RAF-AFCAS-17-52a

November 2017

منظمة
الأغذية والزراعة
للأمم المتحدة

联 合 国
粮 食 及
农 业 组 织

Food and Agriculture
Organization of the
United Nations

Organisation des
Nations Unies pour
l'alimentation et
l'agriculture

Продовольственная и
сельскохозяйственная
организация
Объединенных Наций

Organización de las
Naciones Unidas para la
Agricultura y la
Alimentación

E

AFRICAN COMMISSION ON AGRICULTURAL STATISTICS

Twenty-Fifth Session

Entebbe, Uganda, 13 – 17 November 2017

COST-EFFECTIVE TOOLS FOR DATA COLLECTION

By

Valerie BIZIER and Michael RAHIJA
Technical Assistance and Training Coordinator – Global Strategy
Statistician, FAO Headquarters

I. Introduction

Data and statistics on agriculture play an increasingly important role in the implementation of the 2030 Sustainable Development Agenda in comparison to the Millennium Development Goals. High quality and timely data from the field not only provides governments with the information needed to design the policies required to achieve the Sustainable Development Goals (SDGs), but are also necessary to monitor progress and impact. SDG17, "Strengthen the means of implementation and revitalize the global partnership for sustainable development", puts statistics at the heart of the post-2015 agenda and stresses the fact that capacities need to be strengthened to monitor progress towards the SDGs by collecting data and computing indicators.

As of March 2017, 232 SDG indicators have been included in the indicator framework developed by the Inter-Agency and Expert Group on SDG indicators (IAEG-SDGs). It is further recommended that wherever possible, these indicators should be disaggregated by sex, age, income quintiles, disability, ethnicity and indigenous status, economic activity, location, and migrant status. This places an enormous burden on national statistical offices and implies a heavy new demand on already scarce resources.

The Sustainable Development Solutions Network (SDSN) puts together a coalition of development experts from many different United Nations institutions and academic institutions to estimate the full cost of monitoring the SDG agenda. For monitoring only a core subset of indicators in 77 lower-income countries, SDSN estimates that 1 billion USD is required. The estimated gap considering donor and national contribution is between 100 and 200 million USD (SDSN 2015). In this respect, there has never been a better time for taking stock of tools and techniques that can lower the cost of data collection.

The Food and Agriculture Organization (FAO) is the custodian agency of a total of 21 SDG indicators cutting across Goals 2, 5, 12, 14 and 15. In addition to compiling and verifying country data, FAO is also tasked with strengthening national capacity for monitoring and reporting on those specific indicators. It follows that given the huge burden of data collection, FAO should develop and promote cost-effective tools as well as share good practices across countries.

In this context, FAO has developed its own products and incorporated the latest cost-effective technologies into its recommendations and practices. In recent years, particular advancements have been made for the adoption of integrated approaches for data collection and the areas of Computer Assisted Personal Interviewing (CAPI) and geospatial technologies. This report will highlight specific tools recommended by FAO to lower costs and empower countries to produce high-quality SDG data. It will also give an overview of the support provided to African countries in adopting these tools.

II. Development of the topic

2.1. Adoption of an integrated approach for data collection

The adoption of an integrated approach for data collection is key to reduce duplication of efforts in the data production system while filling data gaps efficiently. Several tools have been developed to support countries in adopting such an integrated approach for agricultural statistics, particularly in the following areas:

1. Strategic Plans for Agricultural Statistics (SPARS) and National Strategies for the Development of Statistics (NSDS)
2. Integrated survey framework for agricultural statistics
3. SDGs-related questionnaire modules to be integrated in existing surveys

The next three sections will provide more information on these tools and on key resources that will enable countries to operationalize them.

2.2. Strategic Plans for Agricultural Statistics (SPARS) and National Strategies for the Development of Statistics (NSDS)

The design of NSDSs and SPARSs uses strategic planning approaches and techniques to establish medium- to long-term goals for the development of statistics as well as resource plans to achieve them. While NSDSs have been recognized as the overarching strategy to improve the availability, quality and uses of statistical information across sector, the development of sectoral strategies for the development of statistics aims to respond to the specific data needs of the sector, including sectoral development plans.

