			Food and Agriculture Organization of the United Nations	Organisation des Nations Unies pour l'alimentation et l'agriculture	Organización de las Naciones Unidas para la Agricultura y la Alimentación

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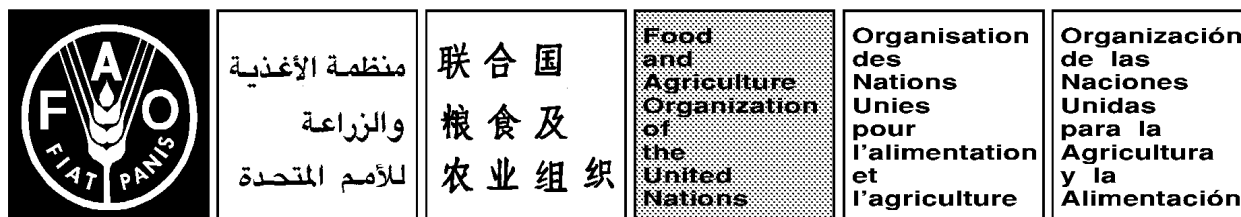## AFRICAN COMMISSION ON AGRICULTURAL STATISTICS

Twenty-fourth Session

Kigali, Rwanda, 1 – 4 December 2015

MACRO - ECONOMIC STATISTICS FOR AGRICULTURE – NEW FAO DATABASES ON AGRICULTURAL CAPITAL STOCK AND AGRO-INDUSTRY MEASUREMENT

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1. INTRODUCTION

As economies grow and develop, the productive landscape undergoes structural transformations and sectors become more interrelated. As a result, determining the overall importance of any specific sector becomes intricate. This is certainly the case for agriculture, where the upstream industry of agricultural production understates the sector's contribution to the agro-industry value-chain and the economy through its links to numerous industries such as fertilizer production, food processing and manufacturing, transportation, wholesale, and retail distribution.

To meet the growing need for consistent statistics to measure the agro-food value-chain, FAO's Statistics Division (ESS) began construction of global macroeconomic statistics databases on agro-industry measurement (AIM), agricultural capital stock and other related structural statistics. The agro-food value chain refers to all economic operations involved in the production and distribution of products that originate from or are used in the production of agriculture output, while the agro-industry refers at least a subset of the "farm to fork" activities in this value-chain that, to this day, lacks a statistical definition. Combined with economic indicators for the agricultural sector, the AIM database attempts to provide harmonized indictors of some key components of the value chain.

The approach used in compiling these databases uses the national accounts framework and existing international databases on national accounts and industrial statistics from the UN Statistics Division, the OECD, the consortiums responsible for the World Input Output Database (WIOD) and the World KLEMS project, and UNIDO. These databases have the advantage of covering a large set of countries, and their use minimises the effort on FAO and the burden and duplication on countries of obtaining and providing the necessary underlying data. The approach is limited, however, in not

covering activity groups further along the value chain and cannot, therefore, be labelled as "from farm to fork". In particular, the databases used are as follows:

- OECD: STAN database.
- WIOD, Socioeconomic accounts.
- World KLEMS
- United Nations, National Accounts Estimates (NAE)/main aggregates and official country tables;
- UNIDO, INDSTAT database.

The National Accounts (NA) framework helps harmonize the databases and focuses on key variables, such as value-added, gross output, employment, compensation of employees, and gross fixed capital formation in both current and constant local currency units (LCU) and US dollars (USD). Capital stock related statistics are calculated for the agricultural sector, and include gross fixed capital formation (GFC), net fixed capital formation (NFCF), consumption of fixed capital (CFC), and gross and net capital stock (GCS and NCS). For downstream industries, ESS, working in collaboration with the UNIDO, focused first on the agro-food industries for the 46 countries captured in the OECD and WIOD databases.

Using this holistic framework captures multiple dimensions of agriculture-related industries and allows integrating different country profiles: in low income countries agriculture remains a large sector in terms of employment and contribution to national product, but is still a largely self-sufficient sector with strong linkages from agriculture to the macro-economy. By contrast, in high-income countries, agriculture accounts for a very small share of employment and national product, but exhibits strong commercial links, inter-sector transfers and competition for inputs and consumers' expenditures.

As far as the vertical dimension of the Agro-industry concept is entailed (i.e., the range of economic activities along the supply chain), the following have been included to date:

- Agriculture production (ISIC Rev. 3, divisions 01 to 05; ISIC Rev. 4, divisions 01 to 03), which includes the agriculture, fisheries and forestry sub-sectors.

