Global Strategy
IMPROVING AG-STATISTICS

Implementation of the Research Plan
July 2013

This document describes the status of implementation, as at July 2013, of the research plan of the Global Strategy to Improve Agricultural and Rural Statistics.

The summary table below aims at assisting the members of the Scientific Advisory Committee in reviewing the documents provided to them.

As agreed at the meeting of the SAC, keeping in mind that the final aim of the research is developing guidelines for enabling developing countries to adopt improved cost-efficient methodologies for producing agricultural and rural statistics, the members of the SAC will:

- Assess the relevance and quality of the documentation developed so far (literature reviews, concept notes, draft handbook);
- Highlight the areas of incompleteness of the literature reviews (if any);
- Advise on the list of specific research items to be addressed;
- Prepare a report including their comments and advices to be sent to the research coordinator.

Some research topics are grouped in thematic domains; e.g., the research topics "Methodological development for internationally comparable environmental-economic accounts for agriculture (Conceptual framework SEEA – Agri)" and "Integrated survey framework for Agricultural Statistics" are grouped under the thematic domain "Framework for agricultural statistics".

	RESEARCH TOPICS	What will be the ultimate product to which this research will contribute?	Documentation available
	Framework for agricultural statistics The work under this thematic domain aims at providing frameworks for integration of agricultural statistics with the perspective of national account and data collection perspective. Therefore, two research topics are conducted: (i) defining a conceptual framework (SEEA-Agri) and (ii) an integrated survey framework		
	• **Methodological development for internationally comparable environmental-economic accounts for agriculture (Conceptual Framework - SEEA-Agri)**	**Technical guidelines on compiling SEEA-Agri**	**Concept note (Mayo)**
	• **Integrated survey framework for Agricultural Statistics**	**Technical guidelines on integrated survey framework in different country contexts**	**Concept note (Falorsi)**
	Improved methodologies for master sampling frames	**Methodological guidelines on building**	

	The purpose of this thematic domain is to develop methodologies on building a cost-effective and sustainable master sampling frame in different country contexts as basis for selecting probability based samples which allow collecting data concerning the land, the farms and the households, for producing agricultural and rural statistics. • **Identifying the most appropriate master sampling frame for the various typologies of countries** • **Improving methods for linking area frames with list frames** • **Improving the use of GPS, GIS and RS for setting up a master sampling frame**	**and maintaining master sampling frames according to country typologies** **Specific guidelines on the use of GPS, GIS and RS for setting up a master sampling frame (2013)**	**Literature review (Ambrosio)** **Literature review (Ferraz)** **Literature review (Iglesias)**
	Improving methods for estimating cost of production in developing countries The purpose of this research topic is to develop methodologies and practical applications for cost of production data collection and analysis The activities for this research topic were initiated in 2012 and a first draft handbook has been prepared.	**Handbook on methods for estimating cost of production in developing countries (2014)**	**Draft handbook**
	Improving methods for estimating livestock and livestock products The aim of this research topic is improving the methods for collecting data on livestock, including cattle, sheep, pigs, goats, and poultry. • Partnership is being discussed with a Gates funded livestock project for building on the results and findings of this project and expanding the scope of the research in 2014. • In 2013, a preliminary draft guidelines initiated by FAO on the enumeration of nomadic and semi-nomadic (transhumant) livestock will be expanded, finalised and published.	**Guidelines on the estimation of livestock and livestock products** **Handbook on enumerating Nomadic and Semi-nomadic livestock (December 2013)**	**Draft handbook**
	Improving methods for estimating post harvest losses	**Guidelines on estimation of post-**	**Literature review (Aulakh and Regmi)**

	The research analyzes the main factors which influence post harvest losses, in order to identify the most appropriate methodology for estimating them. The focus is on cereals and main root crops and the first phases of the food chain (mainly storage by the farmers).	**harvest losses, focusing on cereals and main root crops and the first phases of the food chain**	
	Improving methods for crops estimates The aim of this thematic domain is developing cost-effective methods for more accurate estimation of crop area, yield and production in different agricultural systems and for different types of crops. • **Improvement of estimation of crop area, yield and production** • **Improving methods for estimating crop area, yield, production of <u>mixed crops, repeated and continuous cropping</u>** • **Developing methods for estimating yields of <u>root crops</u>**	**Comprehensive guidelines on crop area, yield and production estimation, with focus on developing country context and for different type of crops**	**Literature review (Graig, Hanuchak and Basso)** **Documentation on test being conducted by LSMS project in Zanzibar for estimating Cassava production**
	Improving the methodology for using Remote Sensing The aim of this thematic domain is developing a methodological publication to clarify how remote sensing data should be used in order to increase the efficiency of estimates of agricultural parameters, including stratifications based on land cover maps created for mapping or monitoring of land cover, taking into account the characteristics of upcoming satellites and the cost-efficiency of remote sensing data in developing countries. • **Developing more efficient and accurate methods for using remote sensing** • **Evaluating the cost-efficiency of remote sensing in developing**	**Methodological publication on the use of remote sensing for producing agricultural statistics**	**Literature review (Benedetti)**

	countries • **Improving methods for using existing land cover – land use data bases**		**Literature review (Latham, Rosati)**
	Adoption of new technology for field data capture, compilation, transfer and dissemination A prototype package for Computer Assisted Personal Interview (CAPI) and similar digital devices is being developed by the Wold Bank/LSMS in partnership with the FAO Global Strategy. This work will produce a free access software to be used by countries for their data collection activities using new digital technology.	**The release of a first version of both the designer and data management system (2013)**	**PPT prepared by LSMS project**
	Improving quality and use of administrative data to produce agricultural statistics This research will aim at developing methods for assessing and improving the quality of administrative data and using them in an integrated agricultural statistics system combining census, surveys and administrative data.	**Guidelines on improving and using administrative data in an integrated agricultural statistics system**	**Concept note (Keita)**
	Improving methodology of food balance sheets The work will lead to improved methods for compiling food balance sheets that can be applied by countries.	**Technical Guidelines on improved methods for compiling Food Balance Sheets**	**Concept note (Prakash)**
	Improving methodology for small scale fishery This research will develop appropriate methods for data collection and estimation for small scale fisheries and aquaculture.	**Guidelines on methods for data collection and for production of statistics for small scale fishery and aquaculture**	**Literature review (Tsuji and GEE)**
	Better integration of geographic information and statistics This thematic domain addresses the need to improve the methods for taking advantage of geographic information for producing agricultural statistics in the field of data collection, analysis and dissemination and for connecting statistical data collected through sample surveys (which can be represented by points in the space) and other kinds of geo-referenced data (polygons and lines).		