In particular, the design and implementation of SPARSs, specific to the agricultural and rural statistics sector, is proven to be useful to:

- Identify, prioritize and address the critical weaknesses in the agricultural and rural statistical systems i.e. data needs, critical gaps, deficiencies, duplications and inconsistencies
- Define and prioritize future short- and long-term agricultural and rural statistical programs and interventions (i.e. technical assistance, research and training)
- Optimize the use of limited resources across priority areas
- Provide a framework for mobilizing, harnessing and leveraging resources and raise the profile of statistics
- Aid in the resolution of coordination issues among different elements of the agricultural statistical system; serve as a framework for coordinating efforts between the agricultural systems, subsystems, and the NSO, as well as between governments and donors for financing agricultural and rural statistical activities; and enable incorporation of new dimensions into existing data production systems
- Ensure a better integration of agricultural and rural statistics into National Statistical Systems and NSDS

The inclusion of the agricultural-related data needs (including SDG requirements) in the NSDSs and SPARSs design and implementation processes is therefore recommended as a mean to rationalize the conduct of statistical activities, optimize the allocation of funds and canalize the capacity development efforts.

The Guidelines on SPARS (Global Strategy, 2014) are currently under revision. A new version of these guidelines, scheduled to be released in early 2018, will integrate several improvements, including: 1) the addition of actual country experiences, 2) the inclusion of the views of key stakeholders involved in the agricultural and rural statistical system, 3) the integration of new methodological approaches and innovations (such as: Agricultural Integrated Survey (AGRIS), Master Sampling Frame (MSF) and Administrative Data System for Agricultural Statistics (ADSAS)), the evolving global, regional and national context and the newly emerging data needs of SDGs, and 4) the provision of supplementary documents that are critical for designing and implementing SPARS (such as: the Users' Satisfaction and Data Needs Assessment Guidelines and the Agricultural Statistics Training Needs Assessment Guidelines).

2.3. Integrated Survey Framework for agricultural statistics

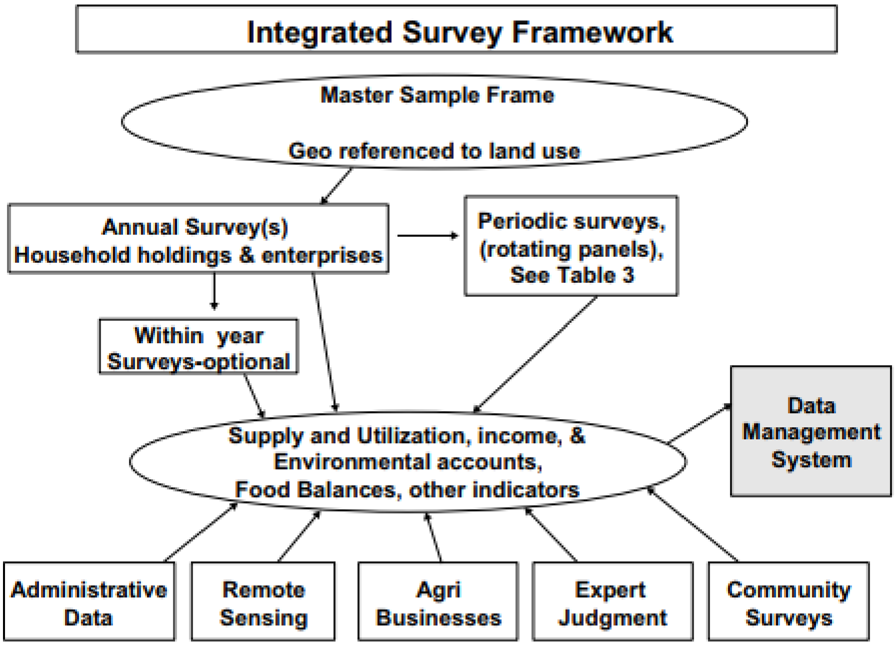
One of the shortcomings of current statistical systems in both industrialized and developing countries is that data are collected by sector, using different sampling frames and surveys. Surveys are often conducted on an ad-hoc basis with no links to a master sampling frame or no use of georeferenced units for data collection. Household surveys are conducted in isolation from agricultural production surveys with no coordination or with sample sizes too small to disaggregate the data into the rural and farm sectors. The results generated from these surveys are also not integrated into a common database that may be accessed by data users.

