satellite images and the subjective method uses survey uses non-probability sampling techniques. This study aims at comparing through descriptive statistics results obtained by these two surveys among the crop years from 2003/04 to 2012/13, checking the differences and the tendency of each survey, as well as their strengths and limitations. According to the results, only the crop year 2007/08 the estimated area by remote sensing was higher compared to estimated area by non-probability sampling. On the evolution of the area estimated by two surveys, it appears that from the crop year 2010/11 survey conducted by the remote sensing area indicates reduction in production, but the opposite is observed in the survey conducted by non-probability sampling techniques. Although the surveys have different methodologies, the results of the estimates are similar, but the last two crop years tend expansion area is different in each of them, possibly, the difference is in the focus of each survey.

Keywords: sugarcane; sampling; area; estimates.

Forecasting Municipal Crops in Brazil – a comparison of alternatives data sources for better accuracy of results

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Abstract

Results from agricultural research are one of the most accessed pages from Brazilian Institute of Geography and Statistics (IBGE) website. However, part of the published results receives criticism for using subjective methods and do not use data based on probability sampling. In municipalities with lower expression in the rural sector, the crop estimative depends on the perception of local

technical, because probability samples demand high economic cost for obtaining results within sampling errors tolerable to the municipal level.

Therefore, to support agricultural research, besides information from the agricultural census and cadastral surveys, data derived from professional discussion of members from local, state, regional and national agricultural statistics committees are used. Subsequently, these results are then aggregated to the system of National Accounts in order to achieve the estimated Gross Domestic Product of the agricultural market.

This study compares the data found in surveys conducted by IBGE with data from other institutions or other publications related to agriculture in general, so that could be possible to reflect about methodologies that will ensure greater reliability to the results provided by IBGE.

Thus, descriptive analyses were conducted comparing data from subjective surveys and census data with estimates of the Brazilian Association of Vegetable Oil Industries (ABIOVE), the Monitoring Sugarcane and Coffee Satellite Images (CANASAT and CAFESAT - INPE). Furthermore, remote sensing images available in public institutions were used in order to evaluate cultivated areas under central pivot and supposed areas with crops of coffee, in the city of Romaria, Minas Gerais State, Brazil.

Despite the criticism, in general, the results obtained by means of subjective inferences, without formal sampling, were more approximated of estimates indicated by satellite imagery or used by the agribusiness, than the census data. This can occur either by census errors, and because specialized professionals have been producing their forecasts based the same independent sources of information collected in this study.

The results suggest that partnerships oriented to the use of administrative records of several sources of information, as well as the use of satellite imagery available in public institutions might define success on estimates of acreage and crop production. Moreover, it would provide a reduction of excess subjective aspects that may be present in committees of agricultural statistics of the various spheres of government. It is hoped that this procedure adds a quantitative component, making the estimates more reliable and less prone to errors, and would contribute to the targeting efforts for planning the agricultural census and others surveys focused on agricultural activity.

Keywords: agricultural estimative; agricultural surveys; agricultural census; satellite images; agricultural data sources.

Beef cattle stocking rate, a key to the conservation of the pastoral system in Brazilian biomes

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Abstract

In Brazil, beef cattle are raised in predominantly extensive systems. The feeding base is represented by native and/or cultivated pastures. The latter may be in a well conserved state or may present some degree of degradation. The amount of animals per hectare, supported by the pasture by each time unit, is basically related to the pasture production. There is interaction between quality and production, and changes in these parameters are strongly affected by the stocking rate. Therefore, the adjustment in the stocking rate is the most important management factor and the main determinant of animal production and pasture composition. Municipal data from the 2006 agriculture and cattle raising business census were considered with the objective to analyze, by means of typologies, the use of pastoral areas in Brazil. In the census, the producers declared their pastoral areas according to the following classification: native pasture areas (PN), cultivated pasture areas in good conservation status (PC) and cultivated pasture areas with some degree of degradation (PCD). They also indicated the number of bovine in each type of pasture. The data were submitted to exploratory factorial analysis, with varimax rotation. The first two factors (extracted by main components) explained 0.83 of the (co)variance, and the estimate of the Kaiser-Mayer-Olkin (KMO) adequacy test was 0.76, which meant good adjustment of the variables selected. The commonalities of the variables selected, PN area; total pasture area (TP), bovines in PN (Bov_PN); bovines in PCD area (Bov_PCD); bovines in PC area (Bov_PC); bovines in total pasture

area (Bov_APT); and the stocking rate (TxLota) were 0.65; 0.97; 0.77; 0.74; 0.79; 0.87; and 0.99, respectively. The first factor was associated with the variables PN, TP, Bov_PN, Bov_PCD, Bov_PC, and Bov_APT, which directs to the latent variable correlated to those municipalities with large pasture areas, in general, and also with the largest cattle population. The variable TxLota presented the most significant factorial load in the second factor, that is, all those municipalities with the greatest concentration of cattle per unit area are represented in the second factor. The municipalities that were best represented in factor_1 are different from the ones represented in factor_2. The non-parametric correlation between the classifications of the two groups of municipalities formed by the factorial scores in the first and the second factors is small (0,24). This indicates that the context of those municipalities with the highest stocking rate is a lot different from the ones with the largest areas and cattle herds. The application of livestock development policies in the different Brazilian biomes should take into account all the distinguishing features of the municipalities, regarding their context, especially the pasture areas and their vocation for primary livestock production.

Keywords: multivariate analysis; typology; land use.

Administrative Records for Official Statistics: food for thought on Uganda's livestock data

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Abstract

This paper presents a methodology to rapidly assess routine livestock data systems and identify options for improvement. The methodology has been developed by the Uganda Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and the Uganda Bureau of Statistics (UBOS) in collaboration with the FAO-World Bank-ILRI-Africa Union Inter African Bureau for Animal Resources (AU-IBAR) Livestock Data Innovation in Africa Project. Uganda, as several other developing countries, does have a system of routine data collection which explicitly targets livestock. The paper describes the routine livestock data system of Uganda; presents and applies to Uganda a methodology to rapidly assess livestock administrative records; and suggests options for improvement, with a focus on 'field experiment' or pilots with control groups as effective ways to promote institutional changes in the system of routine livestock data collection.

Keywords: administrative records; livestock; Uganda.

Building a statistical program to support evidence-based policy and relationships within Government

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Abstract

The Australian Bureau of Statistics (ABS) is Australia's national statistical agency, providing high quality statistics on a wide range of economic, environmental and social issues. By providing trusted statistics to government, business and the community, and through providing statistical leadership across the national and international statistical community, the ABS supports public debate and informed decision making in an increasingly complex world.

In undertaking this role ABS faces a range of challenges including fiscal pressures, demand for

ABS' Rural Environment and Agriculture Statistical Collections into the Future

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Abstract

Since the inception of the Australian Bureau of Statistics' (ABS) Rural Environment and Agriculture Statistics Program (REASP), the Program's statistical collections have continued to evolve alongside the changing information needs of users. In particular, with the move to new and sustainable farming practices, there has been increased demand from users for information on how the agricultural industry in Australia is using the land and associated natural resources. There has also been an increasing focus on understanding the impact of the industry and its management practices on the environment.

The ABS faces a number of challenges and opportunities in meeting these information demands in a rapidly changing external environment. Fiscal pressures combined with the rising cost of our current methods of statistical collection impact on our ability to meet the ever-increasing user demand for more timely and diverse statistical information. At the same time, the evolving information and technological landscape poses opportunities for new methods of statistical collection, compilation and dissemination.

ABS is responding to these challenges and opportunities by transforming the way the organisation collects, manages, uses and disseminates statistical information, to establish the ABS of the future. This initiative encompasses re-engineering our business processes and applications to support standardisation, integration, better information management and re-use; engaging our key users through online dissemination methods; and exploring e-collection to reduce costs and improve the flexibility of collection forms.

Australia is not alone in facing demands for better management of statistical information. Many other countries face the same challenges. The harmonisation of statistical production and information management approaches needed within the ABS is also needed by many other National Statistical Organisations (NSOs).

more complex statistical products and information from key users, and a fast-evolving technological and information environment. In this context ABS must undertake strategies to ensure the continued relevance and sustainability of the statistical program. A critical part of this is ensuring continued engagement with key stakeholders in government, business and the community, to ensure our program remains relevant to their needs, and to gain their support for the ongoing importance of official statistics in informed decision-making.

The ABS's program of Rural Environment and Agriculture statistics has evolved over time in response to changing information requirements. The demand for an expanded view of agriculture data at lower geographical areas has continued to increase, alongside a growing need for environmental data related to climate change, land use, and clean energy initiatives. The 'triple bottom line' view of social, economic and environmental characteristics of agriculture has also emerged as a data priority, driven by international developments to improve agricultural and rural statistics, including the development of the *Global Strategy to Improve Agricultural and Rural Statistics.*

These emerging demands along with the need to remain relevant in the face of the challenges and opportunities outlined above led ABS to initiate a Review of the Rural Environment and Agriculture Statistics Program (REASP).

The Review, conducted over 2011-2012 and continuing into 2013, involved extensive stakeholder consultation to evaluate the program, and took a collaborative approach to identifying the highest priority information needs. Phase 1 of the Review has resulted in a revised statistical program that directly supports national and regional policy development, including the Australian Government's Caring for Our Country and the Carbon Farming initiatives, while maintaining the flexibility to meet emerging policy needs.

This paper will detail the drivers for the review; the mechanisms used to achieve stakeholder buy-in; continuing challenges and opportunities; and plans for subsequent Review phases. It will highlight the importance and benefits of developing a statistical program that supports policy and relationship building within government and that delivers relevant, timely and fit for purpose statistics.

Keywords: ABS; evidence-based policy; government engagement.

The ABS is collaborating with other NSOs to develop the next generation of statistical infrastructure.

The vision of the REASP over the next five years aligns with the vision of the ABS's statistical business process and information management transformation program. That is, to provide data users with access to rural environment and agriculture information that is easily and rapidly located and used, relatable and comparable.

In order to achieve this vision over the next five years, ABS' role in rural environment and agriculture statistics will shift from being primarily a collector of information, towards acting increasingly as a leader and facilitator of national and international statistical communities. This will encompass increased attention on statistical data integration and the use of administrative data to complement and replace survey data. In conjunction with the improvements to statistical compilation and dissemination arising from the transformation program, this will help position the ABS to achieve the program vision while also further building our engagement and relevance with our key stakeholders in government, business and the community.

This paper will outline the projects the ABS is undertaking to progress achievement of the vision; discuss challenges and opportunities; and lessons learned including engagement on international developments.

Keywords: ABS; future vision; rural environment and agriculture statistics.

The importance of system GCEA to Brazilian agricultural statistics

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Abstract

The GCEA system (Agricultural Statistics Coordination Group, Grupo de Coordenação de Estatísticas Agropecuárias), established in 1973, is intended to provide the technical support and cooperation needed to collect and disseminate information related to agricultural activity. It consists of representatives from the private and public areas, directly or indirectly connected to the production and use of statistical information and data from the agricultural sector.

The CGEA is responsible for the creation and maintenance of Municipal Committees on Agricultural Statistics–formed by local representatives of its constituent bodies, plus technicians and/or experienced and representative members of the producing classes–that aims to establish a basic and permanent structure of production and agricultural statistics.

Due to great subjectivity of this method, this type of information survey is greatly criticized as information can be manipulated, since it is not possible to check the quality of the information using a statistical basis for data analysis. However, in some cases this is virtually the only way of obtaining data, taking into account the level of detail, the speed required and the economic and technical conditions available for such survey. This work aims to present GCEA`s operation, describing its virtues and imperfections, in order to achieve a better understanding and improvement of Brazilian statistics.

Keywords: agricultural statistics; Brazil; subjective method.

Technical Conversion Factors for Agricultural Statistics: expert opinions versus direct measurement in the Tanzania livestock sector

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Abstract

There are three major official sources of data for agricultural statistics in the developing world: censuses, sample surveys and administrative data. In censuses and sample surveys, agricultural data are collected regularly through interviews; in the case of administrative data, agricultural data are collected through records of the day-to-day operations of government agencies. However, for many variables good quality agricultural statistics can be generated only when reliable and current technical conversion factors or technical coefficients are available, which convert recorded data and derived statistics to an appropriate unit of measurement for the decision-maker. Examples are extraction rates, which convert agricultural primary products in processed products (e.g. flour from wheat), and dressed carcass weight, which converts the weight of a slaughtered animal into that of traded meat products. Technical conversion factors can rarely be calculated with statistical precision using agricultural census / survey data and administrative records – particularly in developing countries where on-farm consumption is common and the informal economy large – and their value is usually based on either expert opinion or some indirect measurement.

This paper assesses the value of core livestock technical conversion factors in Tanzania from two sources, including expert opinions and direct measurement. It first presents the major livestock technical conversion factors used by the Tanzanian Government, which date back to the late 1980s and/or are adopted from neighbouring countries. This reveals that the estimates of livestock value added in the country's National Accounts over the period 2001-2011 are based on constant technical coefficients, i.e. increases in livestock productivity – also a result of public sector investments – are not reflected in official country statistics. The paper then compares the value of livestock technical conversion factors estimated through an online survey of livestock stakeholders (experts), with that estimated by the Ministry of Livestock and Fishery Development and based on daily direct measurement undertaken by a sample of trained farmers and slaughterhouse managers throughout Tanzania, as part of the implementation of the Tanzania Statistical Master Plan. The paper concludes that direct measurement, when resources are available, is a better option for estimation of livestock technical conversion factors than is retention of assumed values.

Keywords: technical conversion factors; livestock; Tanzania.

Use of dynamic linear model for predicting crop yield trends in foresight studies on food Security

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Abstract

The world's population is projected to pass 9 billion in 2050 and there is increasing concern about the capability of agriculture to feed the world. Foresight studies on food security require predictions of future yield trends (crop production per unit of soil area). These trends are usually estimated from yield time series provided by statistical agencies at national and regional scales. Different types of statistical methods have been proposed to analyze yield time series (linear regression, non linear regression, moving average etc.) but, so far, the predictive performances of these methods have not been evaluated. This paper will describe a simple space-state model to analyze yield time series for several major crops in the world (e.g., wheat, maize, rice). The proposed model is a dynamic linear regression model predicting future yield trends and their associated credibility intervals using the Kalman filter algorithm. The accuracy of yield predictions obtained with our method is evaluated using wheat yield data provided by the Food and Agriculture Organization of the United Nations. We show with these data that the dynamic linear regression model is more flexible and performs better than most of the statistical methods currently used to analyze yield time series.

Keywords: dynamic linear model; Kalman filter; time series; yield trend.

Crop and Yield Forecasting Procedure in Lesotho

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Abstract

Crop forecasting is a process of estimating crop production on the basis of known facts at the time of making the forecast. Assumptions used for forecast are based on conditions such as weather, damage by pests, production of crops between date of forecast and final harvest. Crop forecasting is a sub-sample of the on-going annual Agricultural Production Survey (APS).

The results of this survey are expected to inform the Government planners and other private sectors with forecasted crops production so as to make effective decision concerning availability of food in the country and to make necessary preparations if there is a shortage of food. Lesotho Bureau of Statistics (BOS) reports on the crop forecasting of three major crops, maize, sorghum and wheat.

A stratified multi-stage sampling scheme is adopted for the selection of the sample. Enumerations areas constitute Primary Sampling Units (PSUs), farming households constitutes Secondary Sampling Units (SSUs) and fields under maize, sorghum and wheat form third sampling unit for the estimation of crop yield. Two sub-plots for crop cutting in each selected field form the ultimate units for yield estimation. A maximum of five fields, each for maize and sorghum per PSU constitutes sample for the crop forecasting exercise. In each PSU, an average of 25 agricultural households is selected through systematic sampling from a list of all agricultural households.

In this paper, authors present how Lesotho Bureau of Statistics estimates maize forecasts using Linear Regression Analysis.

Keywords: Agricultural Production Survey (APS); crop forecasting; linear regression analysis.

Agriculture Occupation: a forecast model to Mato Grosso state

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Abstract

Brazil occupies the fourth position among the largest grain producers in the world. With about 160 million hectares of pasture, according to IBGE, Brazil has the largest potential area of expansion for agriculture in the world and may further contribute to global agricultural production. Understand the size and potential of this area as well the occupation will occur is essential to foment actions and investments to ensure sustainable growth of agriculture. To set the model prediction occupation of agriculture in Mato Grosso, the present study was divided into two stages. The first was to determine the potential area to agriculture occupation. In this step was used technology georeferencing to crossing information as vegetation cover, slope, climate and soil type. Merging this information for the year 2011, found a potential area of growth in agriculture of 11.3 million hectares. In these second stage the model was defined occupancy potential of this area. Therefore, was analyzed the data of 93 of the 558 microregions from IBGE, whose to occupancy of temporary and permanent agriculture occurred after 2008. Data from the annual rate of growth indicated a parable curve type with 46 years of cycle. Applying the model curve, respecting the value already occupied by each one of the 141 counties of Mato Grosso, it show an increase of approximately 4 million hectares of agricultural area occupied in the state in 2022.