	Developing robust and statistically based methods for spatial disaggregation and for integration of various kinds of geographical information and geo-referenced survey data The methodological publication that will be developed at the end of this research will clarify how to take advantage of the spatial information of geo-located sample surveys and of spatial auxiliary variables for producing agricultural and rural statistics and assessing their accuracy.	**Guidelines on integration of spatial information of geo-located sample surveys and spatial auxiliary variables for producing agricultural statistics**	**Literature review (Pratesi and Petrucci)**

STATUS OF IMPLEMENTATION OF THE RESEARCH TOPICS INCLUDED IN THE WORK PLAN FOR 2013 AND SPECIFIC ITEMS TO BE ADDRESSED

The programme of research activities for 2013 was discussed at the high level meeting held in FAO Headquarters in December 2012 and was approved by the Global Steering Committee in February 2013.

For all research topics, the plan of action has been defined and relevant information concerning ongoing or already completed research activities has been collected.

Moreover, for 10 of these research topics, also the following activities have been carried out, in line with the time schedule:

- the partnerships have been established and the activities of the partners have been coordinated;
- the relevant literature has been identified and reviewed and the reports have been prepared;
- the gap analysis has been conducted in order to identify the specific research items to be addressed for each research topic.

The 10 research topics are:

3.2.1 Identifying the most appropriate master sampling frame for the various typologies of countries;

3.2.2 Improving methods for linking area frames with list frames;

3.2.3 Improving the use of GPS, GIS and RS for setting up a master sampling frame;

3.3 Improving methods for estimating cost of production in developing countries (a draft handbook has also been developed);

3.5 Improving methods for estimating post harvest losses;

3.6.1 improvement of estimation of crop area, yield and production;

3.7.1 Developing more efficient and accurate methods for using remote sensing;

3.7.3 Improving methods for using existing land cover – land use data bases;

3.11 Improving methodology for small scale fishery;

3.12.1 Developing robust and statistically based methods for spatial disaggregation and for integration of various kinds of geographical information and geo-referenced survey data.

For these research topics, the following main activities will be carried out in the next months of 2013:

- analyse remaining methodological issues and propose possible solutions;
- organize a workshop on the results of these activities;
- test the proposed methodological improvements (where appropriate, field tests will be designed and conducted)

Activities to be carried out in 2014:

- prepare technical reports on findings and recommendations for possible solutions to methodological issues;
- submit the technical reports to peer review and validation;
- disseminate the results;
- finalize a methodological publication.

For the research topics "3.6.3 Developing methods for estimating yields of root crops" and "3.8 Adoption of new technology for field data capture, compilation, transfer and dissemination", in order to create synergies, an agreement has been reached with the World Bank. Specifically, for the topic "3.6.3 Developing methods for estimating yields of root crops", after a literature review concerning data collection issues, the field tests on cassava have been designed and will be carried out in 2014. For the topic "3.8 Adoption of new technology for field data capture, compilation, transfer and dissemination", in 2013, a prototype for Computer Assisted Personal Interview (CAPI) is being developed.

For the following research topics, a concept note has been developed and the partnerships have been established:

3.1.1 Methodological development for internationally comparable environmental-economic accounts for agriculture (Conceptual framework SEEA – Agri);

3.1.2 The Integrated survey framework (for this topic, the concept note includes a brief literature review).

For the following research topics, the partners have been identified but the partnerships have not been established yet:

3.6.2 Improving methods for estimating crop area, yield, production of mixed crops, repeated and continuous cropping;

3.7.2 Evaluating the cost-efficiency of remote sensing in developing countries;

3.9 Improving quality and use of administrative data to produce agricultural statistics;

3.10 Improving methodology of food balance sheets.

Due to the delay in the identification of the partner, likely most of the activities foreseen in 2013 will be postponed to 2014 for the research topic 3.4 Improving methods for estimating livestock and livestock products.

Identifying the most qualified partners, possibly from developing countries, which can contribute to the implementation of the research topics foreseen in the work plan for 2013 has presented some difficulties, since some of them are not available at the moment.

The administrative work for establishing the partnerships has been long and complex. Contractual arrangements are very time consuming, particularly at the initial stages of the partnership. This has delayed the implementation for several research topics.

The research activities contribute to the achievement of the output 3 of the logical framework of the Global Strategy to Improve Agricultural and Rural Statistics "New cost effective methods for data collection, analysis and dissemination developed and disseminated".

As a result of the literature review and the gap analysis, for each research topic, the specific research items to be addressed have been identified and are listed for each research topic, in order to give a detailed overview of the content of the research that will be carried out in the next months.

Output 3 - New cost effective methods for data collection, analysis and dissemination developed and disseminated	
3.1	**Framework for agricultural statistics** This thematic domain is constituted by two research topics: • Methodological development for internationally comparable environmental-economic accounts for agriculture (Conceptual framework SEEA – Agri) • Integrated survey framework for Agricultural Statistics **3.1.1 Methodological development for internationally comparable environmental-economic accounts for agriculture (Conceptual framework SEEA – Agri)** The conceptual framework (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 universally valid, 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 System of National Accounts (SNA); • Providing a consistent, comprehensive, and coordinating framework to link data collected by different surveys and censuses 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, Energy, etc.).

The collaboration has been agreed with Carl Obst, Australia and other FAO Divisions on the following topics: forestry, fishery, land, water, energy and agriculture.

The activities for this thematic domain were foreseen to initiate in 2012 and to be completed in 2013. In fact, the implementation is initiated in 2013 and will be finalized in 2014.

Specific research items to be addressed:

- Agree on general analytical directions
- Determine relevant SEEA accounts and appropriate level of detail
- Select a pilot country(s) (one of the target countries of the Global Strategy)
- Populate as far as possible selected accounts using available FAO data
- Data gaps, some data confrontation
- Compare the data needs of SEEA with the minimum set of core data of the Global Strategy to Improve Agricultural and Rural Statistics
- Identify other data sources
- Review and discuss findings
- As appropriate expand to other countries
- Consider possible resolution of data issues.

3.1.2 The Integrated survey framework for agricultural statistics

This research topic focuses on the strategic objective of producing integrated and consistent agricultural statistics on phenomena related to three different target populations, the units of which are respectively:

- agricultural plots (for what concerns the environmental aspects);
- households (for the social aspect);
- farms (for the economic dimension).