- Food-processing activities covered by ISIC Rev. 3, divisions 15 and 16; and ISIC Rev. 4, divisions 10 to 12, which includes food, beverage and tobacco (FBT).

The database does not, at present, include any other manufacturing activities that require the use of agricultural products, such as the manufacturing of textiles and wood products, and the making of furniture (ISIC Rev. 3, divisions 17 to 21 AND 36; and ISIC Rev. 4, divisions 13 to 17 and 31).

It should be stressed that these are *analytical* databases providing *provisional* indicators. While official country data is the backbone of these indicators, they databases require a significant number of imputations, estimations and assumptions. Data sources and assumptions are well documented, in the hopes that official country statisticians and other experts will help validate or improve the databases and the underlying assumptions, and where possible, provide official country data to replace missing data.

To begin the validation exercises, both databases were subject to scrutiny by experts during workshops and meetings held in Vienna in October and in Rome in November 2015. The Capital Stock database was evaluated by experts from the OECD and the world KLEMS

project, as well as by FAO experts. The AIM database was presented and discussed at an October Seminar on Industrial Statistics, hosted by UNIDO, and then the subject of a two day expert group meeting in Rome in November, drawing on agro-industry experts and statisticians from member countries, international organizations, and academia. Presentations in meetings such as AFCAS provide a further opportunity for validation and improvement, and it is hoped the publication of these provisional databases on FAOSTAT and ESS websites will provide further such opportunities.

2.   METHODOLOGY AND OUTPUTS

The methodology in compiling both databases followed similar steps. A first step was to identify and bridge data across sources. The second was to estimate missing values for countries that had reported at least some official data, in order to create more complete time series. This was done using established statistical estimation and imputation methods. A third step was to calculate final indictors, which included current price versions in both local currency units (LCUs) and US dollars; constant 2005 price indicators in LCUs and USD for capital stock variables; productivity-related indicators, such as the agriculture investment ratio (agriculture GFCF to agriculture value-added) and value-added to employment or capital; value added shares, such the agriculture value-added share of GDP, and FBT value-added share of manufacturing; and the Agriculture Orientation Index (AOI) for capital formation, which normalizes agriculture's investment ratio by that of the total economy.

Database 1: Agricultural Capital Stock and related structural statistics

ESS had previously published in FAOSTAT statistics on agricultural capital stock with country-level estimates up to 2007. This dataset estimated capital stock using the physical inventory approach, which adds up the sector's components of produced assets. Physical investments in capital, or capital formation, can then be calculated as changes in capital stock between two time periods. In the case of agricultural capital stock, produced assets include land development, machinery and equipment, farm structures, livestock, and orchards.

This approach was evaluated and abandoned due to data quality issues in the underlying datasets. This arose in part from low and declining response rates and incomplete data reported by countries, particularly for the machinery and equipment component, and in part, due to methodological issues in the calculation of the components, such as land development. A further limitation of the old approach was the limited country coverage, and the focus on the narrow agriculture sector, excluding forestry and fisheries.

For OECD countries, where data are available on gross capital stock, net capital stock, and consumption of fixed capital, these data were used after bridging. For developing countries, where these data are not available, the new database uses the National Accounts framework and Perpetual Inventory Method (PIMs) with double declining balances. In this approach, capital stock in one period is the sum of capital stock in the previous period, plus the current period flow of capital investments (GFCF) minus the consumption of fixed capital. If GFCF data is available, this method requires assumptions about the initial stock of capital as well as the depreciation rate.

Prior to calculating capital stock, it was necessary to compile a relatively long time series of national accounts variables on value-added, gross output, and GFCF. This required bridging existing data across sources, across series (which could reflect methodological changes at country level), and across ISIC revisions using, where possible, overlapping series.

Imputation and estimation of missing values and series used a combination of hot deck imputation methods (carrying forward data from previous years) and cold deck imputation (using data from a nearest neighbour, in terms of structure and level of economic development, measured by GDP/capital). These methods were used to estimate key ratios, such as sector shares of value-added (VA) that may be more stable than level variables, and then multiplied by the appropriate factor to estimate the final variable of interest. Official country data were used where available, with the table below summarizing imputation methods used to calculate missing observations and series for both the Agriculture, Forestry and Fisheries sector (AFF) and the Agriculture subsector (Ag).