Keywords: agriculture; forecast; Mato Grosso; Brazil.

Time Series Models for Production and Yield Forecasting in Summer Crops of Southern Brazil

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Abstract

The agribusiness sector was the most dynamic sector during the last decade, sustain the GDP in positive

condition in Brazil. In this context, crop rotation plays an important role in spreading risks associated with seasons and markets. The Southern Brazil holds one of major share of total summer crops production in Brazil. In this season, the variability caused by climatic and economic factors may interfere in crop production. An effective way to reduce agricultural vulnerability to these factors is through the development of knowledge about the behavior of crops production. It may improve agricultural policies and collaborate with decision making by farmers. The objective of this study was to evaluate the feasibility to adopt Time Series models to promote low costs skills about crop production and yield forecasts. Historical data of crop production and yield of soybean and corn of seven mesoregions of Rio Grande do Sul, Brazil, for a period of 35 years (1973–2007) was used in the time series model building. The remaining 4 years data (2008–2011) were used for validation of the model. We propose an approach based on the Auto Regressive Integrated Moving Average models (ARIMA) for soybean and corn production and yield forecasting by the year 2020, based on the following diagnostics: AIC (Akaike's Information Criterion), SBC (Schwarz's Bayesian Criterion), R^2 Adj (Adjusted Coefficient of Determination), MAPE (Mean Absolute Percentage Error) and significance of the parameters ($P \leq 0.05$). The assumption of non-stationarity for summer crops production and yield data was confirmed by the models adjustment. The results demonstrate that different ARIMA models can fit trajectories of summer crops production and yield. ARIMA (0,2,2) and ARIMA (2,2,2) were the best adjusted models for soybean and corn crops production and yield in mesoregions of Rio Grande do Sul, Brazil.

Keywords: ARIMA models; corn; soybean.

An analysis of effects of socio-economic variables on fish production of small farmers in the state of Tocantins, Brazil

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Abstract

In the state of Tocantins, fish farming represents one of the greatest potential for agricultural activities, with considerable growth in recent years and greatly exceeding the value of the fishery. Between 2000 and 2009 the production of farming Tocantins grew 445% from 1102 to 6004 tons. This value is currently 79% of total fish production (farming and fishing) in the state. Fish farming is a strategic sector for both the economy and food security of the state. Apart from being a major source of rural employment and income, fish may also play a role of great importance in environmental state of Tocantins. Fish farming familiar stands out for its strong social and economic appeal, given its potential in terms of food security, income generation and diversification of rural establishments. In this context, it is important that the state of Tocantins has significant deficiencies in terms of their social and economic development. In view of this, in 2008, the Ministry of Fisheries and Aquaculture has started a project aimed to promote the development of fish farming with family farmers in the region of Divinópolis city. The fish farmers began activity in approximate number twenty and the project consisted in the distribution of fingerlings and technical assistance. Today, there are about a hundred fish farm families in the region, with the vast majority entering the activity on their own initiative, encouraged by the experience of the first producers. Fish farming is basically developed autonomously or in small groups, especially in relation to the acquisition of inputs (feed, fingerlings etc.) and construction of ponds. The technological level of fish farmers is low, and the common occurrence of problems related to fish mortality, poor water quality and poor feed management. Therefore, using data collected from the producers, this paper seeks to understand the reasons of socioeconomic difficulty of producing fish. It was found that only 30% of farmers who have already begun to attempt production could ever get to the point of selling their fish. Through the use of econometric models of probability for limited dependent variables, it was found that factors such as participation in federal programs to transfer income, total area of water depth property and local production are key factors in determining the likelihood of producer to sell their fish. A producer who produces on pond, which receives federal financial helps and family who owns a large area of water depth has a high probability of success on their property aquaculture.

Keywords: aquaculture; fish farming; logit; State of Tocantins.

Computation of Agriculture: decision support e-Portal

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Abstract

Computation of Agriculture is an attempt to organize agriculture related information in presentable format. The collection and storing of data and retrieving information out of it is the major role expected to be played by this system. The agricultural related information collected will generate indices which will help to gauge agricultural progress of different administrative divisions. There is an attempt to relate agricultural progress with socio-economic status of the region. Another aspect of this e-Portal is to provide market and agricultural harvest related information across the regions to reduce black-marketing by the selfish business men. Forecasting and decision making section of this system may help famers and agri-business professionals to grow effectively.

Keywords: data organization; key performance indicators of agriculture; forecasting.

PNAG: Brazilian Project for an Annual Survey on Agricultural Activity

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Abstract

The Agriculture Activity National Survey – PNAG is the central survey of the National System of Agricultural Holding Sampling Surveys Project – SNPA , under development in the Coordination of Agriculture of IBGE. PNAG was planned to be a multipurpose and continuous survey, in order to cover the main demands set out in the Global Strategy (GS), from the point of view of quality improvement as well as regarding the expansion of the scope of agricultural statistics. It is a multipurpose survey in different aspects: first and foremost, for its thematic diversity, covering various aspects listed in GS – social, economic and environmental; second, for covering different units in the same survey; finally, for being designed to enable the same statistical operation to generate basic sectorial statistics and economic performance statistics of sub-segments, as well as longitudinal analysis.

So is, to contemplate and yet to be designed so that using the same statistical operation, are produced basic industry statistics, economic performance statistics of sub-segments, and still serving for longitudinal analysis. This poster presents key aspects of Project PNAG, with emphasis on solutions found regarding the survey design. Issues concerning survey design related to the Project SNPA as a whole are also addressed.

Keywords: sample survey; agricultural survey; multiporpose survey.

Adjustment Methodologies for the Census of Agriculture

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Abstract

The National Agricultural Statistics Service (NASS) conducts a Census of Agriculture every 5 years, in years ending in 2 and 7. It is based on NASS's list of farm operations. The Census of Agriculture needs to be adjusted for non-response, under-coverage and misclassification. Capture-recapture is evaluated as the adjustment methodology. However, capture-recapture requires a second, independent survey. The

second survey used in this methodology is NASS's June Area Survey (JAS) which is conducted annually in June. It is an area frame based survey with in-person interviews and is run independently from the Census of Agriculture. The probability of capture used in the capture-recapture methodology is evaluated.

Keywords: Census of Agriculture; June Area Survey; non-response; under-coverage; capture-recapture.

Using County Assessor's Records to Improve Data Collection Efforts for the June Area Survey

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Abstract

The National Agriculture Statistics Service (NASS) conducts the annual June Area Survey (JAS), which is based on an area frame. Segments of land comprise the sampling units for the JAS. Finding and interviewing all farm operators can be challenging and costly, especially in previously unenumerated segments. In highly-cultivated land areas, names and addresses obtained from the Farm Service Agency often provides good starting information to identify operators within the selected land area. However, in areas with small-scale agriculture, screening to identify farm operators is often time-consuming, expensive, and subject to misclassification. For 2012, geo-referenced county assessor parcels were intersected with the sampled JAS segments to reduce prescreening costs, raise efficiency in data collection, and reduce misclassification of farms. A controlled experiment was conducted to evaluate the usefulness of the county assessor's data. Sixty-percent of the intersected segments were assigned to a treatment group where the county assessor data were utilized during the prescreening process. This paper discusses the results of this experiment.

Keywords: county assessor; controlled experiment; area frame; screening; geo-referenced.

Marketing of Agricultural Produce & Statistics Maintained by Self Help Groups (SHGs): a case from India

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Abstract

Linking statistics with decision making is presented here while marketing of agricultural produce by the farmers at the village itself or its vicinity takes place. This unique mechanism of selling agricultural produce has been developed under the patronage of an organisation known as Society for Elimination of Rural Poverty (SERP) –Indira Kranthi Patham (IKP) in Andhra Pradesh of India. SERP was established by the Government of Andhra Pradesh as a support structure to facilitate social mobilization of rural poor women in 22 rural districts of Andhra Pradesh. SERP being a Government institution has been working exclusively for poverty elimination through empowerment of rural poor by nurturing Self Help Groups (SHGs) of women. The statistics reveal up to February 2012 total number of 1027930 SHGs was spread over to 11412578 members in Andhra Pradesh. And further SHGs' are organized in every village known as Village Organization (VO) and thus 38646 VOs have been formed, and VOs in the next stage form *Mandal Samakhyas* (in short MS; *Mandal* means group of villages normally15-20) and in Andhra Pradesh 1098 MSs have been formed. The State with an area of 275000sqaure kilometers is the home of about 84 million people as per 2011 Census. Of the total population, 33.49% people live in urban areas indicating more people stay in rural region. The state is pioneer for the development of Self Help Groups (SHGs) in rural areas and used the SHGs extensively as a primary tool of poverty alleviation and empowerment. In addition to income generation and other development works, SHGs in the state have been assigned marketing of agricultural produce. In other words, farmers who are interested can sell their

produce in the village itself or its vicinity through SHGs. For this, the SHGs (all women) have been trained to handle marketing of goods for which they are given commission by the Government. Necessary infrastructure has also been provided to the SHGs. The main objective of marketing through SHGs is to enable the farmers to obtain the best price for their agricultural / forest produce vis-à-vis to create marketing facility at the door step.

The VOs have been successfully implementing village level collective marketing of paddy, maize, red gram, cashew, and NTFP etc. The marketing interventions of SERP-IKP have registered a significant increase in recent years mainly in paddy procurement. The field study reveals SHGs have been performing their activities systematically vis-à-vis statistics are maintained meticulously and many farmers thus have been benefitted. The case is unique so being emulated to other states of India. This can also be taken up in other countries particularly developing countries where farmers have been facing to market their agricultural produce.

Keywords: agricultural produce; marketing; SERP-IKP; Self-help Group (SHG).

Fish consumption in Brazil: is the internal market able to accommodate the strong growth projected for Brazilian aquaculture?

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Abstract

According to estimates from the Food and Agriculture Organization of the United Nations (FAO), the world population will increase from the current 7 billion people to 8.3 billion in 2030 and to 9.1 billion in 2050. Given these estimates, the UN agency estimates that the need to increase agricultural production by 2050 will be around 60%. Given these projections and the fact that the more animal protein produced in the world today is fish, reaching 154 million tons in 2011, aquaculture has been identified as one of the possible solutions to increasing global demand for this protein. This occurs because the fishing sector (capture), although still represents approximately 59% of total fish production has shown, in total, stability in their production in recent years around 90 million tons. This trend of growth of aquaculture is also repeated in Brazil. The sector grew by 31.2% in annual production between 2008 and 2010, reaching 479,399 tons. It is in this context of expected strong growth of aquaculture production in Brazil in the coming years as the need arises to check the ability of the market to absorb this increased supply. Some industry players believe that the per capita consumption of fish in Brazil, today around 9 kg/capita/year should increase because the minimum consumption stipulated by UN is 12 kg/capita/year. Moreover, it is also believed that the growth of national aquaculture production could supply much of the Brazilian consumer demand for fish which is now served by imports. Currently, the trade deficit Brazilian fish is approximately $ 1 billion and this figure has increased in recent years. Considering the issues raised, we used economic models that attempt to provide more clarity to the relationship between domestic consumption of fish in Brazil and other exogenous variables. We investigated how the income of the population and the price of fish are related to domestic consumption. It was also what the behavior of the fish consumption due to the increase of production, i.e. if one can say that the increased production of seafood will be accompanied by an increase of internal consumption. Calculating regressions, we found a significant relationship between domestic consumption and production of fish in Brazil. It was found that the larger the production variation becomes larger variation in the consumption of one year to another. However, the econometric model with control variables shows that fish production has no significant causal relationship with domestic consumption. It was also found through a VAR, the possibility of production lagged values having relationship with domestic consumption. The econometric modeling shows that the variation in fish production in Brazil two years ago has negative effect on the variation of current domestic consumption of fish.

Keywords: aquaculture; consumption of fish; vector autoregressive; elasticity of demand for fish.

The dynamics of maize price formation in Malawi

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Abstract

Understanding the factors affecting the formation of commodity markets is the first step in the development of robust tools for policy analysis. This study uses a mixed methods approach to delve into the dynamics of maize price formation in Malawi using monthly time series price data from across different local markets. The objective of the study is to get a better understanding of the factors influencing price formation and of the inter linkages in the Malawi maize market. Findings from the assessment will be used by policy analysts and modelers to develop tools for analyzing the sub-sector that take into account local market price dynamics.

Keywords: market price analysis; commodity market analysis; historical volatility; Southern Africa.

Maize hectarage response to price and non-price incentives in Malawi

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Abstract

A study was conducted to explore the nature in which smallholder maize producers respond to price and non-price incentives. Specifically the study aimed at assessing the hectarage response of smallholder farmers in maize production to price and non-price incentives. Using a case study of farmers in Lilongwe District, Central Malawi -the study employed an Auto-regressive Distributed Lag model to assess smallholder maize farmer's responsiveness to price and non-price incentives. Time series data for a period of 20 years ranging from 1989 to 2009 was used for the analysis. Study findings show that the important factors affecting smallholder farmers' decision to allocate land to maize included the lagged hectarage allocated to maize, availability of labour and inorganic fertilizer. Lagged maize prices and weather were found to be statistically insignificant in influencing farmers' decision to allocate land to maize. Study conclusions are that price incentives on their own are inadequate to influence smallholder farmers' decision to allocate land to maize. This is because farmers are largely constrained by land and cash resources with which to hire labour and to purchase inorganic fertilizer in order to respond to higher market prices. Therefore policy needs to go beyond market and price interventions as a means of incentivizing staple food production as non-price incentives are critical in influencing smallholder farmers' production decisions in relation to maize in Malawi.

Keywords: food security; price and non-price incentives; auto-regressive distributed lag.

Demographic Projections, the Environment and Food Security in Uganda

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Abstract

Uganda's population growth currently stands at 3.6% given the above population growth, feeding Uganda's future population is an important challenge .this paper considers what we know about the relationship between population and food security and what population projections suggest will be the case over the next half century. It considers how the major sources of population change will affect food security in Uganda during this period. Furthermore, it articulates the implications of population shocks, including HIV/AIDs and conflicts, on food security. The paper also discusses the implications of

population increases on the environment and the use of land. Finally it suggests that land reform can be used to ameliorate some of the negative consequences of growth on food security.

Keywords: food security; environment, demographic projections; population; mortality.

Comparing Measures of Food Security in a Volatile Context: findings from a high frequency survey in South Sudan

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Abstract

This paper summarizes and compares food security measures from an innovative high frequency survey in South Sudan. South Sudan's food security situation became increasingly concerning during the 2012 economic crisis associated with the shutdown of oil production and escalating political tension with Sudan. The survey demonstrated that new survey technology can be deployed to monitor food security indicators in near real-time. The main focus of this paper is a comparison of the collected measures for the WFP's Food Consumption Score (FSC) and the Household Hunger Scale (HHS) developed by USAID's Food and Nutrition Technical Assistance (FANTA) project. We find that that observed measures for the FCS and the HHS move in opposite direction in our panel sample from round 2 to round 3 of the survey. A future version of this paper will include comparisons with a third measure, the Household Food Insecurity Access Scale (HFIAS) which is currently being collected, and will examine how these three food security measures correlate with other key indicators collected by the survey and regional variation.

Keywords: South Sudan; food security; food consumption score; household hunger scale; high frequency data collection; CAPI.

Use of data in public policy development: impact on agriculture

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Abstract

The 2012-2013 Brazilian National Agriculture and Livestock Plan (PAP) embraced the challenge to increase agricultural production from two to three billion tons; and to increase meat production from 200 to 470 million tons in the next decades. Accompanying public policies to support such an endeavour address rural-risk management, rural credit (investment in cost and storage), and price-support. Beginning this year, public policies will also include revamping technical assistance to producers, seeking to improve farmers' income, providing economic, social and environmental sustainability. Brazilian government plans incentives to medium size farmers and livestock producers, and cooperatives (MAPA, 2012).