While NSDSs and SPARSs can assist countries in better coordinating the statistical system, the integrated survey framework proposes a holistic approach to data collection with the objective of linking all data collection operations, establishing a closer link between the results of different statistical processes and different statistical units, and enable a cross-cutting analysis of the economic, social and environmental dimensions of agriculture.

Table 1 illustrates the integrated survey framework envisioned in the foundational document of the Global Strategy to improve Agricultural Statistics (further referred as Global Strategy) (WB, FAO and UN, 2010). The World Program for the Census of Agriculture (WCA) (FAO, 2017) also argues forcefully for the development of such integrated systems and its modular approach follows this framework to a certain extent (FAO, 2017).

The key elements of the framework are: (1) the development of a master sampling frame for all agricultural surveys, (2) the adoption of sample designs such as overlapping samples, and (3) the synchronization of questionnaire designs and surveys. It also takes into consideration the data sources in addition to sample surveys that provide input for the survey framework. Finally, it advocates for a data management system that will provide easy access to agricultural statistics for dissemination purposes, ensure proper storage and retrieval of survey results and enable access to farm, household, and georeferenced data for research.

Figure 1: Integrated Survey Framework for Agricultural statistics



Source: WB, FAO and UN, 2010

In this approach, the master sample frame becomes the basis for the selection of probability-based samples of farms and households with the capability to link the farm characteristics with the household and then connect both to the land cover and use dimensions. The synchronization of questionnaires and surveys can be done through a survey questionnaire that contains the same set of core items every year and rotating sets of supplemental questions each year. The design is based on the premise that data is to be collected for some items at least annually, while data collections for other items are only needed on a periodical basis.

In the recent years, FAO has made some progress in identifying, testing and documenting best practices, methods, innovative approaches and tools to develop and use a master sampling for agricultural surveys and implement an integrated agricultural survey. Its main products - the *Handbook on Master Sampling Frames for Agricultural Statistics* (Global Strategy, 2015a) and the *AGRIS toolkit* (to be released soon) - should guide countries in elaborating their own integrated survey system (see AFCAS paper on session 5.1 for more details).

2.4. SDGs-related questionnaire modules to be integrated into existing household surveys

Several large-scale household surveys conducted on regular basis - such as the Household Budget Surveys, the Living Standards Measurement Studies, the Labour Force Surveys, the Demographic and Health Surveys, the Multiple Indicator Cluster Surveys and others - can be used to collect additional information relevant to the compilation of SDGs indicators. While this approach can increase respondents' burden and add to the collection period of the surveys, these disadvantages are definitely offset by the cost and time savings associated with the use of these well-established data collection operations.

To support countries in taking advantage of existing surveys, FAO has designed questionnaire modules to collect information on SDG indicators 2.2.1 (Food Insecurity Experience Scale) and 5.a.1 (Gender and Land Tenure). Countries are encouraged to seek opportunities to integrate these survey modules in their current operations.

III. Computer Assisted Personal Interviewing (CAPI)

CAPI technologies allow statistical agencies to collect information using mobile devices such as personal digital assistants, tablets, laptops or smartphones. Several countries have started to adopt this technology to conduct data collection for surveys and censuses, reducing their data collection costs overtime while improving the quality and the timeliness of their statistical products.

The two main barriers to a wider use of CAPI in the production of agricultural statistics remain:
1) the initial investment related to the acquisition of the necessary equipment and technology;
2) the extent of capacity-building required to assist statistical agencies to adapt to this technology.

The next section will explain how the availability of several studies that show the cost-effectiveness of using CAPI, the progress put forth in making the CAPI technology more accessible and user-friendly, and several capacity development initiatives that can contribute to overcome these barriers.