The stress on integration allows achieving a better coverage of specific statistics for which a suitable solution cannot be found by surveying only a specific unit. The research focuses mainly on:

- sampling design methods (how to collect the data of interest);
- estimation methods (how to produce estimators of the target parameters using existing data);
- quality framework.

The research topic is being implemented with the support of researchers from the Mozambique National Institute of Statistics, the Italian National Institute of Statistics and the University la Sapienza of Rome.

A first research report on a conceptual note for integrated survey framework has been released and discussed in a internal seminar at FAO.

It is expected to release the first version of guidelines at the end of January 2014.

Some presentations describing the first research results have been submitted and accepted in some scientific meetings:

- ISI meeting (end of august);

	• ICAS IV (end of October); • Symposium of Statistics Canada on imperfect frames (December). The activities for this thematic domain were foreseen to initiate in 2012 and to be completed in 2013. In fact, the implementation is initiated in 2013 and will be finalized in February 2014. Specific research items to be addressed: • Definition of a quality framework related to the overall process in the integrated survey framework; • Optimal sampling design which best fits the various national informative contexts; • Integrating survey data which share some common statistical units and typologies of units using a probabilistic approach; • Multi-surveys approach: guidelines on integrated estimation combining different surveys through dynamic weighting and/or projection estimator; • Multiple purpose approach in periodic surveys: longitudinal estimation in integrated framework via parametric and non-parametric modelling; • Estimation methods accounting for the uncertainty in the integration of sources related to different units and typologies of units; • Development open source R software tools for the estimation methods accounting for the uncertainty in the integration of sources related to different units and typologies of units.
3.2	**Improved methodologies for master sampling frames** The master sample frame is the sampling frame to be used for selecting probability based samples which allow collecting data concerning the land, the farms and the households, for producing agricultural, rural and social statistics. According to the characteristics of the country (kind of agriculture, statistical system, landscape, size of farms and fields etc.) different approaches are the most reliable for producing agricultural and rural statistics. The main ones are: sample surveys based on the list of farms (in case a complete and updated list of farms is available) and sample surveys based on area frames. The optimal approach is combining the area frame with the list frame while building the frame (geo-referencing the parcels of land of the farms). However, in countries where the list of the farms is out of date and the parcels are not geo-referenced, this approach cannot be followed and a feasible alternative is combining estimates obtained from an area frame with the ones produced through a short list of large, commercial farms. The kind of area or list frame, the way of linking list and the area frames, the way of using the geographic information varies according to the specific situations and the aim of the research is improving these methods. Thus the following research topics have been identified: • Identifying the most appropriate master sampling frame for the various typologies of countries; • Improving methods for linking area frames with list frames; • Improving the use of GPS, GIS and RS for setting up a master sampling frame. The methodological publication that will be delivered at the end of the research on this thematic domain will clarify, according to the typology of country, what a kind of masters sampling frame is appropriate, how to build it, taking advantage of the

technological development, and how to link the different kinds of frames at the design level or at the estimator level.

3.2.1 Identifying the most appropriate master sampling frame for the various typologies of countries

The research identifies the most appropriate master sampling frame for the different typologies of countries, according to the kind of agriculture, statistical system, landscape, size of farms and fields, kind of physical boundaries, etc. Several kinds of frames have been developed in the last decades: lists frames, area frames constituted by parcels of land, with physical or regular, theoretical boundaries (generally generated by regular grids), rectangular parcels called transects, very small circles called points, clusters of points, and so on.

Collaboration has been set up with Javier Gallego, Joint Research Centre and Luis Ambrosio, University of Madrid, Spain.

The report on the review of related projects and literature has been completed, as well as a database of relevant documents, classified according to their main characteristics (methodological papers, case study, project reports, etc.).

Specific research items to be addressed:

- Identifying the kind of master sampling frame to be used under the different characteristics of the countries, e.g.:
    a. availability of a recent census of agriculture with good coverage
    b. availability of a recent census of agriculture with low coverage
    c. availability of a recent sample census of agriculture
    d. availability of a recent population census with a few questions on agriculture (Guidelines for Linking Population and Housing Censuses with Agricultural Censuses, FAO and UNFPA, 2012 http://www.fao.org/docrep/015/i2680e/i2680e.pdf)
    e. availability of administrative data and their quality
    f. average level of education
    g. level of informal economy
    h. kind of key variables
- Where to use a list frame;
- Where to use an area frame with physical boundaries;
- Where to use other kinds of area frames (square segments, transects, points) and number of sampling stages;
- Where to select farms through an area frame;
- Efficiency of selection of farms from an area frame in the different conditions (farmers' houses spread in the rural areas or grouped in large villages, etc.), e.g. time needed for identifying the farmer, reliability of personal interview showing the fields on a geographical support, amount of missing data etc., and comparison with selection from list frames;
- Efficiency of selection of farms, through clustered or un-clustered point sampling (e.g. farms selected through points from sampled area segments, problem of points on non utilized agricultural area (see Gallego F.J., Delincé J., Carfagna E. (1994) Two-Stage Area Frame Sampling on Square Segments for Farm Surveys. Survey Methodology, vol. 20, No. 2 , pp. 107-115.); time needed for identifying the farmer;
- Improvement of methods for estimating the spatial variability of the key variables,

including the comparison between the estimate of the overall spatial variability for the key variables and the estimate of the spatial variability for each key variable and identification of the compromise solution at a second stage.

3.2.2 Improving methods for linking area frames with list frames

The research identifies the most appropriate list frames for the different categories of countries and improves the methods available in the literature for combining area frames with list frames at the frame level, as well as at the estimator level; taking into consideration the different kinds of area and list frame which can be the most appropriate for the different kinds of countries.

Collaboration has been set up with Cristiano Ferraz, Federal University of Pernambuco, Brazil.

The report on the review of related projects and literature has been completed, as well as a database of relevant documents, classified according to their main characteristics (methodological papers, case study, project reports, etc.).