In the state of Sao Paulo, these hefty plans could bump into a worrying reality. Sugarcane was responsible for 55.3% of all Brazilian sugarcane planted area in 2010, an area that grew 5%/year from 1991 to 2010 (from over 1.8 million hectares to 5 million). In the same period, the state's bovine herd shrunk 0.4%/year (from over 12 million heads to 11 million), while the country's total bovine herd increased almost 2%/year. In addition, while Brazil had a decrease of 0.95%/year in rural population during that time (1991-2010), the state of Sao Paulo experienced a much higher, 1.63%/year decrease in its rural population, from 2,274,064 to 1,676,948 inhabitants. Given that extensive sugarcane plantations, with intensive use of technology, drives out of the fields small farmers and families, while cattle ranching, on the other hand, helps to settle these very farmers into small and medium size properties, it is likely that the rural exodus experienced in the state of Sao Paulo reflects the consequences of an increased sugarcane area, accompanied by the decrease in the state's bovine herd.

The objective of this paper was to propose that, by consulting publicly available data, public policy makers could prevent or avoid situations in which to

meet government targets is necessary to revert already established negative economic and social conditions, already in advanced, difficult to reverse stages. The authors used the case study of the Brazilian state of Sao Paulo to make this point.

Keywords: cattle; livestock; official data; public policy; rural exodus; sugarcane.

What Are the Links Between Population Dynamics and Climate Change?

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Abstract

Population dynamics and climate change has been a greater concern worldwide as there has not been a simple relationship found. Hence climate change has been described as the biggest health threat of the 21st century. This is described as a result of high consumption of fossil fuel and greenhouse gases in the developed countries. Population growth however is said to be an important variable that can worsen the impact of climate change in this complex relationship. Researchers further indicate that rapid population growth endangers human development, poverty eradication and weakens the capacity of poor communities to adapt to climate change.

The paper will review the extent to which population dynamics have impacted on climate change and economic development as Lesotho population depend on natural resources for livelihood though are faced with climate and environmental challenges.

The findings indicate that carbon emissions per capita are very low in Lesotho as most of the emissions that the nation produces come from land use change and the agriculture and energy sectors however rely heavily on the ecosystem goods and services to support livelihoods hence limited land available for agricultural activity. This has led to extensive land degradation, loss of biodiversity and low agricultural productivity. The decrease in farmland adds to a growing fear of the limits to food production. Most of the households were not connected to electricity (73.3 percent), 2011/12 CMS. This force people to harvest biomass to satisfy their energy needs, thus Lesotho currently relies on biomass for 72 percent of its energy needs. On the other hand, there is an improvement with access to safe drinking water in the urban areas from 62 percent in 1996 to 73.9 percent in 2006 population census.

Although urbanization is the driving force for modernization, economic growth and development, there is increasing concern about the effects of expanding cities, principally on human health, livelihoods and the environment. In Lesotho, there has been a declining population in rural areas from 1996 to 2011 and an increasing pattern in urban areas from 16.9 percent in 1996 to 23.7 percent in 2011, thus Lesotho is increasingly becoming urbanized.

There has been some progress though at a low base, in terms of setting aside protected areas for the conservation of biodiversity. However, a large number of plant and animal communities remain either endangered or critically endangered.

Although currently personal transport, home-heating and ventilation do not contribute much to emissions in Lesotho than they have in other countries but there is need for monitoring as electrification levels increased and personal vehicle ownership becomes more commonplace. Furthermore, access to safe drinking water and adequate sanitation is still pronounced in the rural areas.

Keywords: population dynamics; climate change and environmental challenge.

Analysis of cointegration in Brazilian bean market

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Abstract

The co-integration techniques have been widely used in studies that examine the process of integration of product markets. In this study, we sought to confirm the analysis of the bean market with threshold autoregressive (TAR) models. The results of the study indicated the presence of market transaction costs in bean marketing. These costs may be related mainly with the freight component of production since it is positively associated with distance from markets.

Keywords: cointegration; threshold; bean.

Economic Analysis of Adaptation Strategies to Climate Change: a cost benefit analysis

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Abstract

Climate change poses threats to the agricultural sector and negatively affects subsistence farmers who have a low adaptive capacity. Therefore adaptation capacity is needed to counteract the impacts of climate change. However, while adaptation is considered crucial for addressing potential challenges of current variability and future climate change, there are many knowledge gaps in the assessment of the cost and benefits of adaptation to climate change in the agricultural sector. There is thus a need to build capacity, particularly on fine-tuning methodologies to understand a range of estimates and trade-offs related to local level adaptation to climate change. This thesis presents an economic analysis of adaptation to climate change. This study draws on the existing literature on best strategies and tailors its use on testing local level economic methods for analysis of adaptation projects. The thesis focuses on the exploration of Cost-Benefit Analysis of adaptation options to climate change in order to provide comprehensive evidence for policy makers. Three main methods of economic analysis namely; Net present value (NPV), Benefit-Cost ratio (BCR) and internal rate of return (IRR), were used for each of the adaptation strategies. The results of this thesis show that farmers who practice late planting and recommended fertilizer amount in the context of climate change are the ones who will get the highest crop production more than farmers who practice early planting and common fertilizer. Therefore this study recommends that farmers in Maphutseng should adapt late planting and recommended fertilizer amount in order to protect themselves from the negative impacts of climate change.

Keywords: climate change; climate change adaptation; Lesotho; Maphutseng; cost-benefit analysis.

Food Safety: the reality of the city of family farmers Itapuranga Goiás

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Abstract

This study aims to assess the food security of small farmers in the municipality of Itapuranga - Goiás. In order to reach this objective, the study analyzed comparatively producers who are in the food security and insecurity to check the relationship of the food (in) security variables, tenure, size ownership, education of the producer, the value of family income and agricultural finance. Technique of comparison analysis and investigation groups of frequencies were performed, based on the data collected, considering the number of studied variables. The research was conducted in the municipality of Itapuranga - Goiás, from January to March 2013. The calculation was made with the value determined by confidence level of 90%, the sampling error of 5%, p = 0.85 and q = 0.15, with a sample of 138 producers. The techniques for

comparison analysis and investigation groups of frequencies were performed. Data were categorized into tables and tabulated with Microsoft Excel software (SPSS). The results showed that the variables, farm size, farm income and participation in organized segments were related to the food security of farmers in the study area.

Keywords: food security; family farming; farm and agricultural financing income.

The Effects of Diversification of Production and Non-Agricultural Income for Food Safety of Family Farmers of the Municipality of Itapuranga – Goiás

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Abstract

The purpose of this work was to evaluate the effects of diversification of production and non-agricultural incomes to food security of farmers of the municipality of Itapuranga - Goiás. To the scope of the proposed objective, the study analyzed comparatively the producers who are in a situation of food security and those who are in a situation of food insecurity for the verification of the relationship of (in) security, considering the variables, diversification of production, origin of income and total income. Technique of comparison analysis and investigation groups of frequencies were performed, based on the data collected, considering the number of studied variables. The calculation was made with the value determined by confidence level of 90%, the sampling error of 5%, p = 0.85 and q = 0.15, with a sample of 138 producers. Data were categorized into tables and tabulated with Microsoft Excel software (SPSS). The results verify allowed that the variables, source of income and total income had relationship with food security, however in the diversification of production was not perceived relationship with food security for farmers in the area searched.

Keywords: food security; diversification of production; family agriculture and non-agricultural incomes.

Agribusiness's Share of GDP in Rio de Janeiro State

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Abstract

The agricultural activity in the state of Rio de Janeiro represents about 0.4% of the state's GDP, according to the IBGE. This estimate alone does not adequately reflect the relevance of the sector in the state's economy, because it fails to consider the interdependence and integration of agriculture with other economic sectors. This study calculated the agribusiness sector's share of GDP, which in addition to the farming sector itself (crops and livestock activities), includes other sectors (either in part or entirely) that are strongly connected (either upstream or downstream) to the farming sector. These other sectors include input

producers, processors (agroindustry), and distribution (commerce, as well as financial and logistical services). The results of this study revealed the state´s agribusiness's GDP to be R$ 12.15 billion (3.5%) in 2008, and agroindustry was found to be the largest sector. Within the agribusiness sector, special importance is attributed to small scale horticultural and flower producing activities, which enjoy the advantages of proximity to the major consuming center represented by the metropolitan area of the state's capital.

Keywords: agribusiness; Rio de Janeiro; GDP.

What world price?

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Abstract

We analyze price relationships among rice export prices from January 2000 to December 2012 to verify delineation in the international rice market using clustering and cointegration approaches. The results show that Thai 5% brokens and Thai 100% Grade B in the high quality cluster are cointegrated and that the prices of Viet 25%, Thai 25%, Pak 25%, and Viet 5% brokens in the low quality cluster follow the same long-run trend. Viet 25% and Thai 5% can be considered as representative international prices in the low and high quality rice markets, respectively. However, we find evidence to show that Viet 5% tracks both low and high quality clusters, and thus, may be the best single stand-in for – world price of rice. We also examine world to domestic price transmission and found that majority of domestic rice markets are cointegrated with Viet 5% and Viet 25%. The study highlights the importance of differentiating rice types in the trade structure to identify world to domestic price linkages more accurately.

Keywords: rice; price transmission; market integration.

Management of market risk for vegetables: propositions, analyses and reflections on Juazeiro Producer Market, Bahia, Brazil

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Abstract

The aim of this paper is to demonstrate that the Brazilian vegetables, especially whose traded at Juazeiro Producer Market (JPM), have the potential to use financial tools, in a view to minimizing their risk of price, given that they still cannot be classified as a commodity, and therefore do not enjoy the hedging mechanisms available in the futures or options markets. On the other hand, a recent study has indicated the feasibility to implement future market for fruits, given that the characteristics of volatility and market size were considered positive for the success of future contracts (FERREIRA; SAMPAIO, 2009), which can be used as benchmarking for vegetables, once they have the same characteristics. The results of this paper showed that regarding the use of time series for forecasting future prices, the ARIMA method proved effective, since most vegetables showed correlation between the price series current and forecasted above 0.70 and the Theil's U coefficients below 0.10. Regarding the use of VaR to indicate the level of risk in the returns of vegetables prices, the Historical Simulation proved the most effective technique, followed by Monte Carlo Simulation, the Autoregressive Conditional Volatility and Exponentially Weighted Moving Average. Moreover, it was also possible to identify the probability distribution functions and λ factors decay, as well as three risk groups among vegetables (low, intermediate and high). What about the use of hedging, the simulations showed its applicability, since it found optimal hedge ratios between 73% and 98%, with effectiveness ranging between 13% and

80%. Theoretically, it was possible to show a quadratic relationship (with downward concavity) between the maturity of hypothetical futures contract (or lag) and the optimal ratio/hedge effectiveness.

Keywords: price risk management; time series; value-at-risk; hedging strategies; vegetables.

Measuring Impacts of Cross-border Trade in Food Staples on Household Welfare in East Africa

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Abstract

Cross-border trade in food staples among the East African countries is mutually beneficial for achieving food security and improving household welfare. Net exporters are expected to gain from the large regional market, while the net importers are expected to enjoy relatively more stable supply of food at fair prices. In the past decade various initiatives have been implemented and intensified to make cross-border trade in food staples freer. As a result the volume and value of cross-border trade in food staples has greatly increased in the region as reported in various trade statistics. What remains unclear is the extent to which this increased trade has contributed to household welfare. This study attempted to fill this knowledge gap.

The study blended qualitative and quantitative approaches to determine household welfare changes attributable to cross-border trade in food staples. Qualitative approach involved focus group discussions with border communities and key informant interviews. This was followed by quantitative analysis using the Demographic Health Survey (DHS) data for three East African countries. DHS data is a geo-referenced multi-national, multi-year data collected with the aim creating an internationally comparable body of data on the demographic and health characteristics of populations in developing countries. The data set contains information on the wealth status of the households summarized in an endogenously generated wealth index. In this study, the impact of trade on welfare was measured by analysing the change in household wealth index overtime using Difference-in-Differences approach on propensity score-matched food surplus and food deficit households. Results indicate that free cross-border trade in food staples is beneficial to both the producing and consuming households. However, the benefits are only feasible when trade flow is uninterrupted. Countries that implement periodic bans on exports disadvantage their producers, as much as their consumers benefit, which may in the long run discourage production. The findings of the study have relevance in informing trade policies in the East African region.

Keywords: cross-border trade; household welfare; East African region.

Calculation of price indexes for the sugarcane sector in Brazil

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Abstract

This article details a new methodology of calculation of index numbers, which aims to get the changes in prices of key inputs and services used by one of the most important sectors of agribusiness in Brazil: the

sugarcane sector. The region of analysis is restricted to the area with the highest sugarcane production in the country: the South-Central Traditional Region, which includes the states of São Paulo and Paraná. The mathematical model is based on the Laspeyres Price Index whose basket of inputs/services and the vector of weights were based on a project of the University of São Paulo, which has been calculating and analyzing the costs of this sector for several years. Moreover, beyond the mathematical analysis of index numbers, this article shows details of two particular types of adjustments: the economic and technical. The economic adjustments are related to the several problems that result from the commercialization of the inputs. On the other hand, the technical adjustments are related to agricultural and industrial themes such as: hand-labor, land leasing, agricultural mechanization and industrial mechanization. The main results of the paper show up an economic and technical analysis, which are based on 19-month series of several indexes created from the proposed methodology. These results show the importance that this kind of research has in the sector, especially because of the lack of robust indicators that could show the monthly evolution of the prices of key inputs and services used by the sugarcane industry.

Keywords: index numbers; Laspeyres Price Index; sugarcane sector.

The influence of rural credit in agricultural gross added value

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Abstract

This paper aims to identify the relations between the granted amount of rural credit and the increase of gross added value of the agribusiness in Brazil using the Johansen's method. Taking into consideration that financial intermediation arises as a mechanism to minimize market imperfections, allowing and facilitating (mediating) the allocation of resources, highlighting the crucial and strategic role of the interventionist state, in the case of rural credit, where there are directing and controlling of the quantity supplied and as well the price, justifying the importance of the study. Through research emerged various empirical studies demonstrating the contribution of the financial system for economic growth, especially studies of development of endogenous growth models. In Brazil, these studies range from the importance of the development of the financial system for economic development process to investigate causality between agricultural GDP municipal and rural credit. It appears that economic growth often has been explained by financial variables, demonstrating the existence of causality. The variables included in the study were: rural credit (crural) and the gross added value of agriculture (vabag), he variables included in the study were: rural credit (crural) and the gross value added of agriculture (vabag), considering quarterly series, covering 50 trimesters. The data relating to the first variable were extracted from the database of Banking Statistics, released by the Central Bank of Brazil, considering the total amount of loans granted to the agricultural sector, disregarding their purposes, and the data of the second variable were extracted from the of Trimesterly National Accounts provided by the Brazilian Institute of Geography and Statistics IBGE. The methodology used was the Soraen Johansen's (1995), characterized by a multivariate analysis, whose goal is to identify whether the time series have unit roots or not. In the case of the test show off unit roots, those are provided on vector autoregression VAR , in order to test the existence of linear combinations, also called cointegration vectors. Thus, the study demonstrated that the model of Johansen Co-integration enables the identification of the relationship between rural credit and the gross added value of agribusiness in Brazil, noting that its application allowed presenting a regression model that will facilitate projections and the development of some government plan or public policy.

Keywords: vector auto regression; agricultural growth; Johansen co-integration.

Segmentation of Brazilian labor market and manpower allocation between agricultural and non-agricultural sectors from 2004 to 2009

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Abstract

The aim of this paper is to evaluate the impact of sectoral segmentation between agricultural and non-agricultural sectors on the allocation of manpower in the Brazilian labor market from 2004 to 2009. The labor market segmentation reduces the mobility of workers among sectors, changing the allocation of workers and generating income differential among them. By this theory, the experience leads to adaptation of behavior and opinion of employees in the workplace. So, in this paper, it is proposed a new division of the manpower into the following groups according to their experience in the agricultural and non-agricultural sectors and the Brazilian data available: Occupied - agriculture; Occupied – non-agriculture; Unemployed - agriculture; Unemployed - non-agriculture; Unemployed - in search of their first job; Unemployed - not occupied for more than a year; Inactive. In this way, to analyze the impact of segmentation on the manpower allocation, a multinomial choice model is estimated in order to determine the effect of each characteristic on the probability of an person belong to one of the proposed situation of employment, unemployment and inactivity. Data used is from the National Sample Survey of Households (PNAD) 2004 to 2009. The results show that there is segmentation between agriculture and non-agriculture and mobility between the sectors is primarily limited by the following characteristics: formal education, marital status, being indigenous and living in rural areas. In Brazil, the segmentation of labor market leads to higher probabilities of allocating individuals with less formal education, spouses or who live in rural areas in the agricultural sector. These features reduce worker mobility between agricultural and non-agricultural sectors and are used to determine the fulfillment of jobs in agricultural and non-agricultural labor markets. Because of the mobility reduction between sectors, the labor market segmentation results in different working conditions even for comparable individuals. To minimize the consequences of segmentation and increase the welfare of the worker, targeting policies could be implemented to increase the mobility of workers between sectors, namely: schooling policies for agricultural workers and rural residents; policies that facilitate the inclusion of spouses in the non-agricultural labor market; policies to increase geographic mobility and the improvement of public transportation between rural and urban areas and between rural and metropolitan areas; incentive for non-agricultural companies to settle in rural areas.

