Experiences with Census of Agriculture in Africa

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[The views expressed in this paper are personal to the author and do not necessarily represent those of the institutions with which he is associated.]

ABSTRACT: The census of agriculture is a main source of benchmark agricultural data and a vehicle for further development of national agricultural statistical systems in African countries. However, the number of countries able to carry out the census has remained low over the years because of the high costs and complexity of the operation.

Data on large-scale holdings are usually collected on a complete enumeration basis using self-administered questionnaires, while small holdings are covered on a sample enumeration basis using the method of farmer interviews and/or objective measurements. Non-response rates among large-scale holders are high, while the rates among small-scale holders are invariably very low. Data processing is carried out using microcomputers and customized data processing programmes. Census reports are the main dissemination medium.

Census data quality is assured through publicity of the census, pre-tests of survey instruments and procedures, use of pre-coded questions, staff training, instituting operational control of document flow, establishment of field organization, close supervision of activities, manual and screen editing and checking tabulations for consistency.

Organizational, operational and technical problems include, *inter alia*, limited technical skills, delays in supplying equipment, unreliable power supply, high costs of field operations, underdeveloped infrastructure, frame creation, area and yield measurement, etc. Major weaknesses of the agricultural census programme include inadequate coordination with that of the population census, limited reporting and insufficient documentation of field experiences, failure to provide small area statistics and limited dissemination and utilization of census data.

It is proposed to develop a census programme that collects both agricultural and population data and to expand the scope of current agricultural surveys to include census-like indicators as a stopgap measure.

1. Introduction

Agriculture is the dominant sector of most African countries, accounting for between 50 percent and 70 percent of total national production, more than 80 percent of the export earnings, more than 80 percent of the economically active population, etc. In a sense, agriculture is the "engine of growth" of these national economies. Most countries have a dual agricultural economy of a small-scale/subsistence subsector and a large-scale/commercial subsector.

1.1 Small-scale/Subsistence Subsector

Most African agriculture is carried out by millions of small holders who are geographically dispersed, grow a variety of crops on small holdings using household labour primarily for their own consumption, carry out rainfed agriculture at low levels of inputs (improved seed, fertilizers, pesticides, mechanization and management), do not know the size of their plots/fields, do not keep records, are mainly not literate or numerate, and do not have a definite mailing address.

This is graphically illustrated by the following selected results from the 1994/95 Tanzania Census of Agriculture.

- Average agricultural household size was just over 5 persons.
- About 72 percent of members of rural households had no formal education; however, 30 percent of these could read and write.
- Average holding size was about 3 hectares.

- An estimated 12 percent of crop farmers owned ploughs, 5 percent used agricultural credit, 28 percent used improved seed, 0.1 percent owned a tractor, 36 percent used organic manure, 1 percent had permanent employees, 28 percent used agrochemicals, and 15 percent used inorganic (chemical) fertilizers.
- 3 percent of crop farmers practised drainage, 3 percent carried out irrigation, and 74 percent sold some produce.
- 98 percent of cattle were indigenous breeds, 1.4 percent were improved dairy breeds, and 0.6 percent were improved beef cattle.
- 58 percent of those raising cattle carried out vaccination, 21 percent dipped their cattle, 37 percent carried out animal castration, and 7 percent owned cattle shelters.
- Women were responsible for 64 percent of tilling, 70 percent of sowing, 71 percent of weeding, 73 percent of harvesting, and 56 percent of marketing.

Most of this paper relates to data collection and handling from this subsector.

1.2 Large-scale/Commercial Subsector

The large-scale/commercial subsector is insignificant in both number of holdings and overall contribution to total agricultural production. In Tanzania, for example, out of about 4 million estimated holdings, only about 1,000 (or about 0.03 percent of the total) are in this subsector. Holdings in this subsector have land titles, a definite mailing address, and proper records are kept on their operations.

1.3 Census of Agriculture

Development and monitoring of the agriculture sector requires data on a wide range of indicators. A census of agriculture is one of the main sources of such data (see Subsection 2.1). Available records indicate that only one country in Africa (South Africa) participated in the 1930 World Census of Agriculture (WCA) programme. The number increased to 3 in 1950, 16 in 1960, and peaked at 22 in 1970. After this, the number of countries participating in the census fell to 17 in 1980 and 14 (only 26 percent of the total) in 1990.