Specific research items to be addressed:

- In which categories of countries to use an area frame with physical boundaries linked, at the design level, before selecting the sampling units, with the geo-referenced farms and households from the list and evaluation of its cost-efficiency;
- In which categories of countries to produce estimates from an area frame with physical or theoretical boundaries combined with estimates derived from one or more lists of commercial of special farms, at the estimator level (multiple frame approach);
- Using the list of farms generated by the population census with a few questions on agriculture (coverage of the list, availability of auxiliary variables for stratification);
- Analysis of the contribution of different frames for different categories of countries;
- Identification of the optimum size of the list frames in a dual or multiple frame approach;
- Optimal combination of the estimates from the different domains and compromise solution;
- Comparing the efficiency and practical issues of the dual and multiple frame estimators (including the screening estimator);
- Optimum allocation of the sample to the different frames, for each of main variables, given the cost functions and the efficiency of each frame;
- Compromise solution for the allocation of the sample to the different frames;
- The use of permanent random numbers for coordinating sampling from multiple frames;
- Incorporating auxiliary information into multiple frame estimators;
- Using multiple probability proportional to size (MPPS) for each frame;
- Impact of MPPS on multiple frame estimators;
- Model based sampling in multiple frame approaches;
- Multi-level and spatial-time models in multiple frame approaches;
- Impact of model based sampling on multiple frames estimators (efficiency, robustness, etc.);
- Combining registers with list and area frames.

3.2.3 Improving the use of GPS, GIS and RS for setting up a master sampling frame

The traditional approach to set up an area sampling frame was based on collection of printed maps and aerial photographs (not always ortho-rectified) and involved a large amount of manual work. Current technologies, in particular the ability of GIS to efficiently handle different layers of geographic information, in particular RS-based thematic maps, have made this task much lighter. Stratification for example can be performed in a more efficient way. The evolution of Global Positioning System (GPS), with sufficiently accurate devices at affordable prices, has substantially changed the field work more than the definition of a sampling frame, but both aspects cannot be separated, because the choices in the definition of the sampling frame need to take into account the field survey aspects.

Research is being conducted for improving the use of GPS, GIS and remote sensing for setting up a master sampling frame for integrated survey for the various categories of countries, according to the landscape, the economic structure, the size of farms, the spatial distribution of important crops and livestock species, and the kind of data sources available in the country.

A collaboration has been set up with Luis Iglesias, University of Madrid, Spain.

The report on the review of related projects and literature has been completed, as well as a database of relevant documents, classified according to their main characteristics (methodological papers, case study, project reports, etc.).

The implementation of this research topic will be completed at the end of 2013.

Specific research items to be addressed:

- Improving the methods for using GPS, GIS and remote sensing for linking different frames, in order to create a master sampling frame;
- Identifying the appropriate stratification for different kinds of frame, including area frames (primary sampling units and segments with physical boundaries, segments with theoretical boundaries, clustered and un-clustered point sampling), according to the key variables and precision requirements, when the land cover data base is developed on purpose;
- Identifying:
    - suitable sensors, taking into consideration upcoming satellites;
    - appropriate data acquisition calendar, based mainly on the type of crops and their calendar;
    - appropriate spectral and spatial resolutions;
    - land use/ land covers information analysis techniques for MSF construction;
    - Automatic extraction of permanent physical boundaries;
- Evaluating the impact of the use of GIS / GNSS -(GNSS/GPS-PDA-TABLET)
    - Impact of GPS, GIS and CAPI on data collection, analysis and dissemination for the different kinds of frames (geo-location, surfaces measurement, geo-coding list frames elements):
    - Cost effectiveness of the use of GPS, GIS and CAPI for data collection;
    - Use of photo-interpreted images as basis for ground data collection (only changes to be drawn);
    - Accuracy and cost-efficiency of the use of GPS, GIS and CAPI for data collection for the different kinds of frames (lists and the various kinds of area frames);
    - Data analysis of agricultural variables that can be performed if geo-referenced data have been collected;

	• Use of GPS for point sampling.
3.3	**Improving methods for estimating cost of production in developing countries** The importance of rural economy is very high in several developing countries and the economical sustainability of the farms, particularly in a period of price volatility, is strictly linked to their cost structure. Though most developed countries produce estimates on cost of production, coverage in developing countries is low, with only 21 having reported in a 2011 FAO questionnaire that they had past experience or future plans in this domain. The objectives of this research focuses on development of methodologies and practical applications for cost of production data collection and analysis, taking into account the different institutional and statistical collection capacities of countries as well as the structure of the agricultural sector (e.g. data collection capacities and experience including availability of an updated list frame of farms, level of informal economy in the country etc.). The activities for this research topic were initiated in 2012, and a draft handbook on best practices has been produced and discussed with several countries in a meeting held in Vietnam to enable exchange of experience and good practices. The draft handbook is currently being reviewed by a small group of experts, and will be revised based on field tests to be implemented in 2014. The literature review has been carried out by the Joint Research Centre as in-kind contribution. The final handbook will be delivered by the end of 2014. Specific research items to be addressed: • Advantages and disadvantages of integrated vs. stand-alone survey systems; • The possibility and capacity to use sources other than survey data (administrative data, farm diaries, etc.); • Capacity to implement appropriate estimation methods for cost items such as labour costs and other opportunity costs; • Allocation of joint costs (overhead costs, fixed capital, joint products, etc.); • Frequency of data collection, and imputation of owned inputs (family labour, inputs produced on the farm, etc.). • Guidance on analytical uses of CoP data and construction of derived economic indicators, micro, macro, meso, research (also AEI, GHG); *and* • Potential development of an easy-to-use, modular, scalable, flexible, open source software platform for CoP data compilation at the country level.
3.4	**Improving methods for estimating livestock and livestock products** The aim of this research topic is improving the methods for collecting data on livestock, including cattle, sheep, pigs, goats, and poultry, because livestock production is a major contributor to food supply and income. Consumption increases as countries develop, therefore resulting in more livestock consuming grain and adding to methane emissions. Accurate estimation of livestock numbers and production is a challenge in many countries, particularly in Africa because of the nomadic and semi-nomadic livestock systems. Social constraints also create difficulties in obtaining accurate numbers on livestock in pastoral