Keywords: agriculture; labor market; segmentation.

Agricultural Market Information System in Sri Lanka: costs, transmission, reliability, volatility and adequacy to the policy needs

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Abstract

Sri Lanka commenced Agricultural Market Information System (AMIS) in 1979-80s. AMIS is the key mechanism for market data collection, analysis and dissemination of information. Data gathering exercises have developed a better data base on prices

of many agricultural commodities. Though, in Sri Lanka, it is obvious to note that the integration of agricultural market information system at national, regional and global levels still in infancy. Majority of the activities put into practice in the process, while the withdrawn of international donor supports, most of activities and program have been stooped or stagnated due to serious financial scarcity. Information service was turn into the more unworkable activities and inefficiency of the system lead to the lack of financial resources. Lacks of resources and higher cost of data collection were generating the more complicated environment and the expectation of the AMIS was far below than the achievements. There are some benefits and few positive impacts of the market information system. Policy makers, researchers, academicians and other officials were received the benefits and very few traders are get some remuneration. Politicians are significant. Sri Lanka, has raise question of why, failure of information system, is it defective policy implementation or malfunctioning of implementation? The key issue is price volatility and AMIS has not adequacy to the policy analysis and needs. Empirical evidences have confirmed that the developing and implementing of efficient and sustainable agricultural market information systems are not easy task on the process of agricultural transformation. Benefits of such systems shows that are debatable and failure to operate timely, accurate, reliable date and statistics to those who are need market information. Poor understanding of the purpose of data, ineffective communication, outdated technologies, perspectives towards ICT of being "too costly", underutilization of data and information, lack of internationally comparable and compatible methodologies, limited capacity of national programs, sharing viewed as loss of competitive advantage are key problems. Then, the reliability of the AMIS is huge evils. Sri Lanka, is generated in much "date and statistics' on agricultural marketing, but it is not adequately and effectively analysis and interpretations to generate "information" that will be useful to "farmers, traders, and rural communities to make their decisions on crops. It has not helping farmers to improve their bargaining power at the rural markets, while reducing transaction cost and controlling the cheating by middlemen and other intermediary agents. Actual benefits and remuneration of the market information system, are not properly receiving to millions of small farmers those who are living in remote rural agricultural areas. Transmission of the data and information in the AMIS is unmoving. Judging by the Sri Lankan experiences, paper conclude, agricultural information systems, realized that information is not equivalent to "date and statistics" The problem that can be described as; the key reality, there are "oceans of data, rivers of information, but only drops of knowledge in AMIS. The key challenge is "transforming the oceans and rivers into knowledge for informed decisions in agricultural markets" that meeting confronts, to build networks to address gaps and problems in agricultural markets.

Keywords: market information; food price; policy making; agricultural markets.

Index of Living Conditions (ILC) Index of Livelihoods (IL): a methodological proposal to measure well-being in rural

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Abstract

This paper aims to present a proposal for index to analyze quality of life in rural areas, namely: the Index of Living Conditions (ILC) for rural territories and Index of Livelihoods (IL) and Index of Living Conditions (ILC) applied to tobacco growers. The importance of this work is to discuss and refer to some quantitative and qualitative devices used in the construction of methodological tools that are able to capture the reality of living conditions in rural areas. This proposal also becomes important for the elaboration of research procedures that may guide the construction of public policies for rural development. Thus, this paper presents a description about the two indices, their methodological configurations and initial results as well as comparatives and criticisms about these proposals. Therefore, one of the first aspects analyzed as a result, is that the ILC,

based on the Capability approach of Amartya Sen (1996, 2000, 2001), to point to the living only by the perception of the respondents, in other words, by the interpretations and subjectivities of respondents seems insufficient to measure quality of life. Thus, the IL, to seek more objective data capture by means of what Frank Ellis (2000) called "capitals", or what people have (assets), seems to complement and contribute significantly to the analyzes of welfare in rural areas . Thus, there is a methodology, based on primary data capable of capturing both objective questions and subjective quality of life, making it possible analyze what people have as well as the perception that the same possess of their conditions life, or the uses that make of capital available to them.

Keywords: index of living conditions; index of livelihoods; rural development.

Mineralization of Nitrogen from Organic Fertilizer in the Green House Production of Tomato and its effect on soil microbial parameters

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Abstract

Four rates of compost (0, 5, 10 and 20 tha-1) was applied as soil amendment in the cultivation of two tomato varieties (Beske, a local variety and Improved Ibadan local, an improved variety) in the COLPLANT green house, University of Agriculture Abeokuta(UNAAB). The compost rates were replicated four times. Furthermore, incubation study applying similar compost rates and replicates was carried out in the laboratory to estimate the rate of nitrogen mineralization in compost in order to better understand the effect of compost rates on the availability of soil nitrogen and the effect on the growth and yield of tomato. Nitrogen mineralization from both experiment were synchronized. Data collected was analyzed using analysis of variance and the Least Significant Difference test. Result showed that plant height was not significantly affected by compost rate while the highest number of leaves was observed at 10tha^{-1}. Both ammonification and nitrification were higher at six weeks after amendment (WAA) in compost amended soils and the rates increased with increasing compost rate. The rates and pattern of ammonification and nitrification were similar in both laboratory and greenhouse experiment. Furthermore, significantly higher microbial count was observed at 20tha^{-1}.

Keywords: ammonification; analysis of variance and nitrification.

Rural households' transitory food insecurity and Coping strategies in Ethiopia Highland

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Abstract

This paper explores the supply and demand- side factors in determining household food security situation in rural Ethiopia. It also investigates households' food insecurity coping strategies. A probit regression model used and the regression result show that both the demand and supply-side factors affect households' food security status. From the demand side household size, livestock ownership and access to market determine households' food security; while on the supply-side technology adoption and farm size. However, the demand-side factors have higher marginal effects than the supply side-factors

suggesting that interventions focused on these factors might help improving household food security status. The principal coping strategies to household food insecurity is reducing amount of food consumption and number of meals per day. This implies that passing food shortage under serious malnutrition is a common phenomenon in the study area.

Keywords: rural households; transitory food insecurity; coping strategies; Ethiopian highland.

Synthetic Indices for Family Producers in The Northeast Of Brazil

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Abstract

In the 1990's, the discussion over growth on family farm culminated in regulation by Law 11,326 or the Family Farming Law created on July 24, 2006. The penning of this law opened a legal precedent for the creation of official statistics and studies that provide new analytical perspectives to support the more efficient implementation of public policies.

In this context, the 2006 Agricultural Census, conducted by The Brazilian Institute of Geography and Statistics (IBGE), emerges as a significant information source. Initial analysis showed that 84% of Brazilian rural households presented the family model, with the Northeast region containing more than half of family farms in Brazil (2.2 million), where 6.4 million people were employed in the year of the survey. In light of such developments, the Northeastern region of Brazil shows great potential for studies concerning these themes.

This paper seeks to explore the aforementioned potential, focusing on family producer characteristics in order to create, through multivariate statistical modeling, municipal synthetic indices representative of these characteristics in order to identify patterns that exist within the Northeast of Brazil. Additionally, this study will initiate a comparison of spatial behavior related to these indices and the target population of these governmental programs created to family farmers.

Four indices were obtained by factor analysis techniques: the first index indicates that family producers are longer rooted in the property; the second index is associated with producers that recently purchased property or have precarious possession; the third index refers to producers whose members have completed at least an elementary level of education; and the fourth index represents family producers who do not reside in family establishments. Among the results obtained, this study highlights the existence of spatial behavior and suggests many similarities between the first two indices mentioned above and the target population of some governmental programs.

Keywords: family producer; factor analysis; synthetic indices.

Evolution of Brazilian agribusiness and its labor market

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Abstract

Brazil is the sixth largest economy in the world, representing for 3.5% of the wealth produced in a universe which the 10 largest economies produce 64% of the total world production, according to World Bank data. Besides it`s the largest global producer of soybeans, sugar cane, coffee and orange juice, according to the USDA, and has the second largest commercial cattle herd in the world, setting brazil as a major producer and exporter of food. This performance is the result of the development of Brazilian agribusiness, focus of the national economy since the correlation, the Brazilian agricultural production explain 94.4% of gross domestic product. CONAB was used to analyse the evolution of Brazilian

agriculture, and for the labor market, the source is the ministry of labour, the classification of information across bysectors IBGE and CNAE 2.0 class, to delimit the formal employment in agribusiness since the year 2006 until November 2012. The economics sectors were select by CNAE relating with the agribusiness, in others words it was select in before, into and after the farm. Agribusiness represents 22% of national GDP and in this context, the labor market in this segment also increased. The number of formal employment grew 17% since 2006, from 4.46 to 5.22 million jobs in 2012 and nowadays represents 11% of formal employment in Brazil. The wages also increased, the average Brazilian, increased 10% for agricultural technicians, who now earn r$ 2,032, while workers in mechanization earn on average r$ 400 more than other agricultural workers, both had increased by 10% in average salary, the first with the salary of r$ 1,220 and the second with r$ 790. So nowadays the producers are looking for experient employees with a good qualification and they are paying more for that.

Keywords: agribusiness; employment; production.

Beef Cattle Reference Price Methodology for Mato Grosso State - BR

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Abstract

Mato Grosso is an important state for Brazilian agribusinesses, especially because of the yield chains of soybeans, corn, cotton and beef cattle. It has the largest Brazilian commercial livestock, around, 29,2 million heads; a slaughter of 5.8 millions heads in 2012; Due to importance of the supply chain of beef cattle in the State, it became necessary to develop mechanisms to guarantee transparency to this market. One way to ensure this could be by organizing the price indicators that can guide the market. Therefore, representative methodology was developed to Mato Grosso, which initially consisted only of the state cattle buyers' prices, in other words slaughterhouses' prices. Due to the limitation of this initial concept, for example, the discrepancy between the price, provided by the slaughterhouse and the received by the farmer, it was necessary to a new methodology. This way, a new measurement was prepared which takes into account the prices of slaughterhouse and the breeders prices. Furthermore, new parameters have to be consider in the slaughterhouses, like the distance established by the slaughterhouse for their trucks bring the purchased cattle without deduction in the cattle's price. If the distance to be traveled exceeds the scope of action, the prices paid to the farmer suffer a deduction proportional to the distance. The model also have some conditionals for establish pricing, for example, when the seller price is lower than the buyer price, the buyer price must prevail, geographic limitation for transit of animals among regions. The method used was appropriate at least to 132 of 142 towns, allowing the creation of a daily price indicator, reliable and representative to Mato Grosso.

Keywords: beef cattle; daily price; market; Mato Grosso.

Prediction of Crop Land Shares for Environmental Impact Assessment over EU

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Abstract

The agricultural sector contributes to 9.3-10.6% of total greenhouse gas (GHG) emission, and there is a growing interest in modelling environmental impacts

of agricultural activities. For the quantification of agri-environmental indicators and the estimation of GHG, the distribution of crop shares over the Homogenous Spatial Units (HSU) is required, as many indicators depend on the local combination of land use and environmental conditions. These Spatial Units should express highest possible homogeneity for important factors so that their characterizations and results can be regarded as representative. In this paper, we investigate the prediction of the crop shares over the new HSU2 (fine meshed grid 1km*1km). Results are aggregated to be compared with the crop shares. Most of predictions follow the trend of crop shares from the statistics.

Keywords prediction; crop shares distribution; greenhouse gas emission; spatial downscaling.

Understanding the Link between Nutritional Status and Women's Empowerment in Agriculture: evidence from Ghana

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Abstract

This paper investigates the link between women's empowerment in agriculture and the nutritional status of women and children using 2012 baseline data from the Feed the Future population-based survey in Ghana. The sample consists of 3,344 children and 3,640 women, and is statistically representative of the northernmost regions of Ghana where the Feed the Future programs are operating. We use a new survey-based index, the Women's Empowerment in Agriculture Index (WEAI), which directly measures women's empowerment, inclusion and agency in the agriculture sector across five domains in agriculture, namely: agricultural production, access to and control over productive resources, control over the use of income, leadership in the community, and time allocation (Alkire et al. 2013). We conduct individual-level analyses of nutrition outcomes including indicators on stunted, wasted and underweight children, underweight women, and feeding practices such as exclusive breastfeeding, and diet diversity for women and children. Preliminary results suggest that women's empowerment is more strongly associated with infant and young child feeding, and only weakly associated with child nutrition status. Similarly, we find that women's empowerment in credit decisions is positively and significantly correlated with women's dietary diversity, but not the likelihood of being underweight. This suggests that improved nutritional status is not necessarily correlated with being empowered in all the domains of empowerment, and that different domains may have different impacts on nutrition, consistent with other findings in the empowerment literature (Kabeer 1999).

Keywords: women's empowerment; gender; agriculture; nutrition; Ghana.

Water Use for Irrigation Purpose by Agriculture Holdings as Bases for the Production of Statistical Data at River Basin District Level

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Abstract

International policy on water use has been oriented to promote and develop more sustainable ways of

using water resources and most of them focuses on agriculture that still represent - in a Mediterranean country such as Italy - a highly water demanding sector. That determined that also the statistical demand on such matter increased enormously recently.

Thus, due to international mandatory Regulation, Istat, the National Institute of Statistics, had to produce for the first time official statistics on water use at farm level.

The main focus of the present paper is to show the methodology used for geocoding agriculture holdings and their component units at census enumeration area and for estimating water use per farm in order to calculate the water consumed by agriculture at River Basin District level, that is the most important territory classification referring to water use and management issue.

Keywords: irrigation; river basin; agriculture.

Dichotomy between Urban and Rural Areas: statistical data may not reveal the synergy between these two existing spaces

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Abstract

The gains in non-agricultural activities represent a new dynamic in rural Brazil and now has representation in Brazil from the 1990s. In this perspective, the Brazilian countryside is undergoing a reconfiguration, pointing to an intensification of the urbanization of rural areas, especially in peri-urban areas. The installation of industries in rural areas, the deployment of agribusinesses and food exporters and utilization of rural labor for those industries, are tying the stretches between urban and rural areas. Thus, rural households are increasing income through agricultural and non-agricultural activities. The rural environment is no longer exclusively agricultural. It went on to have a diversified productive base and integrated economy in the region. The growing rural human being mobility, as well as an improvement in communication and access to information and greater integration between markets, reduces the dichotomy between urban and rural. On the other hand the expansion of the cultivation of sugar cane on a region can increase the (Gross National Product) GNP per capita of the region and enable an increase economical activity. Thus, the rural household pluri-activity can be an alternative to increase the income of these families as they, increasingly integrate with the local market. It is known that with rising incomes and improving the welfare of the rural population can reduce the rural exodus that became increasing in the country since the 1970s. However, in areas with predominantly or expansion of monoculture, as an example of cane sugar, may be an increased land concentration and a worsening of income distribution in a region, and to record an increasing in rural migration, Environmental degradation and reduced local production diversification. An analysis of several indicators, socio-economic and environmental, through the Dashboard of Sustainability is possible to tell which category has the highest rate of farmer sustainability, whether smallholders or monoculture. However, the secondary data available in Brazil today does not support a thorough analysis of the participation of each actor and to which the interconnection between the actors and their synergy in local economic activity. Since, given the narrowing between urban and rural, the statistical data available are not able to demonstrate the extent to which gives the rural-urban dichotomy. Thus, it is relevant to point out and discuss ways to provide consistent statistical data and be, in fact, able to demonstrate the local reality of a region within the welfare actors.

Keywords: welfare; dichotomy; economic activity.

Determinants of Rural Poverty in Brazil: a spatial approach

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Abstract

The issue of poverty is a recurring theme in the economic literature. Currently, it is a subject of intense debate, especially regarding its complexity of measurement and conceptual definition, and also about its connection with various other aspects of the contemporaneous economic and social realities. However, the studies of this phenomenon become too limited when not taken into account the regional, local, social and individual specificities, as well as its urban-rural dynamic. Thus, the recognition of the complexity of the issue has been rebuilding the research agenda on poverty, thereby enabling the development and incorporation of new approaches to its study and measurement.