This paper is a review of the main experiences with census of agriculture in Africa. Section 2 outlines the importance of the census, while Section 3 presents main experiences including some weaknesses of the census of agriculture programme in the region.

2. Importance of the Census of Agriculture in Africa

The census of agriculture is of crucial importance to African countries for reasons which include the following.

2.1 Benchmark Data

Where it has been completed, the census has been the main (if not only) source of comprehensive benchmark data on the organization and structure of the agriculture sector, including size and distribution of agricultural holdings by type of enterprise, basic demographic characteristics of holders and households, inventory of production factors, tenure arrangements for production factors, land use patterns, agricultural practices (e.g. irrigation), drainage, etc.

2.2 Vehicle to Further Develop the National Agricultural Statistical Information System

The census has provided a convenient vehicle to further develop the national agricultural statistical system in many ways. In particular, the census programme has:

- fostered *user-producer dialogue*, essential to develop the national agricultural statistical system. Prior arrangements for this have tended to be unsatisfactory and infrequent.
- provided an opportunity to rationalize the agricultural statistical system, including initiating collaboration arrangements between the Ministry of Agriculture (MOA), Central Statistical Office (CSO) and other major agricultural data producers who often collect data in an uncoordinated manner. The advantages include cost-effective resource use, production of consistent, comparable data, avoiding working at cross-purpose, better data quality, etc.
- enhanced development and/or upgrading of the workplace skills of personnel.
- enhanced capacity to collect field data by strengthening the*field organization* through training and provision of equipment and transport for supervisors and enumerators.
- enhanced *data processing and analytic capabilities* through training and provision of computers and related equipment.
- developed, in some countries, integrated computerized*databases* for systematic storage, easy access/retrieval and updating of agricultural time series data.
- provided a good basis for intercensal current agricultural surveys.

3. Some Experiences with the Census

3.1 Nature of the Census

The census of agriculture is a monumental, very expensive and complex statistical operation, invariably undertaken by national governments with donor support. The census is implemented by the Central Statistical Office (CSO) or the Ministry of Agriculture (MOA). In some countries, the census is a joint activity of the two institutions.

3.2 Technical Assistance

Many countries still have limited skills in such critical areas as census management, sample design, data processing, analysis and reporting. Accordingly, technical assistance is usually sought and given by international organizations, principally the Food and Agriculture Organization of the United Nations (FAO). Previously, this was given in the form of long-term advisors. Increasingly, however, it is in the form of short-term international consultants with the bulk of the work being done by national (counterpart) staff.

3.3 Geographical Coverage

Like the current agricultural surveys, censuses of agriculture cover rural areas. Urban areas tend to be omitted due to their perceived low contribution to total production. However, it is increasingly evident that agriculture is an important activity in urban areas especially among the poor, particularly women, as a survival strategy, a source of income-substituting food and employment.

3.4 Coordination with Population Census

The censuses of agriculture and population are the most important censuses in any African country. While the census of agriculture benefits greatly from that of population, especially if carried out soon after, there is often no coordinated implementation. The agricultural census may precede that of population or be implemented long after. In recent years, however, international organizations like FAO have increasingly stressed the need for coordination.

In very few countries, coordination has been very successful. In Zambia, a short agriculture module was successfully "piggybacked" onto the 1990 population census to collect data on crop area and production for main food and cash crops as well as livestock and poultry. In Mozambique, some agricultural questions are included in the 1997 population census. The Central African Republic has developed a census programme that covers both areas.

3.5 Census Structures

In order to strengthen government structures to enable them to conduct the census, *ad hoc* structures are invariably established. These structures usually include committees.

Usually two types of committees are established — one to deal with policy matters, and the other to handle technical and operational aspects of the census. In some countries, it has been found useful to duplicate these committees at sub-national (regional/provincial) levels.

Besides committees, a *field organization* is usually set up where one does not exist.

3.6 Sample Design

3.6.1 Large-scale/Commercial Holdings

Because of their small number, these are usually surveyed on a *complete enumeration basis*.