	societies and estimation of livestock products, especially with regards to small animals. After a careful analysis, till now we have not found a partner from a developing country who can give an important contribution to the implementation of this research topic and is available, in these months. Due to the delay in the identification of the partner, likely most of the activities foreseen in 2013 will be postponed to 2014. In 2013, the guidelines previously initiated by FAO on the enumeration of nomadic and semi-nomadic (transhumant) livestock are being finalized. This is one of the quick wins mentioned in the Action Plan of the Global Strategy.
3.5	**Improving methods for estimating Post harvest losses** Quantitative food losses refer to the decrease in edible food mass available for human consumption throughout the different segments of the supply chain. In addition to quantitative losses, food products can also face a deterioration of quality, leading to a loss of economic and nutritional value. Post harvest losses can have a strong impact on food security in several developing countries. The research analyzes the main factors which influence post harvest losses in order to identify the most appropriate methodology/methodologies for estimating them. Collaboration has been established with Robert VanOtterdijk, FAO – AGS, the Economic Research Service of the United States Department of Agriculture (ERS) and Joint Research Centre. ERS, in partnership with Purdue University has prepared a report on the review of related projects and literature (Jaspreet Aulakh – Purdue University and Anita Regmi – formerly of ERS). This report is the basis for identifying the strengths and weakness of methodologies and gaps to be filled through further research. Specific research items to be addressed: • Develop a database with identified ongoing and already completed research activities (operational and prototype projects), peer reviewed papers and books concerning methods for estimating post harvest losses, with particular reference to cereals and main root crops and for the first phases of the food chain (mainly storage by the farmers); • Assess applicability in developing countries of developed methods; with particular reference to costs, skills and organization requirements; • On the basis of the critical analysis and the identification of advantages, disadvantages, requirements and limitations of the methods proposed in the literature, outline the research gaps for estimating post harvest losses, with particular reference to cereals and main root crops and for the first phase of the food chain (mainly storage by the farmers); • Create a data base of sets of survey data (from measurements and interviews) collected through operational and prototype projects and analyze these data sets, in order to identify the main factors which influence post harvest losses in different typologies of countries; • In order to take into account cost constraints, assess the reliability of interviews against

	objective measurement, used as benchmark, and explore the capacity of statistical models to produce estimates of post harvest losses; • Formulate an initial proposal for a methodology for estimating post harvest losses to be reviewed by experts; • Design and conduct empirical studies for testing the proposed methodology.
3.6	**Improving methods for crops estimates** The problem of estimating the area, the yield and thus the production of crops still has not a satisfactory solution. The problem becomes even more difficult to solve in case of mixed crops, repeated and continuous cropping and when the yield of root crops has to be estimated, like for the very important crop cassava. At early stages of the growing season, the acreage of crops is often estimated through a mixture of data sources, including interviews on sowing intention and multi-temporal classification of remote sensing data. The limitations of each of these methods for given conditions have not been sufficiently analysed, in particular the potential bias and subjectivity. Often, yield forecasting and early warning are based on agro-meteorological models, which generally involve regression analysis of time series of ground data and official statistics and sometimes various kinds of remote sending data. At later stages, ground observations, through area or list frames or farmers interviews are used for estimating the area and the yield of crops. The result of the research of this thematic domain will be improved methodologies for forecasting and estimating area, yield and production of important crops in developing countries, at different stages of the growing season, taking into consideration the different kinds of crops and typologies of countries. **3.6.1 improvement of estimation of crop area, yield and production** The aim of this research topic is improving the methods for: • Estimating the area of crops at the different stages of the growing season. These methods are based mainly on ground observations, sometimes combined with remote sensing data or farmers interviews; • Estimating the yield of crops at the different stages of the growing season, taking into consideration the specific problems posed by the different kinds of crops. These methods are based mainly on ground observations and time series regression models (e.g. regression models based on the number of ears per plot etc.), sometimes combined with remote sensing data or farmers interviews; • Yield forecasting (mainly agro-meteorological models) and early warning (mainly early warning systems). These methods are generally based on interpolation and integration of meteorological data, data on soil, sowing date, e.g. models which combine evapo-transpiration models, like Penman's model, yield time series, vegetation indexes, like NDVI. Generally, these models are not based on extensive collection of yield data on the ground and generally involve remote sensing data. For the sub-topic 1, collaboration with Mike Craig, USDA, USA has been established, for the sub-topic 2, with George Hanuschak, USDA, USA and for sub-topic 3 with Bruno Basso, Michigan State University, USA. For each of the 3 sub-topics, the report on the review of related projects and literature has

	been completed, as well as a database of relevant documents, classified according to their main characteristics (methodological papers, case study, project reports, etc.). Specific research items to be addressed for area and yield estimation: • Identification of most efficient area frame for estimating yield and production of main crops, including cost considerations (travel and observation costs) for different categories of countries (including the kind of infrastructures in the country); • Development of efficient sample designs for estimating yield and production of main crops; • Proposing efficient estimators for area and yield (particularly at the early stages of the growing season); • Space - time models for area and yield estimation • Optimum rotation of sampling units for space time models • Analysis of model based sample designs adopted for estimating area and yield of main crops and their improvement; • Analysis of models commonly adopted with respect to efficiency and robustness; • Assess applicability, in developing countries, of regression models based on the number of ears per plot etc., for yield forecasting at initial stages of growing season (need to create time series on data in order to estimate the parameters of the models); • Methods for quality control in all phases of statistical process; • Reliability of farmers declarations, according to kind of crops, size and other characteristics of farms; • Assess the feasibility of using crop cutting as benchmark for farms declarations and extension workers guesses; • Estimation of bias of crop cutting; • Requirements of crop cutting (organization, laboratories, etc.); • Testing data of peaceful drones; • Model based sample designs; • Use of previous data for model estimation; • Impact on model based sample designs of inappropriate model; • Multiple Probability Proportional to Size (MPPS) sample design: analysis of the method, theoretical and practical implications of its use, advantages, disadvantages and requirements; Specific research items to be addressed for yield forecasting: • Identify the kind of yield forecasting model and early warning system which can be developed, according to the type of available data (weather, soil, remote sensing etc.); • Assess reliability and applicability in developing countries of crop simulation models; • Assess reliability of yields forecasted and early warnings on the basis of the type of model adopted and the quality of data used (scale of data, acquisition date etc.); • Assess under which conditions it is preferable to interpolate input data or forecasted yields; • Methods for production forecasting; • Assess the impact of upcoming remote sensing data on yield and production forecasting models and early warning systems; • Improve methods for including remote sensing data in yield and production forecasting

models, crops simulation models and early warning systems, also taking into consideration upcoming satellites.

3.6.2 Improving methods for estimating crop area, yield, production of mixed crops, repeated and continuous cropping

In many countries, the practice of sowing mixed crops in the same field is very common. Mixed cropping provide protection to farmers against weather uncertainties. But the method of sowing mixed crops is not uniform. The crops in mixture are sown either row-wise separately or mixed altogether. Also the technique for apportioning the area for different inter-crops differs from country to country and sometimes, like in India, from state to state. Therefore, a standard statistical methodology for estimating the area and the yield under mixed crops, repeated and continuous crops needs to be developed.