3.1. CAPI and cost effectiveness

Proving the cost effectiveness of using CAPI is a means to assist countries in successfully advocating in favour of the initial investment related with the adoption of this technology to the budget authorities. The central question regarding the cost effectiveness of using CAPI is whether or not the cost of purchasing equipment (i.e. tablets, batteries, etc.) is offset by the elimination or reduction in printing, storage, and data entry costs. Table 1 below shows the results of a cost analysis across the first 4 waves of the Uganda National Panel Survey (UNPS), which included a detailed agricultural module. Equipment costs here included tablet devices, data transfer, and generators for recharging devices.

Table 1: *Cost per interview in Uganda in 2005 PPP values*

Description	**Wave 1**	**Wave 2**	**Wave 3**	**Wave 4**
Year	2009-2010	2010-2011	2012-2013	2013-2014
Sample Size	3000	3000	3000	3000
Number of questions	1090	1097	1152	1148
Method of data collection	PAPI	CAPI	CAPI	CAPI
Costs				
Enumerators salaries	91.46	81.05	63.96	61.42
Supervisor salaries	45.27	40.12	31.66	30.40
Data Entry	28.38	-	-	-
Cleaning costs	NA	NA	NA	NA
Paper questionnaire cost	35.04	6.21	4.44	3.68
Electronic equipment cost	-	8.14	7.26	7.07
Cost per interview	200.16	135.52	107.33	102.56

Source: Rahija, et. al. 2016

Results show that electronic equipment costs more than data entry, and paper questionnaire cost (Rahija 2016). This is consistent with other studies showing that reduction or elimination of costs such as double-data entry, paper storage, and printing makes CAPI a cost-effective alternative to PAPI (Zhang, et al 2012; King, et. al 2013, Leisher 2014).

3.2. Progress in making the CAPI technology more accessible and user-friendly

The CAPI technology has never been more accessible and customized to potential users' needs. The number of new CAPI software packages is growing continuously. The market is a mix of open and closed sourced products. In some cases, there are products developed in the private sector that are built on the same open-sourced platform. Table 2 below shows a list of the most common CAPI software suites with their relevant features.

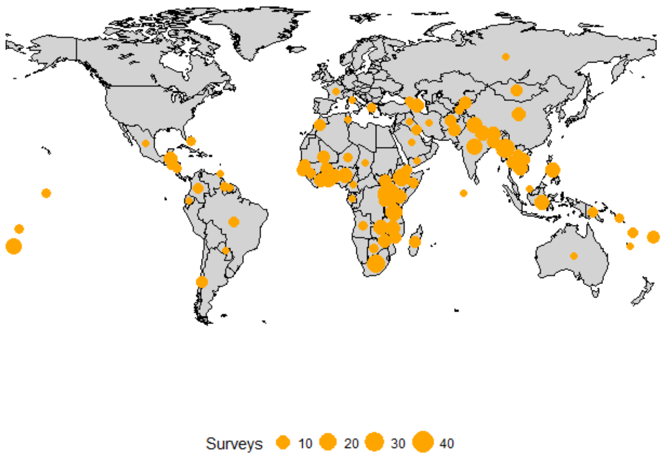
Table 2: *CAPI software suites*

Criterion	**Survey Solutions**	**CSPro**	**Open Data Kit**	**Blaise**
Cost	Free	Free	Free	$$$
Server requirements	Cloud or local, can be accessed anywhere	FTP, Dropbox	ODK Aggregate Server	IIS, ASP, relational database server
Learning curve	Shallow, little programming	Steep, uses unique language	Moderate, Excel based	Steep, uses unique language
Development Time	Short	Long	Moderate	Long
Questionnaire programming skills	Minimal training	Training required	Some training needed	Training required
Case management	Built in	Must be progammed	External program	Built in
Export formats	SPSS, STATA, TXT	SPSS, SAS, STATA, R, CSV, TEXT	XML, CSV	TXT, XML, ASCII,
Web Interviewing capability	Yes	No	No	Yes

Source: Global Strategy, 2016.

As Table 2 shows, available platforms have various comparative advantages. Through the Global Strategy, FAO has contributed to the development of Survey Solutions, which is specifically designed to allow NSOs to apply CAPI with minimal training and costs. In fact, FAO also uses Survey Solutions as the software suite of choice due to its shallow learning curve and advanced features for carrying out agricultural surveys. To date, Survey Solutions has been used in more than 100 countries (See Figure 2).