The main objective of this paper is to examine the spatial distribution of poverty in the rural areas of the Brazilian microregions, as well as the distribution of variables related to the incidence of poverty in these regions, since there is a predominance of it in the rural way. Although descriptive and historical analyzes are critical to contextualize the problem, the identification of causal effects is of great importance. Due to it, the proposed model will seek to capture the main characteristics that affect the poverty rates in the rural areas, using spatial statistics and exploratory spatial data analysis (ESDA), aiming to find correlations among the variables considered in the geographical level and the possible incidence of clusters.

From the perception that the poverty must be evaluated beyond a purely monetary approach, this paper seeks to analyze it in a broader perspective to consider not only the viewpoint of income or private goods consumption. The poverty, seen here through a line encompassing a basket of consumption that meets the individual basic needs, must be given, therefore, in terms of economic, social, political and individual factors.

With respect to economic factors are variables such as the percentage of the labor force participation by gender, the condition of the producer in relation to land, the size of the establishment, the average income of the family, the legal status of the producer, among others. The individual and social factors include age, years of schooling, migration rate, income inequality, life expectancy, housing conditions, etc. Finally, political factors are represented by variables that seek to capture the existence of public policies for poverty reduction in the region, e.g. the number of families contemplated with the Bolsa Família program and other incomes obtained by the producer.

To tecognize the structure and interactions natures of a phenomenon in space is relevant for suggesting patterns and recurrences that may assist the formulation of public actions through regionalized policies. This is because, firstly, it may be able to quantify assumptions of the existence of regional disparities in living standards and identify areas which are lagging behind in the process of economic development. Second, it promotes guidance to the programs whose scope is partly alleviate poverty through fields such as education, health and food security. Finally, allows to highlight geographic factors associated with the poverty, such as unfavorable edaphoclimatic conditions or the distance from major cities.

Keywords: rural poverty; exploratory spatial data analysis; Brazil.

The Influence of the International Price on Brazilian Exports of Milk Powder

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Abstract

This study intends to analyse the main determinants of Brazilian exports of milk powder from 2000 to 2011. For this purpose, it will be used the theory of export supply to a country whose exports do not influence the international market, explained in the

literature review. As methodology, the model will be estimated by the vector auto-regression (VAR). As hypothesis, it will be established that according to the theoretical model applied, the international price of whole milk powder from Oceania would be the main determinant of Brazilian exports of milk powder. Other variables besides exports of milk powder and international prices of milk powder are: domestic price of milk powder, national income, purchased raw milk and real exchange rate. International prices from Oceania are used because the continent is a big player in the global dairy market, so their prices are references for other countries exports. Three methods of econometric time series will be used to confirm the accuracy of the hypothesis: the causality test, analysis of variance decomposition of the forecast error and the elasticity of impulse response. The importance of this work is that considering that Brazilian exports of milk powder increased only during periods of favorable world economy, there is a concern that export industries only have incentives to export when the conjuncture is propitious, being dependent on exogenous factors, which is not healthy for the production and export chain.

Keywords: milk powder; export supply; vector auto regressive (VAR).

Regional Food Price Inflation Transmission

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Abstract

In a context of high and more volatile food prices, understanding to what extent and speed food price changes on international markets are transmitted to consumers is key in assessing the vulnerability of households to price shocks. This is an important dimension of food security appraisal, especially for developing countries, where consumers tend to spend a higher proportion of their income on food items.

The aim of this paper is to provide measures of the transmission of price changes from international markets to consumers, at regional and sub-regional levels. This analysis, based on FAO's new regional consumer food price indices, is useful in establishing typologies of regions and sub-regions with respect to their levels and speed of price transmission. Regional estimates of food inflation transmission can also be used to predict consumer-level impacts of international price shocks for different regions of the world, contributing to improve the information basis on which to base policy mitigation actions and to increase the efficiency of these actions by focusing on the regions or sub-regions likely to suffer the most.

Keywords: food price inflation transmission; regional consumer food prices; international food prices.

Coefficients for N and P content of cereals and temporary grasses for use in the Swedish nutrient balances

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Abstract

Gross Nutrient Balances (GNB) for nitrogen (N) and phosphorous (P) are key agri-environmental indicators (AEI) within the EU and are relevant to at least one of the indicators for agricultural statistics as defined in the Global Strategy. Therefore, there is an increased need to obtain harmonised statistics related to crop nutrients. Statistics Sweden has calculated and published national soil surface nutrient balances intermittently since 1991. In 2003, the method was partly adjusted to follow the one recommended by the OECD and Eurostat to increase comparability between countries. In spite of changes in crop breeding and farm management, the coefficients for N and P content in crops and crop residues have not been revised. The objective of this action is to obtain updated and well-defined coefficients for N and P content in harvested

cereals, temporary grasses and crop residues and to estimate the amount of crop residues in Sweden. The N and P concentrations in grain and straw of cereals used in the official Swedish nutrient balances have been compared with concentrations reported in scientific literature for crops grown in Sweden or under conditions similar to those in Sweden as regards climate, soil type, production systems, management practices, *etc.* Comparisons have also been made with coefficients reported from the Swedish national environmental monitoring programme, and the Swedish variety trials as well as with coefficients used in other calculations, *e.g.* the OECD/Eurostat GNB, the national greenhouse gas inventory and the data modelling of N and P leaching from Swedish arable soils. N and P concentrations have been determined by analysing samples collected as part of the Swedish national environmental monitoring programme. For estimation of crop residues removed from the field, a sample survey of 3 000 agricultural holdings was conducted during the autumn/winter 2012/2013. A sensitivity analysis of the effect of using a range of different N and P coefficients for harvested products and crop residues on the Swedish GNB has been conducted. Results from the action show that for grains of the three main cereal crops in Sweden, *i.e.* winter wheat (*Triticum aestivum*), spring barley (*Hordeum vulgare*) and oats (*Avena sativa*), there are discrepancies in the coefficients used in the Swedish nutrient balances and what is reported and/or used by others. The N and P content in crop residues of these three cereal crops varied considerably. For example, N in straw of winter wheat and oats used in the Swedish nutrient balances were in line with the concentrations used in the OECD/Eurostat GNB and by the Swedish Board of Agriculture. However, they were higher than those used by the Swedish Environmental Protection Agency for the greenhouse gas inventory. The sensitivity analysis provides a basis for decisions on which variables it is worth investing resources in to obtain more precise coefficients and hence a more accurate estimation of the output. The outcome of this action can serve as a basis for recommendations on sound methodologies to obtain better practices in terms of obtaining N and P crop content coefficients, considering factors such as scientific ground, cost-efficiency and practical feasibility. Ideally, harmonised coefficients should be used by all reporting systems within each country. Differences in coefficients between countries should be supported by well-documented and confirmed evidence of differences in crop products in terms of N and P content.

Keywords: nutrient balance; GNB; nitrogen; phosphorous; crop; ley; straw; crop residues; sensitivity analysis.

Brazilian Livestock Markets: price analysis and forecasts for cattle and poultry productions

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Abstract

The livestock production represents one of the most important Brazilian agribusiness activities. It supplies local markets and have great importance for Brazilian exportations and world markets. Although the livestock markets had evolved, price fluctuations may lead to wrong decisions related with product's negotiation time. Thus, the present study aims to analyse the volatility of cattle and poultry prices, two of main Brazilian livestock markets products. Besides that, we analyse current and future scenario of those livestock products in terms of production, offer, demand, exportation and importation. In order to analyse the financial returns volatility of cattle and poultry, we applied Autoregressive Conditional Heteroscedastic (ARCH) and Generalized Autoregressive Conditional Heteroscedastic (GARCH) models. For current and future products scenarios, we used geometric mean models through Regression Analysis. The results of this research indicate that prices fluctuations, positives or negatives, affect the Brazilian livestock products value. Furthermore, we observed that cattle and poultry have markets growth tendency. We conclude that a deep Brazilian livestock price volatility understanding could give supports for the producer's decision-making process, allowing an incomes collateral effect minimization of those activities in future scenarios.

Keywords: Brazilian agribusiness; prices volatility; projections.

Short term outlook for cattle's stock in Mato Grosso

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Abstract

The meat world demand is increasing due to growing income in developing country. In this way, a study about the forecast of cattle supply for the next two years in Mato Grosso, the first in beef cattle production in Brazil, is interesting, once the state is the second in exports too. The methodology is based in cattle prices behavior and their consequences in cow slaughter that can reduce or increase calf production. The calves' production is important to understand the stock future of cattle male ready to slaughter. Thus, the objective was to verify the evolution of the stock of animals ready to slaughter in 2014 and 2015. The database used for the measurement was the number of male animals per age, from than zero months until those with more than thirty six months announced by Defense Institute of Agricultural Protection by Mato Grosso (INDEA – MT) in the period of vaccination against FDM in November 2011. With based in the INDEA data, was elaborated a forecast the cattle life that was separate per age range: 1 - from zero until 12 months; 2 - from 12 months until 24 months; 3 - from 24 months until 36 months; 4 - more than 36 months. So, as the INDEA have the data about the number of calves' head of 2011 (3.72 millions) and 2012 (3.62 millions) the cattle's offer in 2014 and 2015 was estimate. The estimate was realized with base in the historical mortality rate, slaughter and inputs and outputs of animals of the state per age range. As in Mato Grosso between 2011 and 2012 the calves production increased due to decrease of cow slaughter in the period, based in higher cattle prices, the cattle's offer in 2014 will grow in 0,7% and in 2015 will fall in 4,5% in annual comparative. In this way, the number of heads that was 4.25 millions in 2013 will go to 4.28 millions in 2014 and 4.08 millions in 2015. To the next two years, the cattle stock forecast is fall, demonstrating that the animals' offer in Mato Grosso will decrease. If the domestic and international demand won't fall in the same intensity, the prices can grow, beginning a new cycle.

Keywords: calf; forecast; cattle stock.

Status of intra-COMESA trade in food staples

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Abstract

Member states of Common Market for Eastern and Southern Africa (COMESA), with the support of development partners, have implemented many cross-border trade-promoting initiatives. However, the results of these initiatives remain unclear because of the underdeveloped trade data infrastructure. This infrastructure is a prerequisite for assessing the impacts of regional trade policies. If there is no mechanism to measure and evaluate progress in trade policy implementations, then it would remain unclear whether member countries are making best use of available opportunities. This paper analyses recent intra-COMESA trade trends in key food staples (maize grain, rice grain, maize flour, wheat flour, beans and pulses, cassava, onions, tomatoes, live bovine animals, milk and cream, bovine meat, fish and crustaceans) among 10 countries in Eastern and Southern Africa (ESA) namely (Burundi, Democratic Republic Congo (DRC), Djibouti, Ethiopia, Kenya, Malawi, Rwanda, Uganda, Tanzania and Zambia) for the 2008-2011 period selected on the bias of the availability of trade data.

Quantitative tracking of the changes in food staple trade flows adopts a methodology developed by Regional Strategic Analysis and Knowledge Support System (ReSAKSS) in 2010. The approach tracks changes in the volume and value of staple food trade in the Eastern and Southern Africa (ESA) region and constructs commodity-by-country trade flow matrices for formal, informal and total trade in the region. The trade matrices rely on mirror records of the trade statistics reported by trading partners. In constructing the formal trade matrices the export value reported by the export

country is compared with the sum of mirror imports by the countries selected for the indicator. The higher of the two figures is used as the export value of that product by that particular country. The formal trade data used in this study is compiled from COMStat while the informal trade data is compiled from the Uganda Bureau of Statistics (UBOS) and the Market Analysis Subgroup (MAS) partnership consisting of Eastern Africa Grain Council (EAGC), Famine Early Warning Systems Network (FEWSNET), World Food Program (WFP) and Food and Agriculture Organization of the United Nations (FAO).

The results show that between 2008 and 2011, formal trade in volume terms has increased by 33%, while informal trade has increased by 45%. In value terms (US$), formal trade over the same period increased by 61%, informal decreased by 26%. The results show different trends between formal and informal trade flows. However the total trade shows an increase of trade flows in volumes and value terms of 37% and 27% respectively using 2008 as the baseline. The study recommends the need for the region to invest in trade data infrastructure for evidence based effective decision making.

Keywords: COMESA; food staples; trade.

Inclusion of questions on environment in agricultural censuses

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Abstract

A way to understand how agricultural practices may be affecting the environment and contributing to degradation as well as climate variability and change, is collecting environmental information through instruments of universal coverage, i.e. an agricultural census. This document aims to present some of the most relevant and recommended questions to collect environmental information.

Keywords: census; environmental questions; agriculture and livestock.

Present and future of the Agricultural Sector`s Supplying and Price Information System in Colombia - SIPSA and the interaction with the Agricultural Statistical System: some stylized facts

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Abstract

Nowadays markets are not domestic at all, but they are more globalized; therefore, it is necessary to have quality information that enables the different commercial chain agents to make the best decisions in order to improve the population welfare.

Keywords: food; transaction costs; institutional economy; information; prices.

Dimensional structure analysis of the Brazilian Scale of Food Insecurity

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Abstract

To assess the prevalence of household food insecurity (FI) the Brazilian government uses the Brazilian Scale of Food Insecurity (BSFI), which is a 15-item (household with children or adolescents / HHCh) or an

8-item (household with adults only / HHAd) instrument based on the Household Food Security Survey Module (HFSSM) developed in the USA. Besides internal consistency, the BSFI has been partially evaluated through a Rash model analysis, which by design requires the assumptions of single dimensionality, conditional independence and equal item discrimination parameters. On an operational level, to classify the severity of FI, an additive total raw score is traditionally created and households are classified into four mutually exclusive "equidistant" levels: 1) food secure (score = 0); 2) mild FI [score : 1-5 (HHCh) or 1-3 (HHAd)], 3) moderate FI (6-10 or 4-6), and 4) severe FI (11-15 or 7-9)]. However, this procedure has never been properly scutinized. To redress these gaps, the objectives of this study were to evaluate the dimensional and cutoff point structure of the BSFI. The analysis used a representative sample of households of Rio de Janeiro, Brazil. The sample comprised 1,121 households, and 1,105 (98.6%) completed all questions about household FI (620 HHCh and 485 HHAd). Data collection occurred from May to December 2010. To assess the dimensional structure of the BSFI and in tandem the Rash assumptions we turned to a full-fledged latent variable analysis, both exploratory analyses within a confirmatory factor analysis framework and CFA proper. Latent class analyses were next carried out to address the cutoff point structures of both scales (HHCh and HHAd). Identification of potential thresholds was carried out by contrasting the modeled categorical latent variables with raw scores and the respective variables grouped thereafter.

Keywords: food insecurity; structural equation models; Brazilian survey.

Agricultural Prices and Markets in India: improving market efficiency for price discovery

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Abstract

Agricultural prices have tremendous economic and political implications due to their impact on the income and demand of the population in rural areas, terms of trade between agriculture and non-agricultural sectors, inter sectoral allocation of resources, rate of capital formation and technological absorption, and the overall development of the sector. Agricultural Prices mirror the health of agriculture sector. Prices are the signals for resources allocation on the one hand and the determinants of the pattern of consumption and level of living on the other. Price formation in turn takes place in markets where the buyers and sellers of the product transact their businesses. For prices to be fair the markets need to be efficient.

Agricultural marketing encompasses the entire range of activities that direct the flow of goods and services from the primary producer to the ultimate consumer. How well organised are these markets determines the speed and efficiency of the transaction, and accuracy and reliability of the price. For a well organised and efficient market physical infrastructure in terms of market yards/ floors, loading and unloading equipment to handle the produce, weighing, standardisation, grading, packaging, etc; presence of fairly large number of buyers and sellers of the produce; and free and fast flow of information about the quality and quantity of market arrivals and their prices are the prerequisites.

There are a variety of agents involved in moving the agricultural produce from the farmer to the consumer. After an agricultural product leaves the farm-gate, it passes through one or more markets and a chain of market intermediaries comprising of the wholesalers and retailers before reaching the ultimate consumer. During the last five years very high fluctuations in agricultural product prices have been observed. Further, there have been large differences between the farm harvest prices (which the producer/farmer gets) and the wholesale prices (involving large quantities) on the one hand and the wholesale prices and the retail prices (what the consumer pays) on the other. While some variations between these prices are understandable due to the marketing and transportation costs, unduly large variations with large time lags between the farm harvest prices and wholesale prices; and wholesale and retail prices are indicators of poor infrastructural development, weak transmission mechanism and inefficient markets. In such markets the farmer may not be getting a fair share for his produce while the consumer may be paying much higher than warranted. This calls for a thorough review of the marketing infrastructure and governance system to improve market efficiency and price discovery.