The resulting GFCF series were used, along with assumptions on initial capital stocks and depreciation rates, to calculate capital stock indicators. Finally, using the implicit exchange rates and deflators from the UNSD National Accounts Estimates, indicators were produced in current and 2005 constant prices, in both LCU and USD.

This resulted in the creating of key variables for 223 countries and territories from 1970 to 2013, covering both the broad agricultural sector, including forestry and fisheries (AFF), and the narrow subsector, excluding forestry and fisheries (Ag).

ESTIMATION/IMPUTATION METHODS WHEN OFFICIAL COUNTRY DATA ARE MISSING		
	Agriculture, Forestry & Fishery (AFF)	**Agriculture (Ag)**
Value added (VA)	• Replace missing observations with bridged data of Value Added. • Replace missing series with UNSD National Accounts Estimates (NAE).	• Replace missing observations with bridged data from UNSD-NAE. • Replace missing series using nearest neighbour VA_AG/VA_AFF, multiplied by country VA_AFF.
Gross Output (GO)	• Impute missing observations using GO_AFF/VA_AFF of adjacent years, multiplied by current year VA_AFF. • Impute missing series using nearest neighbor GO_AFF/VA_AFF, multiplied by county VA_AFF.	• Impute missing observations using GO_Ag/VA_Ag of adjacent years, multiplied by current year VA_Ag. • Impute missing series using nearest neighbour GO_Ag/VA_Ag, multiplied by country VA_Ag.
GFCF	• Impute missing observations using most recent, or an average of the most recent, available GFCF/VA for AFF. • Impute missing series using simple linear and logarithmic) regression equations regressing GFCF/VA on GDP/capita ($0.74<R^2<0.9$).	• Impute missing observations using most recent, or average of most recent, available GFCF/VA for Ag. • Impute missing series with GFCF_Ag= VA_Ag/VA_AFF x GFCF_AFF and using simple linear and logarithmic) regression equations regressing GFCF/VA on GDP/capita ($0.74<R^2<0.9$).

Since the initial database was constructed back to 1970, assumptions on the initial capital stock had little impact on the final estimates from about 1990 onwards. Assumptions on depreciation rates, however, did have an impact. For OECD countries, depreciation rates of about 0.08 were based on reported data. In these countries, machinery and equipment (M&E) and structures make up the majority of agricultural capital, with both making up similar shares but M&E having much higher depreciation rates. In developing countries, in

the absence of data, it was assumed depreciation rates were significantly lower and based on their economic structure and level of development.

The resulting capital stock estimates were based on assumed depreciation rates of between 0.4 and 0.08. Assumptions about these depreciation rates require validation, or better yet, country level studies or official country estimates.

Some key trends and statistical analysis from this database are presented in the accompanying power point presentation.

Database 2: Agro-industry measurement (AIM) database

For the AIM database, ESS worked in collaboration with the Statistics Unit of UNIDO, under a newly created FAO-UNIDO working group on statistics, whose mandate was to produce agro-industry and food waste/loss statistics.   Some of the key questions this database seeks to answer include the following:

- What is the total (direct and indirect) economic contribution of the agriculture sector?

- How do countries benefit from links between the agriculture and agro-industrial sector and subsectors, like food processing?

- How do these linkages vary across countries and across commodities?

- How do these linkages impact sustainability, food loss, trade, job quality, poverty, and food-security?

As a first step, the AIM project focused on food, beverage and tobacco (FBT) manufacturing and the 46 countries covered by the OECD and WIOD databases. UNIDO's INSTAT database was used as the basis of the project, as it provides data covering the FBT sector of manufacturing while also allowing for both greater sub-sector disaggregation and expansion to other manufacturing sectors that rely heavily of agricultural inputs. The variables initially covered include value-added, gross-output, employment and compensation of employees (wages and salaries).

This coverage was selected as a proof-of-concept, and because of the challenges in covering a larger array of manufacturing activities covered in the agro-food value-chain. Indeed, there is at present no international statistical definition of "agro-food industry." The UN Statistics Division (UNSD) and FAO both receive questions about such a statistical definition. This is an important step in expanding the sector coverage and the variable coverage of the AIM database, and an important next step for this project, requiring inputs from both experts and country officials. It is worth noting that such a definition which would likely require inclusion of both activities, as defined in detailed elements of the ISIC classification system, as well as products, as defined in elements of product classifications such as the Harmonized System (HS), the Central Product Classification (CPC), and the Classification of Individual Consumption According to Purpose (COICOP).