Figure 2: Survey Solutions use since 2012



Source: Authors' own calculation based on data received from the World Bank.

3.3. Capacity development initiatives in Africa

In Africa, several capacity development initiatives or efforts have contributed towards training and assisting countries in adopting the CAPI technology, particularly Survey Solutions, for conducting agricultural surveys. The variety and range of resources available will continue to alleviate the know-how barrier associated with the adoption of the technology.

Through the Global Strategy, regional workshops were carried out in Tanzania and Côte d'Ivoire. These hands-on workshops on the use of Survey Solutions for agricultural surveys brought together the technical staff involved in the collection of agricultural statistics in NSOs or Ministries of Agriculture as well as trainers and experts involved in statistical capacity development. Country-level capacity development activities were also conducted in Kenya and Tanzania. Similar activities are planned for 2017 in Botswana, Niger, Senegal and Liberia.

The Global Strategy has also developed through its training component a 10 module e-learning course and some training material to support in-classroom training, which covers the application of CAPI in every aspect of data collection. Training sessions or trainers' workshops were conducted thus contributing to improving the quality of the training on CAPI offered by the main regional statistical training centres for the next generation of statisticians. Some of these training centres have become centres of excellence in using CAPI, thus allowing them to support survey operations using CAPI.

FAO has also developed an expertise in assisting countries using Survey Solutions for data collection operations. Even in the implementation of its new flagship initiatives, such as the Agricultural Integrated Survey (AGRIS), FAO will build on the tools developed by the Global Strategy, which include Surveys Solutions versions of all the AGRIS generic questionnaires.

The African Development Bank and the World Bank have a network of experts that can provide training and technical assistance on Survey Solutions in the region. Countries have also started to assist each other in building the necessary capacity for using CAPI technologies.

IV. Geospatial technologies for agricultural statistics

As previously mentioned, the SDG indicator framework calls for geospatial disaggregation for relevant indicators. Focusing on national averages potentially hides inequalities. Fortunately, the use of geospatial tools such as Global Positioning Systems (GPS) can help NSOs incorporate geo-referencing into data collection. Geo-referencing farms and parcels provides the opportunity for geospatial analyses of agricultural variables, improving sampling, and optimizing logistics. Furthermore, GPS devices and tablets can be used for area measurement thus alleviating the need for time-consuming and expensive rope and compass methods.

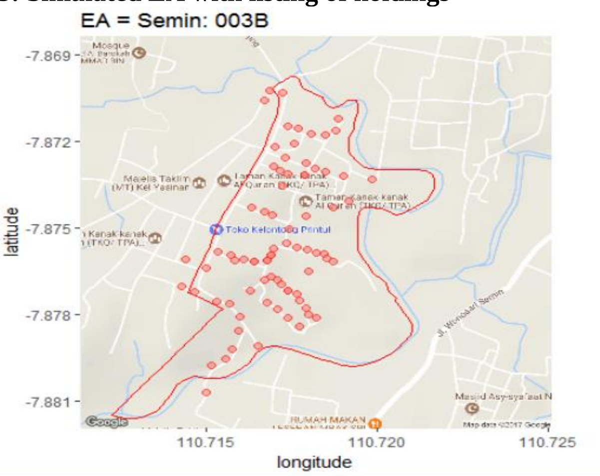
The use of remote sensing in statistical production is also becoming more attractive to lower costs while improving data quality. Its domains of application are various, and significant efforts have been made to overcome the barriers of costs, accessibility, quality resolution and lack of capacity-building resources associated with this technology. The next section will describe in more detail the cost-effectiveness of GPS and Remote Sensing and the resources (including tools) available to support countries in harnessing these technologies.

4.1. Geo-referencing farms

Due to the availability of low cost tablet and GPS devices, using geo-referencing in large scale farm surveys is now realistic. In addition to advanced geo-spatial analyses of agricultural variables, geo-referencing provides opportunities to improve field logistics and sampling frames. In the Survey Solutions CAPI software, geo-references can be taken by the tablet marking the exact location of the farm, parcel, etc. In Figure 3 below, simulated data shows a geo-referenced holding integrated with the boundaries of an enumeration area (EA).