After a careful analysis, the partner institution which seems to be particularly appropriate for improving the methods for estimating crop area, yield and production of mixed crops, repeated and continuous cropping is the Indian Agricultural Statistics Research Institute (IASRI), given its experience in this field. The content of the plan of action was agreed in April; however the IASRI can cooperate only in case the Indian Ministry of Agriculture (ICAR) approves the plan of action and the cooperation. Unfortunately, the authorization is still pending.

3.6.3 Developing methods for estimating yields of root crops

The difficulties in properly estimating the yield of crops is more challenging for root crops, particularly when the crop is harvested in small quantities, over extended periods of time because of better in-ground storability, often even spanning across agricultural seasons.

This is the case, for example, for crops like cassava, which is a particularly important staple crop in many Sub-Saharan African countries and discrepancies in estimation from different sources points to substantial problems. As a result, traditional recall methods commonly used in household surveys may be highly inaccurate and thus questionable.

While different methods have been proposed and applied in the field, the lack of best practices remains a constraining factor in providing opportune technical advice to countries on the correct method. Although crop cutting remains the gold standard, it is impractical in most large scale surveys, particularly if multi-purpose in nature. At the other end of the spectrum, it is increasingly accepted that using recall methods spanning over several months, generates inaccurate estimates of continuous crops like cassava.

In order to create synergies, an agreement has been reached with the World Bank for collaborating in this field. After a quick literature review, the field tests have been designed. In order to compare the different methods for measuring cassava production quantities and cultivated area, different methods will be compared: crop cutting, diaries and recall. For area measurement, traversing, Global Positioning System (GPS) and farmer's self-reporting are compared.

Other potential issues in properly quantifying cassava production relate to (1) the state of the crop (fresh vs. dry) and (2) the almost universal use of non-standard units e.g. units, heaps, etc.. To solve the first problem, all quantities for each method are for fresh cassava. For the crop cutting exercise, both fresh and dry weights are taken and conversion factors estimated. Regarding the second issue, visual aid in printed and electronic format is used to facilitate the quantification of units of different sizes to be later converted into standard units using uniform conversion factors.

	The study takes crop-cutting as the gold standard for the quantification of production, while compass and rope is used to benchmark the GPS and self-reported measures of land area. As part of a research grant from the UK Department for International Development (DfID), the World Bank Living Standards Measurement Study (LSMS) team is working on an experiment in Zanzibar with the Ministry of Agriculture and Natural Resources to improve the estimation of cassava yields. The experiment foresees the collection of cassava production data using four different methodologies, namely: (1) a diary, assisted through frequent visit by local Block Extension Officers (BEOs); (2) a diary, assisted through frequent phone calls to the farmers from a call centre established as part of the project; (3) two six-month recall interviews; and (4) a 12-month recall visit. In addition, crop cutting is being carried out on one random plot per cassava farm. Land areas for all cassava plots is being measured using several methods, including compass-and-rope, GPS and farmer's self-reporting. A sample of approximately 1,200 cassava-producing households has been randomly assigned into the four groups. Fieldwork started in May 2013 and is expected to be completed in April 2014. The Global Strategy is collaborating with the World Bank in a second validation exercise in Malawi. The preparation of the field test will start in the fall.
3.7	**Improving the methodology for using Remote Sensing** A document on best practices for crop area estimation with remote sensing has been prepared by GEOSS (GEOSS, 2009), focusing on the use of remote sensing data as an auxiliary variable for improving the precision of estimates for specific crops. However, several methodological aspects of the use of remote sensing data for producing agricultural and rural statistics still have to be improved. This thematic domain is constituted by three research topics: • Developing more efficient and accurate methods for using remote sensing • Evaluating the cost-efficiency of remote sensing in developing countries • Improving methods for using existing land cover – land use data bases The methodological publication which will be developed at the end of the research for this thematic domain will clarify how remote sensing data should be used in order to increase the efficiency of estimates of agricultural parameters, including stratifications based of land cover maps created for mapping or monitoring of land cover, taking into account the characteristics of upcoming satellites and the cost-efficiency of remote sensing data in developing countries. **3.7.1 Developing more efficient and accurate methods for using remote sensing** The development of more efficient and accurate methods is necessary for using remote sensing for crop area and yield estimation, crop forecasting and early warning, forestry and deforestation and land use/land cover monitoring, e.g. automatic change detection and quality control and validation of land cover data bases; see, for instance, Gallego, 2004; Carfagna and Gallego, 2005 and Carfagna and Marzialetti (2009 a, b) for a methodological contribution. Remote sensing data have been used for producing vegetation indices that show overall crop conditions plus information about changes in land cover/use. Wide literature is available in these fields, for a recent review see Gallego et at., 2010, Doraiswamy et al., 2005,

Dorigo et al., 2007.

In spatial survey sampling, several typologies of statistical units can be defined: points, polygon (regular or irregular), economic units (i.e. farms and agricultural households), and administrative units (i.e. provinces, communes, villages). The use of remote sensing data when the statistical units are farms or households requires a complete digital map of each unit. In these circumstances, the farms or households can be treated as irregular polygons. This research will develop more efficient and accurate methods for using remote sensing for producing agricultural and rural statistics, in combination with the different typologies of sampling units, including points, which present specific problems related to co-registration errors.

A document on best practices for crop area estimation with remote sensing has been prepared by GEOSS (GEOSS, 2009), focusing on the use of remote sensing data as an auxiliary variable for improving the precision of estimates for specific crops. However, several methodological aspects of the use of remote sensing data for producing agricultural and rural statistics still have to be improved.

Collaboration with Roberto Benedetti, University of Chieti-Pescara, Italy and Javier Gallego, Joint Research Centre has been established.

The report on the review of related projects and literature has been completed, as well as a database of relevant documents, classified according to their main characteristics (methodological papers, case study, project reports, etc.).

Specific research items to be addressed:

- Influence of the upcoming satellites on possible improvements in the design and/or estimation methods, with particular attention to the application of very high resolution remote sensing data and to the quality of data available free of charge (including Google Earth);
- Development of more efficient and robust statistical methods for using remote sensing data at the design level, mainly auxiliary information for stratification and/or sample selection (probability proportional to size, multiple probability propositional to size, selection of sampling units with minimum correlation);
- Development of some extensions of the regression and calibration estimators traditionally adopted, in order to improve the efficiency of the estimators and to solve some problems posed by the use of some typologies of sampling units, namely points, households etc.;
- Analysis of the robustness of the estimators currently adopted for producing agricultural and rural statistics and development of more robust ones (facing also the problem of zero inflated data sets);
- Comparison of regression and calibration estimators with small area estimators, for the different kinds of remote sensing data and landscape, from the efficiency and robustness viewpoints;
- Improvement of statistical methods for quality assessment of land use/land cover databases and of methods for change detection of land covers.