Since the INSTAT data is based on national industry surveys, the variables covered needed to be re-scaled and estimated to national accounts levels. This was done following the estimation of missing observations. Re-scaling was performed using composition ratios, such

and manufacturing to total economy value-added. The 46 countries were selected for the AIM database as they provided sufficient detail in their national accounts to enable testing of the quality of re-scaled estimates against actual data.

To create more complete time series, multivariate models were used to estimate missing observations and to now-cast data to the most recent year. The models use as endogenous variables previous year's variable and auxiliary variables, such as the CPI and GDP growth, for all countries in the database. UNIDO plans to disseminate these more complete series in the near future, along with metadata on the underlying models and assumptions.

For purposes of efficiency, transparency and reproducibility, statisticians in ESS built automated procedures in R-script to integrate industry and national accounts data across sources, impute missing values in the INSTAT series, and re-estimate/re-scale variables to national accounts levels. The initial investment in building these models has allowed for relatively rapid implementation and evaluation of alternative estimation methods, including the newly estimated INSTAT series, and can be readily extended to other agro-industry activities.

The 46 countries in the AIM database currently include all OECD countries, most of the BRICS countries, and several other developing countries. They are: Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, China, Taiwan, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States of America.

In compiling the AIM database, ESS had also investigated the possibility of using an input-output (IO) approach to construction. Because of the resource intensity of this approach and limited IO data available for developing countries, this was discarded in favour of the approach used. Nonetheless, it is worth pointing out the IO approach, where complete IO tables are available, has the following strengths not available from the current approach.

- Complete coverage of the agro-industry in terms of the full set of agro-related activities, ranging from pre-production, harvest activities, and postharvest activities up to distribution services and trade. This weaknesses needs to be assessed in future work.

- The ability to internalize the trade dimension, which is not available in INSTAT data. However, combining UNIDO and COMTRADE databases may be one mechanism to estimate the trade dimension.

The next steps in the AIM database include validation by countries of the approach and assumptions used. Following that, FAO will prioritize, with inputs from countries and subject to resource and data availability, the following potential next steps in expanding the AIM database:

1. Expand country coverage to include more developing countries.

2. Create of constant price series (LCU and USD), which requires selection of appropriate deflators.

3. Develop an international statistical definition and classification system of the Agro-industry.

4. Expand sector disaggregation to include some or all of the following FBT sub-sectors:
   - Production, processing and preservation of meat, fish, fruit, vegetables, oils and fats
   - Manufacture of dairy products
   - Manufacture of grain mill products, starches & starch products, & prepared animal feeds
   - Manufacture of other food products
   - Manufacture of beverages
   - Manufacture of tobacco

5. Evaluate and improve the quality of labour/employment statistics, which may be inconsistent with household/labour force survey data.

6. Expand manufacturing sector coverage to include other agro-related in manufacturing of textiles, wood products, and furniture.

7. Expand of variable coverage to include GFCF, exports and imports.

3. QUESTIONS FOR DISCUSSION WITH AFCAS MEMBER COUNTRIES

- For both databases, what are the thoughts in using the National Accounts framework? Are there issues related to bridging data, and how might they impact data quality? What are the appropriate deflators in constructing constant price series? Given the large number of estimations and imputations, what are the concerns in FAOSTAT dissemination of these analytical databases, and how should they be addressed?

- For the Agricultural Capital Stock database, are there other sources of official country data that could be used? Is information available on appropriate depreciation rates, particularly for agriculture machinery and equipment? Are there countries that would be willing to collaborate with ESS to share this type of data/information for their country, and assess its impact on the resulting estimates?

- For the AIM database, what should be ESS's priority next steps, particularly given resource constraints?

- For both domains, what are capacity development needs at country level in improving country level estimation of capital stock, and in collecting data on agro-food industries?

4. PROPOSED RECOMMENDATIONS FOR AFCAS MEMBER COUNTRIES

1. AFCAS member countries support the ESS approach to constructing the Agricultural Capital Stock and AIM databases, and encourage ESS to publish these data as *provisional analytical databases*, to enable validation and feedback. If a member country has concerns about the quality of estimates/imputations, it agrees to provide official country estimates, where possible, or information to improve the estimates.

2. AFCAS member countries agree to participate in a FAO-UNIDO process to develop an international statistical definition of "agro-industry", based on existing classification systems, and to share definitions used at country level.

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