It can be seen from Figure 3 that some holdings listed in EA 003B are outside the EA boundary. These should be removed prior to sampling. Furthermore, the geo-referenced sampled holdings can be loaded into the enumerator's GPS devices to help reduce travel time, and ensure that the correct holding is enumerated.

Figure 3: Simulated EA with listing of holdings



Source: Authors' own simulation.

4.2. Global Positioning Systems for Area Measurement

Recent research suggests that using GPS devices for area measurement is a cost-effective alternative to rope and compass methods and improves data quality. The Living Standards Measurement Study showed that GPS area measurement methods are a cost-effective and accurate alternative to compass and rope. Based on experiments made in 3 countries and thousands of plots, the differences in measurements taken with rope and compass were on average less than +/- .01 acres. Furthermore, on average, a plot that took only 15 minutes to measure with the GPS, took around an hour to measure with rope and compass (C. Carletto, et al. 2016).

4.3 Use of Remote Sensing in data production

As the technology to harness the use of satellite images and Geographic Information Systems (GIS) becomes more accessible and affordable, countries are now in a better position to integrate remote sensing techniques in their data production processes. In the context of the 2030 Agenda, these techniques are specifically recommended to collect information on some indicators (e.g. 15.4.2, sub-indicators of 2.4.1) or improve the quality of others (e.g. 2.3.1, 2.3.2, 2.4.1, 15.1.1, 15.2.1).

The cost-efficiency of using Remote Sensing in agricultural statistics "is best evaluated by comparing the gains obtained (usually expressed as a reduction of sampling variance) to the additional costs involved (cost of imagery, data analysis, staff training, and investment in hardware and software)" (Global Strategy, 2017, p.239). At the moment, the domain of application where the relative gains are the more common and significant, is related to the improvement of sampling design of agricultural censuses and surveys (pre-enumeration mapping, sampling frame design, stratification, adoption of an area sampling frame as an alternative to quickly outdated list frames…). The cases of Morocco, China, Haiti and the United States are provided in Global Strategy 2017 and 2015b.

Other domains of application in which the relative gains and costs concerned the improvement of estimators are: (1) the integration of ground survey results and satellite data through regression or calibration estimators to improve estimators and (2) crop monitoring and yield forecasting. Crop acreage estimation with remote sensing has also proven to attain cost-efficiency in countries were parcel size is not a limiting factor. Additionally, while cost-effectiveness was the main topic of this paper, the comparative advantage of using a Remote Sensing approach to obtain timely data should not be overseen. Periodic and timely monitoring of crop yields, essential to food security and market management, can be better achieved through Remote Sensing while minimizing the burden of costly fieldwork.

The future of Remote Sensing in becoming even more cost-effective is also bright. Image prices are expected to decrease, as free-of-charge long-term systems are secured by NASA and ESA at the resolutions required for crop yield monitoring (METOP, MODIS, Sentinel 3) and acreage estimation (Landsat 8, Sentinel 1 & 2). Long-term availability, image resolution (up to 10 m), frame size (up to 290 m x 290 m), revisiting time (up to five days) and the number of radiometric channels (above ten) are also improving. Open-source applications have become the standard in GIS and image analyses, as well as for accessing remote cloud processing tools (hardware and software, such as Google Earth Engine). Finally, although field size remains a limiting factor in 70 countries, the opportunity remains for at least 125 countries to envisage a successful use of remote sensing for current-season crop acreage estimation.

In terms of capacity development, FAO, though the Global Strategy, has released several research products (Global strategy, 2016b, 2015a, 2015b, 2015c, 2014b, 2014c) and more recently a *Handbook* *on Remote Sensing for Agricultural Statistics* (Global Strategy, 2017) to inform countries on the uses and techniques related to remote sensing.