In view of the importance of the sector, it has become imperative to have proper system in place for collection, compilation, analysis and dissemination of reliable and timely information relating to agricultural prices through sound statistical methods and procedures to derive meaningful conclusions. Further, harmonization of concepts, definitions and methodology of compilation of data on agricultural prices is important for data aggregation and intra/inter country comparisons. As price formation takes place in markets, it is necessary to create an efficient marketing system that (i) ensures a fair share of the price to the farmer to incentivise the production, and (ii) fosters competition among the market players.

Organized marketing of agricultural commodities has been promoted in India through a network of regulated markets to ensure reasonable gains to the farmers and consumers by creating conducive market environment for fair play of supply and demand. Presently there are 7246 regulated markets and 21,238 rural periodical markets in the country. Besides, government has evolved agricultural price policy for a balanced and integrated price structure which provides incentives to the farmers for adopting the new technology and maximising production and simultaneously keeps in mind the likely effect of the price policy on cost of living, levels of wages and industrial cost structure. The thrust of the policy is to achieve the twin objectives of assuring remunerative prices to the farmers and providing food grains at reasonable prices to the consumers.

This paper will address to the system of collection of agricultural prices – farm harvest prices, wholesale prices and retail/consumer prices of agricultural commodities in India, how have these prices for some of the major agricultural commodities such as rice, wheat, maize and soybean behaved in the major producing and consuming areas during the last five years, what is the agricultural price policy in the country and how has it been functioning over the years, how are agricultural markets organised and governed, analyse the possible reasons for the wide variations in the wholesale and retail prices of agricultural commodities, how have the terms of trade between agriculture and non-agriculture sector behaved during the last decade and what needs to be done to improve the market infrastructure and price transmission mechanism to ensure that the price discovery takes place in an efficient market and the farmer realises a fair share of the price.

Keywords: agricultural prices; agricultural markets; market efficiency; terms of trade.

Use of data on people with disability in rural production units in Brazil: evaluation and improvement proposals

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Abstract

The Global Strategy to Improve Agricultural and Rural Statistics has its origins in the demands of the International Statistical Institute Conference that occurred in 2007, the same year that was signed by over 100 countries to the Treaty on the Convention on the Rights of Persons with Disabilities, conducted by the United Nations.

Since then it is observed in both segments involving rural statistics and that contemplate the rights of persons with disabilities, parallel actions and initiatives to improve data collection related with target populations and quality of information. The goals converge in seeking to correlate information about people with disabilities who live and / or have working relationship with rural production units.

The Washington Group of Disability Statistics developed a set of questions with the purpose of measurement of disability for be used on national censuses. These data evaluated together with the RAIS numbers quantify the occupation of the workforce of people with disability in Brazil. In a literature review is noted however, that the values obtained in this way are divergent and not assess satisfactorily specificities of these people, with regard to the working primarily in units of agricultural production.

Studies are unanimous in pointing out that the lack of accessibility and information about job skills of disability people by employers are the major factors that contribute to 80% of disabled people of working age have been unemployed. In urban areas there are already public policies aimed at encouraging recruitment, an example is the system quota law, however in rural areas ignorance prevails.

The objective of this work is to propose a methodology that improves the census data in rural areas aiming to equal opportunity and empowerment of people with disabilities with a view to promoting their fundamental rights and sustainable development.

Keywords: disability; labor; statistic.

Side Events

Training for Young Statisticians

Seminar on Methodology for Agricultural Censuses and Surveys

The two-day training seminar is intended for young statisticians working in the field of agricultural statistics, or statisticians new to the field of agricultural statistics. Experts from the National Agricultural Statistics Service and the Economic Research Service of the United States Department of Agriculture will give presentations on the following topics:

- Principles of a Statistical System
- Planning for Agricultural Censuses and Surveys
- Questionnaire Design
- Use of Agricultural Data
- Sampling Frames and Sample Design
- Framework for Data Collection Operations
- Editing, Analysis and Summarization of Survey Data

Date: October 21st and 22nd
Time: 9 am to 5 pm
Language: Presentations will be given in English, with simultaneous interpretation to Portuguese and Spanish.
Registration is required to attend this event.
Organizer: Michael Steiner (USDA)

Participants of the training for young statisticians.

Monday, October 21, 2013	
8:00 – 9:00	**Registration**
Presentations will be given by experts from the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) and Economic Research Service (ERS)	
9:00 – 9:15	**Welcome** Remarks: • Marcia Maria Melo Quintslr, Brazilian Institute of Geography and Statistics (IBGE) • Michael Steiner, International Statistical Institute • Mark Harris, U.S. Department of Agriculture
9:15 – 9:45	• Introduction by Young Statisticians
9:45 – 10:30	**Principles of a Statistical System** Mark Harris (USDA-NASS)
10:30 – 11:00	Break
11:00 – 12:30	**Planning Agricultural Censuses and Surveys** Barbara Rater (USDA-NASS)
12:30 – 14:00	Lunch
14:00 – 15:30	**Questionnaire Design and Testing** Jaki McCarthy (USDA-NASS)
15:30 – 16:00	Break
16:00 – 16:30	**Use of Agricultural Data** Mary Bohman (USDA-ERS)
16:30 – 18:00	**Sampling Frames and Sample Design** Michael Steiner (USDA-NASS)

Tuesday, October 22, 2013	
9:00 – 10:30	**Framework for Data Collection Operations** Barbara Rater (USDA-NASS)
10:30 – 11:00	Break
11:00 – 12:30	**Data Validation and Summary** Jeff Bailey (USDA-NASS)
12:30 – 14:00	Lunch
14:00 – 15:30	**Practice Exercise**
15:30 – 16:00	Break
16:00 – 17:00	**Presentations by Seminar Participants** Papers will be presented by participants of the seminar
17:00 – 18:00	Summary & Closing Ceremony

ADePT Food Security Module

Deriving Food Security Indicators from Household Surveys using the ADePT Food Security Module. Country experiences

The Food Security pre-conference event will be the opportunity for colleagues from statistical agencies worldwide to present the work that has been done in analyzing food security using household survey data and the newly released ADePT Food Security Module.

Case studies that will be presented tentatively include those from: Armenia, Bolivia, Colombia, India, Indonesia, Thailand and Uganda (others may be added).

The workshop will be organized around:

- a presentation of the ADePT Food Security Module;
- case studies presentation;
- a discussion on possible improvements in the data and the analytical tool.

Date: 22 October 2013
Time: 1 pm to 6 pm
Language: English with simultaneous translation into Portuguese
Anybody who is interested is welcome to attend.
Organizer: Carlo Cafiero (FAO).

Detailed Programme

- Institutional Development and Capacity Building (IDCB)
- Statistical Production Process (SPP)
- Analytical and Policy Needs (APN)

Day before - 22 October

19:00 - 21:00	**Cocktail reception, registration and material distribution** *(Terrace)*

Day One - 23 October

08:00 - 09:00	**Registration and material distribution** ***(Foyer)***	
09:00 - 10:00	**Opening Ceremony and Keynote Speech** ***(Velasquez auditorium)***	
	Chair:	**Wasmália Bivar**, Brazilian Institute of Geography and Statistics (IBGE)
	Welcome remarks:	**Pedro Luís do Nascimento Silva,** International Statistical Institute (ISI)
		Pietro Gennari, Food and Agriculture Organization of the United Nations (FAO) and United Nations Statistics Division (UNSD)
		Esther Bemerguy, Brazilian Ministry of Budget and Planning (MP)
	Keynote speaker:	**Romulo Paes de Sousa** (Rio+ Centre), "Food security, sustainable agriculture and rural development - inherently paradoxical?"
10:00 -11:00	**Plenary Session 1: Progress in Implementing the Global Strategy** ***(Velasquez auditorium)***	
	Organizer:	**Christophe Duhamel**, FAO
	Chair:	**Arturo Blancas Espejo**, INEGI Mexico
	Speakers:	**Christophe Duhamel** (FAO), "Overview of the implementation of the Global Strategy"
		Oliver Chinganya (AfDB), **Joseph Ilboudo** (UNECA), "Implementation of the African Action Plan"
		Mukesh Srivastava (FAO), "Implementation of the Asia-Pacific Plan"
11:00 - 11:30	**Tea/Coffee (Foyer)**	
11:30 - 13:00	**Parallel Technical Sessions 1**	
	Technical Session 1.1: APN 1 - Environmental Issues (*Velasquez auditorium*)	
	Organizers:	**Eszter Horvath**, UNSD and **Johan Selenius**, EUROSTAT
	Chair:	**Johan Selenius**, EUROSTAT
	papers:	**Maurice Juma Ogada, Wilfred Nyangena** (Kenya), "Technical Efficiency of Kenya's Smallholder Food Crop Farmers: do environmental factors matter?"
		Adrian Leip, Wolfgang Britz, Claudia Bulgheroni et al. (Italy), "CAPRI: a spatial assessment tool for agri-environmental indicators in the EU"
		Robert Mayo, Carl Obst (FAO), **Gary Jones** (IMF), "Application of the System of Environmental Economic Accounting (SEEA) Central Framework and SEEA Experimental Ecosystems Accounting at FAO: preliminary findings and ongoing work"

11:30 - 13:00	**Technical Session 1.2: IDCB 1 - Indicators on Country Capacity to Produce Agriculture Statistics(*Salvador Dali room*)**	
	Organizers:	**Mukesh Srivastava**, FAO and **Mark R Miller**, USDA/NASS
	Chair:	**Mukesh Srivastava**, FAO
	papers:	**Mukesh Srivastava** (FAO)**, Michael Trant** (Canada), "A Framework for Assessing Country Capacity to Produce Agricultural and Rural" **Oliver Chinganya**, **Vincent Ngendakumana**, **Ben Kiregyera** (Tunisia), "Assessing the Capacity and Needs of Countries to Produce Agricultural Data - the African Experience" **Jairo Castaño** (FAO)**, Anthony Burgard, Allan Nicholls** (Thailand), "Assessing Country Capacity for the Production of Agricultural Statistics in Asia and the Pacific" **Veronica Boero** (FAO), "Countries Capacity to Produce Agricultural and Rural Statistics in Latin America and the Caribbean" **Irina Goryacheva** (CISSTAT), **Giorgi Kvinikadze** (FAO), "Experiences of Initial Country Assessment in the CIS (Commonwealth of Independent States)"
	Technical Session 1.3: SPP 1 - Master Frames for Agricultural and Rural Statistics (*El Greco and Goya room*)	
	Organizer and chair:	**Elisabetta Carfagna**, FAO
	papers:	**Pietro Gennari**, **Piero Demetrio Falorsi, Clara Aida Khalil** (FAO), "An Extension of Indirect Sampling in the Context of Multiple Frame Surveys as a General Approach for Designing Unbiased Sampling Strategies" **Javier Gallego** (Italy), "The Use of a Point Sample as a Master Frame for Agricultural Statistics" **Aberash Tariku Abaye** (Ethiopia), "Master Sampling Frames for Agricultural and Rural Statistics in Ethiopia" **Nomzwakhe Sephoko**, **Limakatso Matsoso**, **Machitja Raphoto**(Lesotho), "Master Sampling Frames for Agricultural and Rural Statistics - experience of Lesotho"
13:00 - 14:30	**Lunch**	
14:30 - 16:00	**Parallel Technical Sessions 2**	
	Technical Session 2.1: APN 2 - Understanding the Nexus Gender - Agriculture through Better Data(*Velasquez auditorium*)	
	Organizer and chair:	**Talip Kilic**, The World Bank
	papers:	**Gbemisola Oseni**, **Paul Corral**, **Markus Goldstein et al.** (USA), "Explaining Gender Differentials in Agricultural Production in Nigeria" **Alberto Zezza** (Italy), "Of Men, Women, and Livestock. Gender Differences in the Ownership and Management of Livestock in Sub-Saharan Africa" **Esha Sraboni, Hazel Malapit, Agnes Quisumbing et al.** (Bangladesh), "Women's Empowerment in Agriculture: what role for food security in Bangladesh?" **Cheryl Doss, Chiara Kovarik, Amber Peterman et al.** (USA), "Gender Inequities in Ownership and Control of Land in Africa: myth and reality"
	Technical Session 2.2: Administrative Data (*Salvador Dali room*)	
	Organizers:	**Jeffrey Smith**, STATCAN and **Marcel Ernens**, EUROSTAT
	Chair:	**Jeffrey Smith**, STATCAN
	papers:	**Phiri Innocent Pangapanga, Shelton Kanyanda, George Kussein et al.** (Malawi), "Economic Constraints in Agricultural Statistics: could administrative data complement agricultural surveys in Malawi National Statistical Systems?" **Daniel G. Beckler** (USA), "Administrative Data Used by the National Agricultural Statistics Service" **A. Reale, M. Riani, M. Greco et al.** (Italy), "Use of Administrative Data for Outlier Detection in the VI Italian Agriculture Census" **Jeffrey Smith, Martin Beaulieu, Erin Smith et al.** (Canada), "Recent Developments in the Use of Administrative Data in the Production of Agriculture Statistics" **Anders Grönvall, Ann-Marie Karlsson** (Sweden), "The Usefulness of Quality Frameworks when Deciding on Replacing Surveys with Administrative Registers - the case of the Swedish sheep register"

14:30 - 16:00	**Technical Session 2.3: SPP 2 - Survey Design and Sampling Strategies for Agricultural Surveys (*El Greco and Goya room*)**	
	Organizers:	**Renee Picanso**, USDA/NASS and **Zelia Bianchini**, IBGE
	Chair:	**Zelia Bianchini**, IBGE
	Discussant:	**Michael Steiner**, USDA
	papers:	**Denis Santos, Marcos Freitas, Maurício Lila et al.** (Brazil), "Brazilian Agricultural Survey System - a description of sampling methods" **Carlos Alberto Rossi** (Argentina), "Redesign of the National Agricultural Survey in Argentina: changes in the sampling frame and data collection" **Mónica Madrid Arroyo** (Colombia), "Statistical Methodologies for Development of Colombian Agricultural Statistical System"
16:00 - 16:30	**Tea/Coffee (Foyer)**	
16:30 - 18:00	**Plenary session 4: Rural Development in the 21st Century: Policy Options and Data Gaps (Velasquez auditorium)**	
	Organizers:	**Gero Carletto**, The World Bank and **Flavio Bolliger**, IBGE
	Chair:	**Gero Carletto**, The World Bank
	Panel:	**Mary Bohman** (ERS/USDA), "Rural Development Policy Issues and Data Needs" **Pietro Gennari** (FAO), "Rural Statistics: Current Gaps and Improvement Perspectives" **William Martin** , "The World Bank and International Association of Agricultural Economists), "Agricultural Statistics for Development" **Maximo Torero** (IFPRI), "Rural Development in the 21st Century: Policy Options and Data Gaps"

Day Two - 24 October

09:00 - 10:30	**Parallel Technical Sessions 3**	
	Technical Session 3.1: APN 3 - Measuring Welfare in Developing Countries in Practice: Beyond Income and Besides Consumption (*Velasquez auditorium*)	
	Organizer and chair:	**Luc Christiaensen**, The World Bank
	papers:	**Rodolfo Hoffmann, Régis Oliveira** (Brazil), "The Evolution of Income Distribution in Brazil: different characteristics of the agricultural sector" **Edoardo Pizzoli, Chiara Piccini, Giuseppe Sacco et al.** (Italy), "Spatial Estimation of Households' Income and Well-Being: applying geostatistics to microdata" **Anoubissi Jean De Dieu** (Cameroon), "Measuring countries welfare" **Isis Gaddis** (Tanzania), **Stephan Klasen** (Germany), "Mapping Multidimensional and Monetary Poverty: the case of Uganda" **Thomas Pave Sohnesen, Luc Christiaensen, Gero Carletto** (USA), "Tracking Poverty via Reduced Consumption Aggregates"
	Technical Session 3.2: IDCB 3 - Carrying out In-Depth Assessment of Agricultural Statistics Systems for Building Strategies for Improvement (*Salvador Dali room*)	
	Organizers:	**Mukesh Srivastava**, FAO and **Mark R Miller**, USDA/NASS
	Chair:	**Mark R Miller**, USDA/NASS
	papers:	**Mukesh Srivastava** (FAO), «Designing the In-depth Capacity Assessments to Produce Agricultural and Rural Statistics" **Mariam ATJ Mapila, Klaus Droppelmann, Isaac Chirwa et al.**(Malawi), "Landscape Analysis of the Agricultural Statistics' Sector in Malawi" **Mwahib Elseid, Nuha Mohamed Ahmed** (Sudan), "Status of Agricultural Statistics in Sudan" **Zhiquan Xu, Wei Zhou** (China), "China's Capacity Assessment to Produce Agricultural and Rural Statistics"