For each specific research items, particular attention is being devoted to the analysis of the peculiarities of each type of statistical units; moreover, the focus is on main characteristics of

agriculture in developing countries, e.g. main crops, small and very small fields, mixed crops etc. The robustness of the proposed methods is verified in presence of eventual violations of the underlying hypothesis regarding the model that links remotely sensed and ground data.

3.7.2 Evaluating the cost-efficiency of remote sensing in developing countries

A wide scientific literature has been developed on the application of remote sensing to agricultural statistics (mainly crop area estimation and yield forecasting) and some papers and reports have been published on the cost-efficiency of remote sensing for agricultural statistics in developed countries, but very little can be found focused on developing countries. This research topic aims at assessing the cost efficiency of the use of remote sensing in developing countries, and improving the methods for assessing the cost-efficiency of remote sensing, in order to take into consideration the specificities of developing countries and the different approaches which can be followed for using remote sensing data for producing agricultural statistics.

After a careful analysis, the partner which seemed to be particularly appropriate for evaluating the cost-efficiency of remote sensing in developing countries and for improving available methodology is Redouane Arrach, Director of the Division of Statistics and Information of the Ministry of Agriculture and Fisheries, Morocco and his group.

Unfortunately, the research of the partner took much time, also because it was focused on experts and institutions from developing countries; thus the contracts are still being prepared.

3.7.3 Improving methods for using existing land cover – land use data bases

During the last decades, there has been a growing interest on application of the satellite remote sensing technology to model the status of land cover and monitoring its changes. In addition, the application of the satellite remote sensing technology is advocated and promoted as a powerful tool for agricultural statistics. Despite the recognition of such importance, current users of land cover information have to cope with three main inadequacies:

- lack access to sufficient reliable or comparable baseline data;
- lack of consistent and validated guidelines for land cover database classification;
- lack of consistent and validated guidelines for land cover data management for agricultural statistics.

The evolution of consistent and comparable land cover products inherently depends on the development of a consensus based approach to land cover classification, one that is ratified through an internationally recognised process.

A collaboration with John Latham and Ilaria Rosati, FAO-NRL geospatial unit, within the Land and Water Division, FAO, has been established.

The report on the review of related projects and literature has been completed, as well as a database of relevant documents, classified according to their main characteristics (methodological papers, case study, project reports, etc.).

Specific research items to be addressed:

- Possible solutions for the use, for agricultural statistics, of land cover data bases developed for mapping or monitoring the land cover.

	• Development of land cover databases in LCCS3 style taking into account also the use for agricultural statistics.
3.8	**Adoption of new technology for field data capture, compilation, transfer and dissemination** New technologies such as GPS, PDA, remotely sensed data from satellite and aircraft as well as geographic information systems (GIS) are playing an important role in the development of cost effective data collection methods and the improvement of data quality. In 2013, a prototype of a new free-ware Computer Assisted Personal Interview (CAPI) software for surveys and censuses is being developed, in partnership with the World Bank, namely the Computational Tools group in the Development Research Department (DECCT) and the Living Standards Measurement Study (LSMS) team. The system being build consists of a questionnaire designer as well as a data management system to support flawless communication and data transmission across parties at different levels of survey operations i.e. headquarters, supervisors and enumerators. The entire system, including extensive documentation, will be made available, free of charge. In addition, a strong technical assistance component to assist countries in the adoption of the software platform is envisaged. Over the past 18 months, work has been on-going: two pilots have been carried out on small surveys in San Lucia and Djibouti and a beta version of the designer is now available to users for comments at www.solutions.wordbank.org. The release of a first version of both the designer and data management system will be in the fall 2013. This first release, with be followed by subsequent released on a quarterly basis for at least another 12-18 months.
3.9	**Improving quality and use of administrative data to produce agricultural statistics** In developed countries, governmental interventions such as subsidies, regulation and legislation often require agricultural holders to report information on acreage. Land ownership and cadastral surveys provide useful information for constructing registers. However, more research is needed for identifying where, how and under which conditions, administrative data can be used for producing agricultural, rural and agri-environmental statistics, with particular reference to developing countries. Moreover, the quality of this kind of registers is lower in many developing countries. Other kinds of administrative data are the reports of agricultural extension development officers and experts guesses. Given resource and capacity limitations, administrative data will continue to play an important role in any agricultural statistics system in the majority of developing countries where sample surveys will continue to have multi-annual frequency with estimates not available at very low geographical level in a context of growing demand for such data. Also, there will always be a need of early warning and pre-harvest crop forecasting data to inform Governments on the prospective food situation which is mainly derived from crop monitoring and other auxiliary information produced by field staff. Methods for assessing and improving the quality of these kinds of data will be developed, as well as methods for using these kinds of data for producing cost-efficient agricultural statistics. A partner has been identified. Next steps: • Review of relevant literature, studies country experiences in developed

	countries (Output: technical report with lessons learned that can be relevant for developing countries) • Review of on-going research on the use of administrative data in Europe and identification of areas of synergy and complementarity. (Output: technical report with lessons learned and areas of collaboration relevant for developing countries) • Analysis of administrative sources being currently used by developing countries and assessment of their strength, weaknesses and suitability for use in agricultural statistics within an integrated and cost-effective system. (Output: technical report with identification of areas of improvement and strategies of using the improved data in an integrated agricultural statistics system) • Identify and analyse gaps and remaining methodological issues and propose possible solutions. (Output: Draft report on ongoing or already completed research activities, literature review, gaps, remaining methodological issues and possible solutions)
3.10	**Improving methodology of food balance sheets** The accuracy of food balance sheets, typically compiled at the national level, is dependent on the reliability of the underlying basic statistics of supply and utilization of foods, their nutritive value and conversion factors that govern the transformation of primary commodities into processed products and vice versa. As the major dietary commodities are rarely made available for consumption in their primary or originating form, wheat grain viz a viz wheat flour is an example, the importance of accurately capturing the transformation is paramount for monitoring food security. Compounding this task is the growing complexity and diversity of products that now enter food baskets, as well as new and enhanced technologies that are being introduced to process food. Through obtaining empirical evidence supported by model-based estimates, this research topic seeks to establish and verify appropriate technical conversion factors, i.e. milling rates, crushing rates, extraction rates, conversion and processing factors, carcass weights, milk yields, egg weights, etc., that indicate the average national rate at which commodities are converted. The benefits of the research are manifold. Not only will a more accurate depiction of food availabilities be obtained thereby enhancing food security metrics, underperforming food processing chains will also be identified. The improvement of the conversion factors will allow: • A better understanding of how basic foodstuffs are being utilized by sectors (food versus feed versus industry); • Better estimates of food availability and in what form (nutrition), e.g. bread or alcohol?; • More informed estimates of food security; • Measuring and monitoring value chain growth and performance: technical efficiency and losses. Next steps: • Develop value chain typologies for commodities (country/dietary importance/income based); • For each typology derive methods to assess the volume of primary commodities undergoing processing: on-farm versus industry and in what form;