In particular, the referenced documents discuss the following topics:

- The cost-effectiveness of using remote sensing for agricultural statistics and how to evaluate it;
- The fundamental requirements and criteria in terms of organizational arrangement, resources and competences for adopting remote sensing in agricultural statistics and conduct geospatial analysis;
- The different remote sensing data sources currently available, their accessibility and their related costs, with a focus on free and open-access sources;
- The various software available for image processing and geospatial analysis, in particular open-source software;
- The land cover mapping;
- The use of remote sensing in designing list and area frames, establishing a master frame for agricultural statistics and improving sampling strategies and estimations;
- Remote-sensing-based approaches for detailed (field-level) annual crop mapping at national scale;
- The use of remote sensing in crop area estimation, crop yield forecasting and informing Early Warning Systems;
- The estimation of forest cover and deforestation from global to nation scales using Earth Observation Technology.

The various technical assistance mechanisms of FAO have supported and will continue to support countries in using remote sensing for their major data collection operations, land coverage mapping and the assessment of forest cover and deforestation.

4.4. FAO Geospatial tools

Two products from the Open Foris toolbox, developed by the Forestry Department of FAO, can be accessed, free of charge, for visual interpretation of high resolution imagery and facilitate the integration of remote sensing techniques in data production.

The first one is Collect Earth. This tool, used directly to collect the indicator 15.4.2, enables data collection through Google Earth. In conjunction with Google Earth, Bing Maps and Google Earth Engine, users can analyze high and very high-resolution satellite imagery for a wide variety of purposes, including:

- Supporting multi-phase National Forest Inventories;
- Conducting Land Use, Land Use Change and Forestry (LULUCF) assessments;
- Creating area frames for agricultural surveys;
- Monitoring agricultural land and urban areas;
- Validating existing maps;
- Collecting spatially explicit socio-economic data;
- Quantifying deforestation, reforestation and desertification.

Its user-friendliness and smooth learning curve make it the perfect tool for performing fast, accurate and cost-effective assessments using a sample-based approach. It is highly customizable for the specific data collection needs and methodologies. The data gathered through Collect Earth is exportable to commonly used formats and can also be exported to Saiku, a tool that facilitates data analysis.

The second tool is the System for Earth Observation Data Access, Processing and Analysis for Land Monitoring (SEPAL). It can be used by countries to collect information for SDGs indicators 15.1.1 and 15.2.1 as well as any other indicators that use satellite imagery, as it includes more image processing capabilities than Collect Earth, which is a visual interpretation tool.

Using the algorithms of the Open Foris initiative, the open source cloud-based SEPAL computing platform facilitates countries' access to Earth observation data as well as the processing of that data. This user-friendly platform allows countries to overcome processing issues related to poor Internet connection or low computing power on local computers.

SEPAL has several interesting features. It can create composites and mosaics of Landsat and Sentinel, process RADAR data, perform image segmentation and land classification, and detect land cover changes. It also allows time-series analyses and sample-based area estimations. Finally, it is compliant with the Global Forest Observations Initiative (GFOI) Methods and Guidance.

These tools and their respective tutorials are available on the Open Foris website: http://www.openforis.org/tools/collect-earth.html

V. Conclusions and recommendations

Improving coordination within the statistical systems and adopting a consistent data collection program can reduce duplications of effort, prevent the release of conflicting statistics, and ensure the best use of resources related with the collection of the SDGs indicators. FAO recommends to take full advantage of the tools and methodologies developed in the recent years in order to adopt a more integrated approach to data collection, namely:

- The design and implementation of NSDSs and SPARSs, which will take into account the SDGs data requirements;
- The adoption of an integrated survey approach to collect information on agricultural households and holdings, such as AGRIS;
- The addition of SDGs-specific survey modules to existing household surveys;

FAO also recommends to integrate cost-effective collection tools and geospatial technologies such as CAPI, GPS and Remote Sensing in their data production system. They not only reduce the cost of data collection but also improve the quality of the data produced. Costs, accessibility and human capacity constraints should no longer be seen as major barriers preventing statistical agencies to adopt these technologies. FAO, through its various programmes, has made key publications and user-friendly tools available to facilitate countries' transition in implementing these technologies.

VI. References

Carletto C., Gourlay S., Murray S., Zezza A. 2016. *Land Area Measurement in Household Surveys. Empirical Evidence and Practical Guidance for Effective Data Collection.* World Bank. Washington, DC.