09:00 - 10:30	**Technical Session 3.3: Crop and Yield Forecasting (*El Greco and Goya room*)**	
	Organizers:	**Naman Keita**, FAO, **Nancy Chin**, FAO and **Javier Gallego**, EC/JRC
	Chairs:	**Naman Keita**, FAO and **Javier Gallego**, EC/JRC
	papers:	**Jean Baptiste Habyarimana** (Rwanda), "Crop Yield Estimation with Farmers' Appraisal on Weather Condition" **U C Sud, Hukum Chandra** (India), "On Precise Estimation of Crop Yield at Smaller Area Level by Integrating Agricultural Survey Data and Population Census Data Through Use Of Spatial Models" **Nansubuga Resty** (Uganda), "Reliability of Rainfall for Crop Production - a case study in Uganda" **Bettina Baruth** (EC/JRC), "MCYFS - MARS Crop Yield Forecasting System, Crop Monitoring in Europe"
10:30 - 11:00	**Tea/Coffee (Foyer)**	
11:00 - 12:30	**Parallel Technical Sessions 4**	
	Technical Session 4.1: APN 4 - The Challenges of Measuring Labor and Employment in Developing Economies (*Velasquez auditorium*)	
	Organizer and chair:	**Katheen Beegle**, The World Bank
	papers:	**Blagica Novkovska** (Republic of Macedonia), "Defining and Measuring Non-standard and Informal Employment in Agricultural Sector" **Joachim De Weerdt, Andreas Kutka** (Tanzania), "Urbanisation and Youth Employment in Tanzania: preliminary analysis in preparation of a full paper" **Marcia Quintslr** (Brazil), "New Resolution Concerning Statistics of Work, Employment and Labour Underutilization and Issues on Work in Agriculture Activities and in Rural Areas"
	Technical Session 4.2: IDCB 2 - Enhancing the Credibility of Survey Data through Better Quality Data (*Salvador Dali room*)	
	Organizers:	**Barbara Rater**, USDA/NASS and **Gero Carletto**, The World Bank
	Chair:	**Barbara Rater,** USDA/NASS
	papers:	**Zaza Chelidze** (Georgia), **Barbara Rater, Michael Steiner** (USA) "Improving Data Quality in Agricultural Statistics in Georgia" **Aberash Tariku Abaye** (Ethiopia), "Ethiopian Data Quality Assesement Framework (EDQAF)" **Souleymane Diakité** (Senegal), "Statistical Methods for the Detection of Falsified Data by Interviewers and Application Survey Data in Africa" **Jonathan G. Kastelic** (USA), "Improving Survey Efficacy Through Data Management and Remote Supervision: experience from recent living standards measurement study surveys" **Linda J. Young, Denise A. Abreu, Andrea C. Lamas et al.** (USA), "Identifying, Reducing, and Accounting for Misclassification Errors in Farm Status"
	Technical Session 4.3: SPP 5 - New Developments in Livestock and Fishery Statistics (*El Greco and Goya room*)	
	Organizers:	**Alberto Zezza**, The World Bank and **Flavio Bolliger**, IBGE
	Chair:	**David Babalola**, Nigeria NBS
	papers:	**Guilherme Guimarães Moreira, Marcos Paulo Soares de Freitas, Antonio José Ribeiro Dias et al.** (Brazil), "Fishery Statistical Metodology: onboard fishing" **Sachiko Tsuji, Jennifer Gee** (FAO), "How to Integrate Agricultural Census with Regular Data Collection of Aquaculture and Fishery Statistics" **Carlo Azzarri, Elizabeth Cross** (USA), "Integrating Data from Different Sources: improved spatially-disaggregated livestock measures for Uganda" **Ugo Pica-Ciamarra** (FAO), **Alberto Zezza** (USA), **Derek Baker** (Kenya) **et al.** "Questions that Count: a livestock module for multi-topic household surveys" **Alberto Zezza, Giovanni Federighi** (Italy) "Milking the Data: measuring income from milk production in extensive livestock systems – experimental evidence from Niger"
12:30 - 14:00	**Lunch**	

14:00 - 15:00	**Plenary session 3: Environmental Issues (*Velasquez auditorium*)**	
	Organizers:	**Johan Selenius**, EUROSTAT and **Eszter Horvath**, UNSD
	Chair:	**Eszter Horvath,** UNSD
	papers/speakers:	**Ademar Romeiro** (Unicamp) "Agro-Environmental Indicators and the Challenge to Gauge Non-linear Paths of Ecosystems Degradation: a conceptual approach"
		Dale Andrew (OECD), **Robert Mayo** (FAO), **Johan Selenius**(Eurostat), "Frameworks for Agro-environmental Statistics in Support of Sustainable Development"
15:00 - 16:00	**Poster Session**	
	Organizer:	**Leonardo Maya**, IBGE
16:00 - 16:30	**Tea/Coffee**	
16:30 - 18:00	**Parallel Technical Sessions 5**	
	Technical Session 5.1: APN 6 - Agricultural Prices and Markets (*Velasquez auditorium*)	
	Organizer and chair:	**Jacques Delincé**, EC - Joint Research Centre
	papers:	**Yegnanew Alem Shiferaw** (Ethiopia), "Modeling Volatility of Price of Some Selected Agricultural Products in Ethiopia: ARIMA-GARCH applications"
		Lovemore Nyongo (Malawi), "Maize Price Differences and Evidence of Spatial Integration in Malawi: the case of selected markets"
		Ousmane Badiane, Anatole Goundan, Mahamadou Tankari (Senegal), "Time Path of Price Adjustment in Domestic Markets of Non-tradable Staples to Changes in World Market Prices"
		Abdinardo Oliveira, Júlia Matos, Brenna Souza (Brazil), "Management of Market Risk for Fruits: propositions, analyses and reflections on Juazeiro Producer Market, Bahia, Brazil"
	Technical Session 5.2: Agriculture Structure - Development of a Harmonized Farm Typology for Policy Analysis (*Salvador Dali room*)	
	Organizer and chair:	**Mary Ahearn**, USDA/ERS
	papers:	**Mukesh K Srivastava, Giorgi Kvinikadze, Adriana Neciu** (FAO), "Developing Farm Typologies: for whom and how?"
		Eloi Ouedraogo (FAO), **Ankouvi Mawoudoudji Nayo** (Ivory Coast), "Agricultural Holdings Typology Construction Using Agricultural Census Data: what typology and what variables to be selected for robust typology?"
		Wagner Soares (Brazil), **Steven Helfand** (USA), "Typology of Farmers in the Context of the Preparation of the National Sample Surveys of Establishments Agricultural (PNAG)"
		Katrin Nagelschmitz (Canada), **Hugo Hernandez Ramos** (Mexico), **Mary Ahearn** (USA) et al., "Farm Classification Systems for North American Agriculture"
	Technical Session 5.3: New Technologies for Data Collection for Agricultural Surveys and Statistics (*El Greco and Goya room*)	
	Organizer:	**Mark Harris**, USDA/NASS
	Chair:	**Andrea Lamas**, USDA/NASS
	papers:	**Fenghua Wei** (China), "The Applications of High Technology Measures in China Agricultural Surveys"
		Jaki S. McCarthy, Michael Gerling, Eric Wilson (USA), "Field Data Collection for an Area Frame Survey Using iPads, the USDA's June Area Survey"
		Sarah Nusser, Andrew Vardeman, Alan W. Dotts (USA), "Geospatial Data Collection in the US National Resources Inventory"
		Susana Pérez Cadena (Mexico), "2012 National Agricultural Survey"
20:00	**Social Dinner**	

Day Three - 25 October

Time	Session	
09:00 - 10:30	**Plenary session 2: The Role of Agricultural Censuses (*Velasquez auditorium*)**	
	Organizer:	**Pietro Gennari**, FAO
	paper:	**Naman Keita** (FAO), "Vision for the 2020 round of Agricultural Census"
	Discussants:	**Fred Vogel** (International Consultant), "A new paradigm for agricultural statistics - a world without censuses" **Jean-Michel Durr** (International Consultant), "Lessons for the Agricultural Census from innovations in the Population Census methodology"
10:30 11:00	**Tea/Coffee (*Foyer*)**	
11:00 12:30	**Parallel Technical Sessions 6**	
	Technical Session 6.1: APN 5 - Measuring Contract Farming (*Velasquez auditorium*)	
	Organizer:	**James MacDonald**, USDA/ERS
	Chair:	**Flavio Bolliger**, IBGE
	Discussant:	**Carlos Antonio Moreira Leite** , UFV
	papers:	**Decio Zylbersztajn** (Brazil), "Empirical Research in Contracts: watch your step" **William D. McBride, James M. MacDonald** (USA), "Assessing Production Contracts in U.S. Hog Production" **Marcelo Miele** (Brazil), "Contracts in Brazilian Pork and Poultry Meat Chains: implications for measuring agricultural statistics" **André Bastos, Márcia Moraes** (Brazil), "Vertical Integration and Sugarcane Production Costs in Brazilian Regions"
	Technical Session 6.2: IDCB 6 - Reconciling Data and Integrating Systems (*Salvador Dali room*)	
	Organizer and chair:	**Jacques Delincé**, EC - Joint Research Centre
	papers:	**Pratap Narain** (India), "Integrated System for Food and Agriculture Decision Makers" **Vladimir Bougay** (USA), **Ayca Donmez** (Spain), "Global Agriculture Repository & Africa Food Price Volatility Project" **Vladimir Eskin, Sophie Hélaine, Robert M'barek et al.** (Belgium), "DataM: integrating global agricultural datasets"
	Technical Session 6.3: Census and Dissemination (*El Greco and Goya room*)	
	Organizers:	**Susana Pérez Cadena, Mauricio Rebolledo Loaiza,** INEGI
	Chair:	**Arturo Blancas Espejo**, INEGI
	papers:	**Edmund Kibuuka, Moses Mnyaka** (South Africa), "Agricultural Censuses: importance, challenges and opportunities in the developing world" **Jerzy Banski** (Poland), "The Atlas of Polish Agriculture as an Example of the Use of Statistics for Decision-Making" **Filippo Gheri, Amy Heyman** (FAO), "Efficiency and Effectiveness: the FAO Statistical Yearbook" **Salih Hamza Abu-El-Yamen** (Sudan), "Towards Bridging the Gap between Data Production and Data Utilization" **Mauricio Rebolledo Loaiza** (Mexico), "Agricultural Geo-Statistical Information Query System"
12:30 - 14:00	**Lunch**	
14:00 - 15:30	**Parallel Technical Sessions 7**	
	Technical Session 7.1: APN 7 - Food Security (*Velasquez auditorium*)	
	Organizer and chair:	**Cheryl Christensen**, USDA/ERS
	papers:	**Erdgin Mane, José VallsBedeau, Gary Jones** (FAO), "The Evolving FAO Investment Dataset: statistics on resource flows to agriculture" **Ankush Agrawal, Nilabja Ghosh, Badri S Bhandari** (India), "Availability of Food and Nutrients in India: the food balance sheet approach" **Elisabetta Aurino** (United Kingdom), "Measuring Food Security: a structural equation approach" **Sarah Andrade, Mônica Pires, Valéria, Santos et al.** (Brazil), "Food security: analysis on basic basket´s items prices in the Northeast region of Brazil" **Juliane Perini, Carmem Bocchi, Marconi Sousa et al.** (Brazil), "Data SAN - multidimensional data and indicators for food and nutrition security in Brazil"

14:00 - 15:30	**Technical Session 7.2: Estimates, Forecasts, Expert Opinions and Assessment - their role in the official statistics on agriculture (*Salvador Dali room*)**	
	Organizer and chair:	**Flavio Bolliger**, IBGE
	papers:	**Miguel Galmés** (Uruguay), "Integrating Expert Opinion in Agricultural Statistics" **Hubert Hamer Jr.** (USA), "Weekly Crop Progress and Condition at USDA-NASS" **Naman Keita, Nancy Chin** (FAO), "The Place of ‹Assessment› in Current Agricultural Statistics for Developing Countries: making best use of available information for timely crop production estimates in the absence of a system of agricultural sample surveys" **Elisabetta Carfagna** (FAO), for **Andrea Carfagna** (Independent Consultant), "Appropriate Survey Methods Different Country Profiles - key challenges, gaps and remaining methodological issues"
	Technical Session 7.3: SPP 7 - Remote Sensing Technology (*El Greco and Goya room*)	
	Organizer:	**Jeff Bailey**, USDA/NASS
	Chair:	**Denise Abreu**, USDA/NASS
	papers:	**Francisco Javier Gallego** (Italy), "Alternatives to Medium Resolution Images for Crop Area Estimation: very high and coarse resolution images" **Xinhua Yu** (China), "Using Remote Sensing Cropland Classification Data to Update Area Sampling Frame" **João Henrique Buschin, Otávio Celidonio, Daniel Ferreira et al.** (Brazil), "Measurement of Avoided Deforestation in the Pasture Areas in Mato Grosso" **Mark Harris, Rick Mueller** (USA), "Reported Uses of CropScape and the National Cropland Data Layer Program"
15:30 - 16:00	**Tea/Coffee (*Foyer*)**	
16:00 - 17:30	**Plenary session 5: Food Security: Food Insecurity in the New Development Agenda: global assessment of local inequalities (*Velasquez auditorium*)**	
	Organizer:	**Carlo Cafiero**, FAO/ESS
	papers/speakers:	**Mark Nord** (USDA/ERS), "Lessons from 15 Years of Monitoring Household Food Security in the United States: extension to low-income countries" **Joachim De Weerdt** (EDI), "Measuring Hunger through Household Consumption and Expenditure Surveys" **Carlo Cafiero** (FAO), "Global Monitoring of Food Insecurity in a Policy Relevant Manner: debunking myths and presenting hopes. Lessons from 40+ years of experience at FAO"
17:30 - 18:00	**Closing ceremony and invitation to ICAS-7 (*Velasquez auditorium*)**	
	Chair:	**Michael Steiner**, USDA
	Final remarks:	**Fernando Abrantes**, IBGE **Pietro Gennari**, FAO **Flavio Bolliger**, IBGE

Day after - 26 October

tbd	**Tour on demand**

List of Participants

Events:
1 - ICAS VI
2 - Training for Young Statisticians
3 - ADePT Food Security Module

Event	Name	Institution	Country
1	Abdinardo Moreira Barreto de Oliveira	UNIVASF	Brazil
1	Aberash Tariku Abaye	Central Statistical Agency	Ethiopia
3	Adio Kolawole Samuel	Ministry of Agriculture Benue State	Nigeria
1, 2	Adriana Helena Gama Santos	IBGE	Brazil
1	Adriana Mendes Nogueira de Araujo	IBGE	Brazil
1	Agnes Reynes Quisumbing	International Food Policy Research Institute	USA
1, 2	Ahmed Ebrahim Seid	Centeral Statistical Agency	Ethiopia
1	Alberto Zezza	The World Bank	
1	Álvaro González Villalobos	Academy of Sciences	Argentina
3	Amara Jabbie Sesay	Community Agricultural Development Project	Senegal
1	Ana Lucia Kazan	IBGE	Brazil
1	Ana Nora Feldman	Indec - Instituto Nacional de Estadística y Censos	Argentina
3	Ana Nora Feldman	Indec - Instituto Nacional de Estadística y Censos	Argentina
1	Ana Paula Porfirio Silva	Instituto de Economia Agrícola	Brazil
1, 2	Ana Rosa Pais Ribeiro	IBGE	Brazil
1	Anders Grönvall	Swedish Board of Agriculture	Sweden
1	André Da Cunha Bastos	Universidade Federal de Goiás	Brazil
1	Andrea Lamas	USDA	USA
1	Andreas Heinrich Kutka	EDI/Surveybe	United Kingdom
1	Andrew Henderson	Australian Bureau of Statistics	Australia
1, 3	Angela Kiconco	Uganda Bureau of Statistics	Uganda
2	Angelo Rafael Nascimento Nunes	Ueg	Brazil
1	Ankouvi Mawoudoudji Nayo	ENSEA	Ivory Coast
1	Ankush Agrawal	Indian Institute of Technology Delhi	India
1	Anne Walleser Kepple	FAO-ESS	
1	Ann-Marie Karlsson	Swedish Board of Agriculture	Sweden
1	Antonio Carlos Simões Florido	IBGE	Brazil
3	Aristides Pereira Lima-Green	IBGE	Brazil
1	Arlei Luiz Fachinello	UFSC	Brazil
1	Aryeverton Fortes de Oliveira	Embrapa	Brazil
1	Aurelio Mate Junior	Ministerio da Agricultura	Mozambique
1	Ayodele David Babalola	NBS	Nigeria
1, 3	Azarias Marcos Nhanzimo	National Statistical Institute	Mozambique
1	Balla Keita	CPS/SDR	Mali
1	Barbara Cobo Soares	IBGE	Brazil
1	Barbara Rose Rater	USDA/NASS	USA
1, 3	Beate Barbara Schmidt	Statistics Austria	Austria
3	Bernard Nyakundi Kimoro	Smallholder Dairy Commercialization Programme	Kenya
1, 3	Biratu Yigezu Gutema	Central Statistical Agency	Ethiopia