	• Establish technical conversion factors of primary foodstuffs based on processing shares, physiological limits, technical efficiency; • Fostering alliances with development partners, e.g. UN Industrial Commodity Production Statistics, nutrition departments; • Country ownership.
3.11	**Improving methodology for small scale fishery** Accurate estimations of small scale fisheries and aquaculture are a challenge in many countries, which are an important source of food security, nutrition (especially protein and trace nutrients), and livelihoods in many countries. The collection of data on inland fisheries and aquaculture (both commercial and subsistence) will depend on developing the appropriate methods for data collection and estimation. A module to be included in the questionnaires for agricultural censuses which will collect information, particularly on the socio-economic characteristics of small scale fishery and aquaculture is being developed. A partnership with Sachiko Tsuji, Senior Fishery Statistician FIPS – FAO and Jennifer GEE has been established. Achievements made so far include: • Initial review and analysis of historical WCA questionnaires with an emphasis on social economic data collection was conducted, whose results would be integrated into the overall designing of fishery and aquaculture modules; • The first round consultation with WCA team identified the items to be integrated into overall WCA designs in order to support data needs for fishery and aquaculture sectors, identified the items better fit in survey questionnaires at the community level and confirmed the need to develop a new survey module of capture fisheries as well as substantially revise the aquaculture module disseminated in 1997; • A partnership was developed with the Project of Memorial University of Newfoundland to establish Information Network to support Small Scale fisheries and agreed to collaborate in i) testing and reviewing the drafts and concepts developed in this project, ii) advocating the methodologies when established, and iii) developing a framework to collect data and information in accordance with fields projects and case studies that could bridge data gaps between WCAs; and • Rough concept of overall framework was established in a direction to integrate the WCAs and supplementary survey results with regular fishery and aquaculture data collection by utilizing a common platform based on SEEA relevant tables (including aquatic resources asset table, water supply and use table, land asset table) and their expansion. Specific research items to be addressed: • Drafting of WCA capture fishery module and revised aquaculture module, and seeking feedbacks, including a presentation at ICAS and AFCAS; • Further brainstorming in extending SEEA concepts and relevant tables to cover general monitoring needs underneath the ecosystem approach of fishery and aquaculture management and Code of Conducts of Responsible Fisheries (EAF/EAA/CCRF) in order to develop a standard template supporting EAF/EAA/CCRF; and • Developing conceptual framework to enable an integration of information collected by

	various surveys to provide continuous monitoring on small scale fishery and aquaculture with least cost.
3.12	**Better integration of geographic information and statistics** Better methods are needed for taking advantage of geographic information for producing agricultural statistics in the field of data collection, analysis and dissemination and for connecting statistical data collected through sample surveys (which can be represented by points in the space) and other kinds of geo-referenced data (polygons and lines). Research is needed for improving statistically based methods for spatial disaggregation and for integrating various kinds of geographical information and geo-referenced survey data, which is essential for crop forecasting and early warning. Under this thematic domain, the research topic "Developing robust and statistically based methods for spatial disaggregation and for integration of various kinds of geographical information and geo-referenced survey data" is being implemented. **3.12.1 Developing robust and statistically based methods for spatial disaggregation and for integration of various kinds of geographical information and geo-referenced survey data** Geographical and statistical information are often available for large spatial (administrative) units. However, for policy making, it may be important to have more detailed information, whether small administrative units or geometric units, such as grid cells of a given resolution. With limited sample size, it is generally unfeasible to produce accurate estimates with the most traditional statistical methods that separately consider the information inside each small unit. The research compares several approaches to disaggregate data with the help of external co-variables. In addition, more efficient methods are studied for small area estimation using geographic information as auxiliary variables. In some cases, spatial data have to be aggregated, in order to have the different information layers with the same spatial resolution, for developing spatial models. Different aggregation methods have been developed for different purposes and have different impacts on the models. This research topic addresses the need for better integration of geographic information and statistics. Particularly, the result of the research activities will be new, more effective and robust methods for the use of geographic information to produce more accurate agricultural and rural statistics; including for connecting economic and social indicators to land use. In addition, more efficient methods will be developed for small area estimation using geographic information as auxiliary variables. The research addresses also the problem of developing robust and statistically based methods for spatial disaggregation and for integrating various kinds of geographical information and geo-referenced survey data, which is essential for crop forecasting and early warning. Finally, the problem of assessing the impact of aggregation, disaggregation, interpolation and integration of geographic data on the models adopted for crops forecasting and early warning is addressed. The main research lines are: • Data disaggregation; • Data interpolation; • Data aggregation; • Data integration;

	• Assessment of the impact of aggregation, disaggregation, interpolation and integration of different data layers on the models adopted for crops forecasting and early warning. A collaboration with Monica Pratesi, University of Pisa, (data disaggregation and interpolation), Alessandra Petrucci, University of Firenze, (data aggregation and integration) and Simone Maffei, Italy (assessment of the impact of these operations on the models) has been established. The report on the review of related projects and literature has been completed, as well as a database of relevant documents, classified according to their main characteristics (methodological papers, case study, project reports, etc.). Specific research items to be addressed: • Proposing efficient estimators for area and yield using spatial information; • Improve small area estimators using geo-referenced information (also taking into account skewed distributions) • Evaluating efficiency and robustness of small area and calibration estimators when geo-referenced data are used • Coping with missing values in spatial data and in auxiliary variables • Addressing the modifiable area unit and other change of support problems and its impact of estimation of spatial parameters (correlograms, variograms atc.) • Possible methods for assessing the impact of interpolation, aggregation, disaggregation on yield and production models (e.g. sensitivity analysis) (Maffei). The methodological publication that will be developed at the end of this research will clarify how to take advantage of the spatial information of geo-located sample surveys and of spatial auxiliary variables for producing agricultural and rural statistics and assessing their accuracy.