Food and Agriculture Organization (FAO). 2017. *World Programme for the Census of Agricultural 2020. Volume 1: Programme, concepts and definitions*. FAO Statistical Development Series 15. FAO. Rome.

Global Strategy to improve Agricultural and Rural Statistics (GSARS). 2017. *Handbook on Remote Sensing for Agricultural Statistics.* GSARS Publication: Rome. Available at: http://gsars.org/en/handbook-on-remote-sensing-for-agricultural-statistics/.

____________. 2016a. *CAPI e-learning course on Using Computer Assisted Personal Interviewing for Agricultural Surveys.* GSARS Publication: Rome. Available at: http://gsars.org/en/category/trainingmaterial/.

____________. 2016b. *Information on Land in the Context of Agricultural Statistics.* GSARS Publication: Rome. Available at: http://gsars.org/en/information-on-land-in-the-context-of-agricultural-statistics/

____________. 2015a. *Handbook on Master Sampling Frames for Agricultural Statistics: Frame Development, Sample Design and Estimation.* GSARS Publication: Rome. Available at: http://gsars.org/en/handbook-on-master-sampling-frames-for-agricultural-statistics/

____________. 2015b. *Technical Report on Cost-Effectiveness of using Remote Sensing for Agricultural Statistics in Developing and Emerging Economies.* GSARS Publication: Rome. Available at: http://gsars.org/en/technical-report-on-cost-effectiveness-of-remote-sensing-for-agricultural-statistics-in-developing-and-emerging-economies/

____________. 2015c. *Spatial Disaggregation and Small-Area Estimation Methods for Agricultural Surveys: Solutions and Perspectives*. GSARS Publication: Rome. Available at: http://gsars.org/en/spatial-disaggregation-and-small-area-estimation-methods-for-agricultural-surveys-solutions-and-perspectives/

____________. 2014a. *Guidelines on Strategic Plans for agricultural and rural statistics (SPARS).* GSARS Publication: Rome. Available at: http://gsars.org/en/guidelines-for-the-integrated-survey-framework/

____________. 2014b. *Developing More Efficient and Accurate Methods for Using Remote Sensing*. GSARS Publication: Rome. Available at: http://gsars.org/en/technical-report-on-developing-more-efficient-and-accurate-methods-for-the-use-of-remote-sensing/

____________. 2014c. *Technical Report on Improving the Use of GPS, GIS and Remote Sensing in Setting Up Master Sampling Frames.* GSARS Publication: Rome. Available at: http://gsars.org/en/technical-report-on-improving-the-use-of-gps-gis-and-remote-sensing-in-setting-up-master-sampling-frames/

King J., Buolamwini J., Cromwell E., Panfel A., Teferi T., et al. (2013). A Novel Electronic Data Collection System for Large-Scale Surveys of Neglected. *Tropical Diseases*. PLoS ONE 8(9): e74570. doi:10.1371/journal.pone.0074570.

Liesher C. (2014) A Comparison of Tablet-Based and Paper-Based Survey Data Collection in Conservation Projects. *Social Sciences*. ISSN 2076-0760.

Rahija M., Mwisomba T., Kamwe M., Muwonge J., Pica-Ciamarra U., *Are CAPI based surveys a cost-effective and viable alternative to PAPI surveys? Evidence from agricultural surveys in Tanzania and Uganda.* International Conference on Agricultural Statistics VII. Rome, Italy. 2016.

Sustainable Development Solutions Network. 2015. *Data for Development: A Needs Assessment for SDG Monitoring and Statistical Capacity Development.* Accessed at: http://unsdsn.org/resources/publications/a-needs-assessment-for-sdg-monitoring-and-statistical-capacity-development/.

World Bank (WB), Food and Agriculture Organization (FAO) and United Nations (UN). 2010. *Global strategy to improve agricultural and rural statistics.* Report number 56719-glb. Available at: http://gsars.org/en/global-strategy-to-improve-agricultural-and-rural-statistics/

Zhang S., Qiong W, et. al. 2012. *Smartphone Versus Pen and Paper Data Collection of Infant Feeding Practices in Rural China*. *Journal of Medical Internet Research*, 14(5): e119.