Event	Name	Institution	Country
1, 3	Blagica Novkovska	State Statistical Office	Republic of Macedonia
1, 2	Breno Augusto Campolina Barbosa	IBGE	Brazil
1, 3	Byron A Reyes	Michigan State University	USA
1	Calogero Carletto	The World Bank	
1, 2	Camiel Pennycooke		Jamaica
1	Camilo José Saavedra	DIEA	Uruguay
1	Carlo Azzarri	IFPRI	USA
1, 3	Carlo Cafiero	FAO	
1	Carlos Alberto Rossi	Indec - Instituto Nacional de Estadística y Censos	Argentina
1, 2	Carlos Alfredo Barreto Guedes	IBGE	Brazil
1, 2	Carlos Carvalho	IBGE	Brazil
1	Carlos Firmino Pedro	NSO	Angola
1	Carlos Mendes da Costa	Instituto Nacional de Estatistica	Guinea-Bissau
1	Carmem Priscila Bocchi	MDS	Brazil
1	Carolina Bremm	Fundação Estadual de Pesquisa Agropecuária - FEPAGRO	Brazil
1, 2	Castilho Bande de Ruben Come	Ministerio das Pescas	Mozambique
1	Catherine Joseph Dangat	Ministry of Livestock & Fisheries Development	Tanzania
1, 2	Chanchal Pramanik	Tata Consultancy Services	India
1	Charles Leyeka Lufumpa	African Development Bank	Tunisia
1	Cheryl Christensen	USDA/ERS/MTED	USA
1	Cheryl R Doss	Yale University	USA
3	Christian Eze Chilaka	The Nigerian Observer	Nigeria
1, 2	Claudio Chagas Figueiredo	Conab	Brazil
1	Cristiano Ferraz	UFPE	Brazil
1, 2	Cyrille Guy Patrick A Mpe Mepoui	Minepat	Cameroon
1	Dale Andrew	OECD	France
1	Daniel Greg Beckler	USDA NASS	USA
1, 3	Daniel Latorraca Ferreira	Instituto Mato-Grossense de Economia Agropecuária	Brazil
1	Dardo Enrique Fagundez	MGAP-DIEA	Uruguay
1, 3	David Makowski	INRA	France
1	David Montero Dias	IBGE	Brazil
1	David Sarfo Ameyaw	Agra	USA
1	Denis Paulo dos Santos	IBGE	Brazil
1	Denise Abreu	USDA	USA
1	Denise Britz do N. Silva	IBGE	Brazil
1	Devotha Antony Mdete	National Bureau of Statistics	Tanzania
1	Dionara Borges Barbosa	MDS	Brazil
1, 2	Edmon Santos Ferreira	IBGE	Brazil
1	Edoardo Pizzoli	ISTAT	Italy
1, 3	Edson Ferreira Lopes	ICNA	Brazil
1	Eliane Gomes	Embrapa	Brazil
1, 3	Elisa Mauro Gomes	IMEA	Brazil
1, 2	Elisabetta Aurino	Oxford University	United Kingdom
1	Elisabetta Carfagna	FAO	
1	Elsa Maria Cardoso Cassandra	INE	São Tomé and Príncipe
1, 2	Emanuela Gracelinda Monteiro Correia dos Santos	Instituto Nacional de Estatística	Cape Verde
1	Emmanuel Jofilisi Mwanaleza	Ministry of Agriculture and Food Security	Malawi
1	Esha Sraboni	International Food Policy Research Institute	Bangladesh
1	Espen Beer Prydz	The World Bank	
1	Fábio Luiz Martins da Silva	Instituto Mato-Grossense de Economia Agropecuária	Brazil
1	Flavia Naiga Oumo	Uganda Bureau of Statistics	Uganda
1	Flavio Pinto Bolliger	IBGE	Brazil
1	Francisco Javier Gallego	JRC-EC	Italy

Event	Name	Institution	Country
1, 2	Franck Cachia	FAO	
1	Frederic Allen Vogel	Fred Vogel Consulting	USA
1	Fuad Ahmadabdalrahman Irteimeh	Department of Statitices (Dos)	Jordan
1, 3	Gbemisola Oseni	The World Bank	
1	Geraldo da Silva E Souza	Embrapa	Brazil
1, 2	Geraldo Noronha Junqueira Filho	IBGE-TO	Brazil
1	Giampaola Bellini	ISTAT	Italy
1	Giuseppina Ruocco	ISTAT	Italy
1, 2	Guilherme Guimarães Moreira	IBGE	Brazil
1, 2	Habekiristos Beyene Haile	Central Statistical Agency	Ethiopia
1, 3	Habtamu Alem Terefe	Norwegian Agricultural Economics Research Institute (NILF)	Norway
1, 3	Haroldo José Torres da Silva	ESALQ/USP	Brazil
1, 2	Henrique Noronha Brito	IBGE	Brazil
1	Hubert Hamer	USDA, NASS	USA
1, 2	Humberto Silva Augusto	IBGE	Brazil
1	Innocent Phiri Pangapanga	National Statistical System	Malawi
3	Isaac Adu Ansere	Sensitization Centre	Ghana
1	Isis Gaddis	The World Bank	
1, 3	Jacques Delincé	European Commission	Spain
2	Jaison Luis Cervi	IBGE	Brazil
1	Jaki Mccarthy	USDA NASS RDD	USA
1, 3	Jean Baptiste Habyarimana	Ministry of Agriculture and Animal Resources	Rwanda
1	Jean De Dieu Anoubissi	Ministry Cameroon	Cameroon
1	Jeff Bailey	USDA NASS RDD	USA
1, 2	Jeffrey Reichman Smith	Statistics Canada	Canada
1	Jerzy Bański	Institute of Geography and Spatial Organization	Poland
1	Joachim de Weerdt	Economic Development Initiatives (EDI)	Tanzania
1	Joao H Buschin	IMEA	Brazil
1	Johan Selenius	Eurostat, European Commission	Luxembourg
1	Jonathan Kastelic	The World Bank	
1, 2	Jorge Andres Labra	Instituto Nacional de Estadistica	Chile
1, 3	Jorge Pinto Filho	SDA -CE	Brazil
3	Jose Carlos Jesus Oliveira	IBGE	Brazil
1	Josef Schmidhuber	FAO	
1	Joseph Ntairo Sserugga	Ministry of Agriculture Animal Industry and Fisheries	Uganda
1, 3	Julia Celia Mercedes Strauch	National School of Statistical Science (ENCE/ IBGE)	Brazil
1, 2	Juliana Bulgarelli Mendes	UFMT - Universidade Federal de Mato Grosso	Brazil
1	Juliane Helriguel de Melo Perini	Ministério do Desenvolvimento Social e Combate à Fome	Brazil
1, 2	Julio Cesar Perruso	IBGE	Brazil
1, 3	Julliet Wanjiku Mwangi	Resakss-Ilri	Kenya
1	Kathleen Beegle	The World Bank	
1, 2	Katrin Nagelschmitz	AAFC	Canada
1	Khaldoun Taha Alaugoul	Statistics Centre - Abu Dhabi	United Arab Emirates
1	Kvinikadze Giorgi	FAO	
1, 3	Leslie Lai	Bill & Melinda Gates Foundation	USA
1	Limakatso Matsoso	Lesotho Bureau of Statistics	Lesotho
1	Linda Young	USDA	USA
1, 2	Lisa Anne O'neill	Statistics Canada	Canada
1, 2	Lovemore Paul Nyongo	Ministry of Agriculture and Food Security	Malawi
1	Luc Christiaensen	The World Bank	
1	Lucas Campio Pinha	Universidade Federal de Viçosa	Brazil
1, 3	Luciana Alves Santos	IBGE	Brazil
1, 2	Luciana Diniz de Oliveira	Conab	Brazil
1	Luis Celso Guimarães Lins	IBGE	Brazil

Event	Name	Institution	Country
1, 2	Mahamadou Roufahi Tankari	IFPRI-Dakar	Senegal
1	Mahmood Abdulrazaq Belselah	Statistics Centre- Abu Dhabi	United Arab Emirates
1	Mantoa Mabele	Bureau of Statistics	Lesotho
1	Marcelo Carauta Montenegro Medeiros Moraes	Embrapa Agrossilvipastoril	Brazil
1, 3	Marcelo Marinho Lacerda Andrade	National School of Statistical Science (ENCE/ IBGE)	Brazil
1	Marcelo Miele	Embrapa	Brazil
1, 2	Marcelo Moraes Duriez	IBGE	Brazil
1, 2	Marcelo Poton Peres	IBGE	Brazil
1, 2	Marcos Thanus Andrade	IBGE	Brazil
1	Maria Auxiliadora da Cruz Fortes	Ministerio do Desenvolvimento Rural	Cape Verde
2	Maria De Fátima Benincaza dos Santos	IBGE	Brazil
1, 3	Marina Aparecida da Silveira	Universidade Federal de Goiás	Brazil
1, 2	Mark Harris	USDA NASS RDD	USA
1	Mark Nord	USDA, Economic Research Service	USA
1	Mark R Miller	USDA/NASS	USA
1, 3	Marta De Oliveira Antunes	IBGE	Brazil
1	Mary Clare Ahearn	Economic Research Service, USDA	USA
1	Mary Elizabeth Bohman	Economic Research Service, USDA	USA
1	Massimo Greco	ISTAT	Italy
1, 2	Mastewal Demil Kassa	CSA	Ethiopia
1, 2	Matieyendou Lamboni	EC-JRC	Italy
1	Maurice Juma Ogada	ILRI	Kenya
1	Mauricio Lila	IBGE	Brazil
1	Mauro André Ratzsch de andreazzi	IBGE/Coagro	Brazil
1	Maximo Torero	IFPRI	USA
1, 2	Maxwell Merçon Tezolin Barros Almeida	IBGE	Brazil
1	Michael Allen Steiner	U.S. Department of Agriculture - NASS	USA
1, 2	Michele Jackeline Rosa	UFMT - Universidade Federal de Mato Grosso	Brazil
1	Miguel Angel Galmes	International Consultant	Uruguay
1	Mlemba Abassy Kamwe	Statistics Office	Tanzania
1, 3	Mohamed Ahmed Barre	FAO	
1	Monica Madrid	Dane	Tanzania
1	Morrice Nyattega Oyuke	National Bureau of Statistics	Tanzania
1, 3	Mukesh Kumar Srivastava	FAO, Bangkok	
1	Mwahib Elseid Osman	Ministry of Agriculture	Sudan
1	Naman Keita	FAO	
1, 2	Narek Suren Vardanyan	ICARE	Armenia
1, 2	Nelissa Jamora	Georg-August-Universität Göttingen	Germany
1, 2	Nelson Americo Afonso	Ministerio das Pescas	Mozambique
2	Nicolau Tadeu Arcaro	IBGE	Brazil
1	Nomzwakhe Sephoko	Lesotho Bureau of Statistics	Lesotho
1	Nsiima Mberwa Longin	Ministry of Livestock and Fisheries Development	Tanzania
1	Nuha Mohamed Elamin Ahmed	Central Bureau of Statistics	Sudan
1, 2	Octavio Costa de Oliveira	IBGE	Brazil
3	Olatunji Tajudeen Abanikannda	Lagos State University	Nigeria
1	Oliver J.M Chinganya	African Development Bank	Tunisia
1, 3	Otávio Lemos de Melo Celidonio	IMEA	Brazil
1, 3	Patrick Mwendalubi Chuni	Central Statistical Office	Zambia
1, 3	Patrick Okello	Uganda Bureau of Statistics	Uganda
1, 3	Paul Maina Guthiga	International Livestock Research Institute	Kenya
1, 2	Paula Marques Meyer	IBGE	Brazil
1, 2	Paulo R B Soares	IBGE	Brazil
1	Paulo Sérgio Mustefaga	CNA	Brazil
1, 2	Peter Anieze Ugwu	Anieze and Co.	Nigeria
1, 2	Phiko Kavinya	Ministry of Agriculture and Food Security	Malawi

Event	Name	Institution	Country
1	Pietro Gennari	FAO	
1	Pratap Narain	Retired officer	India
3	Prince Fidelis Ameh	Bayelsa State Government	Nigeria
1	Priscila Casari	Ufg	Brazil
1	Priscila Koeller Vieira	IBGE	Brazil
1	Rafael Cunha	SEI-BA	Brazil
3	Rafael Kessler Fernandez	IBGE	Brazil
1	Relebohile Augnatus Letele	Lesotho Bureau of Statistics	Lesotho
1, 3	Rennaly Patricio Sousa	University of Ceará	Brazil
1	Resty Nansubuga	Makerere University	Uganda
1	Robert William Mayo	FAO	
1	Roberto Manolio Valladão Flores	Embrapa	Brazil
1, 2	Roberto Soares Duarte	IBGE	Brazil
2	Roberto Wagner Julio	IBGE	Brazil
1	Rodolfo Hoffmann	ESALQ-USP	Brazil
1, 3	Rosana Salles Costa	Instituto de Nutrição/UFRJ	Brazil
1, 3	Rosemeire Cristina dos Santos	Confederação da Agricultura e Pecuária do Brasil	Brazil
1	Salih Hamza Abu El Yamen	Central Bureau of Statistics	Sudan
1, 3	Salou Bande	INSD	Burkina Fasso
1	Sâmela Batista Arantes	IBGE	Brazil
1	Sami Dhawi Al Ryami	DRC	Oman
1	Samia Zekaria Gutu	Central Statistical Agency	Ethiopia
1, 3	Sarah Farias Andrade	Universidade Estadual de Santa Cruz	Brazil
1	Sarah Nusser	Iowa State University	USA
1	Serge Kamgaing	Ministry of Agriculture and Rural Development	Cameroon
1, 3	Seth Natseli Mayinza	Uganda Bureau of Statistics	Uganda
1, 3	Sidney Nii Oko Bampoe Addo	Statistics, Research and Information Directorate, Ministry of Food and Agriculture	Ghana
1	Sonia Albieri	IBGE	Brazil
1	Souleymane Diakite	ENSAE-Dakar	Senegal
1, 3	Sri Hartini Rachmad	BPS Statistics Indonesia	Indonesia
1, 3	Stanley Wood	Bill & Melinda Gates Foundation	USA
1	Stephen Gahwera Bahemuka	Africa Development Bank	Kenya
1	Talip Kilic	The World Bank	
1	Tanise Dias Freitas	UFRGS	Brazil
1, 2	Telma Tompson	IBGE	Brazil
1	Thomas P Sohnesen	The World Bank	
1, 3	Tiago Pellini	Agricultural Research Institute of Paraná - IAPAR	Brazil
1, 3	Titus Titus Mwisomba	National Bureau of Statistics	Tanzania
1	Ugo Pica-Ciamarra	FAO	
3	Umekwe Jude Orji	Ministry of Agriculture Benue State	Nigeria
1	Umesh Chander Sud	IASRI, New Delhi	India
1, 3	Vagner Azarias Martins	Instituto de Economia Agrícola	Brazil
1, 3	Veronica Boero	FAO	
1, 3	Vincent Ngendakumana	AFDB	Tunisia
1	Vladimir Bougay	Knoema	USA
1	Vladimir Eskin	Prognoz	USA
1, 2	Wagner Lopes Soares	IBGE	Brazil
1, 3	Waltuir Batista Machado	Faculdade Alfredo NASSer	Brazil
1, 2	Wei Zhou	National Bureau of Statistics of China	China
1	William D Mcbride	USDA-ERS	USA
1	William Holmes Wigton	AAIC	USA
1, 2	Xinhua Yu	National Bureau of Statistics of China	China
1	Yegnanew Alem Mr Shiferaw	University of Witwatersrand	Ethiopia
1	Ylva andrist Rangel	Statistics Sweden	Sweden
1	Zaza Tchelidze	National Statistics Office of Georgia (Geostat)	Georgia

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Statistical Production Process (SPP)
Analytical and Policy Needs (APN)

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