3.6.2 Small-scale/Subsistence Holdings

These holdings are invariably enumerated on a *sample enumeration basis*. The sample design used is usually a *household-based multi-stage cluster sample design* with census *Enumeration Areas (EAs)* delineated for the most recent population census or *villages* or *localities* as the *primary sampling units (PSUs)* and *agricultural households* as *secondary sampling units (SSUs)*. In a few countries, PSUs are *National Master Sample (NMS)* units. NMSs have been established in some countries to systematize and rationalize the collection of household-based data, including agricultural data. Where the NMSs have been established, it has been found cost-effective to use them as PSUs for the census of agriculture.

The SSUs should ideally be an *agricultural holding*. However, in many African countries, there is no way of getting at a small holding except through the household operating it. Typically, a one-to-one relationship between the holding and the agricultural household exists or is presumed. FAO recommends that agricultural operations carried out and commodities produced by different members of a household be pooled so that there is only one holder. This solves the problem where members of an agricultural household operate separate holdings, especially where polygamy is common. The opposite situation, where a holding is operated by persons belonging to different agricultural households, is rare.

So while the basic sampling unit in the census should be the agricultural holding, in reality the unit in the African situation is the agricultural household.

It is necessary to stress the importance of the household approach in conducting an agricultural census or survey in Africa and other developing countries. Many relationships can exist between a household as a consumption unit and a holding as a production and income generating unit. Use of the household approach allows these censuses/surveys to be integrated into *National Integrated Household Survey Programmes*, where these exist, and permits studies of relationships among socioeconomic and demographic variables.

The PSUs tend to be selected at headquarters using *probability proportional to size (PPS)* with number of households as the measure of size. All households in selected PSUs are listed and screened to create sampling frames of agricultural households. Usually more than 90 percent of rural households are agricultural. From lists of agricultural households in selected PSUs, a sample is selected by enumerators using a *systematic sampling method*. The same sample size of agricultural households tends to be taken from each PSU to even out enumerator workload.

3.7 Training

The census gives great opportunities to develop human resources associated with agricultural statistics where it has been carried out. In particular, training emphasizes the development of skills that directly translate into better job performance. As part of preparation for the census, and indeed during and after the census, training has been carried out for all staff at all levels.

The training generally includes advanced training abroad for managers of the agricultural statistical system, study tours for professional staff to learn from the experiences of other countries with similar socioeconomic conditions, in-country group training, and on-the-job training. Group training has received greater priority attention in the design of the census due to its immediate impact. Training for field data collection is usually carried out in a hierarchical manner. Headquarters staff are trained first (centrally) and then go to regions to train field staff. Training sessions are also held for editing staff and computer personnel.

3.8 Census Instruments

Different survey instruments are usually designed and used to collect data. These include listing forms for compiling frames of SSUs, questionnaires and instruction manuals.

In many Sub-Saharan African countries where there are many language groups, the tendency has been to print questionnaires in the language of the metropolis — English, French or Portuguese — and to translate these during data collection, as most respondents do not know this language. This has been identified as one source of non-sampling errors in census data.

3.9 Data Collection

3.9.1 Field Organization

To facilitate data collection, field organizations tend to be set up where they do not already exist. Where they exist, they are strengthened by staff training and provision of logistical support. Field organizations are important links between those who have data (respondents) and those who need the

data (census organizers). They usually comprise a cadre of field staff (supervisors at different levels and enumerators), offices in regions/provinces and logistical support in the form of equipment and transport (vehicles, motor cycles and bicycles).

3.9.2 Data Collection Methods

Different data collection methods have been used in different countries. These include self-enumeration, farmer interview and objective measurement methods.

Self-enumeration method: Self-enumeration is widely used to collect data from large-scale/commercial agricultural holdings. In the past, a mail questionnaire was used in many countries. However, because of low response rates (around 25 percent in some countries), enumerators are increasingly becoming involved in delivering and collecting questionnaires in this subsector.

Farmer interviews: In all countries, farmer interviews are used to collect agricultural data on indicators such as holding characteristics, agricultural inputs, agricultural practices, crop diseases, livestock numbers, etc. This involves enumerators identifying selected holders, interviewing them using a structured questionnaire and recording responses. The method has a number of advantages including on-the-spot clarification of objectives, concepts and form of information sought, etc. The disadvantages include high costs of locating holders and collecting data, interviewer bias, and response errors especially in reporting crop area and production data. Failure by holders to provide accurate estimates of crop area and production has been attributed to many causes including lack of knowledge about the size of fields and standard measurement units, or unwillingness to report correctly for a number of reasons (e.g. taboos, fear of taxation, etc.)

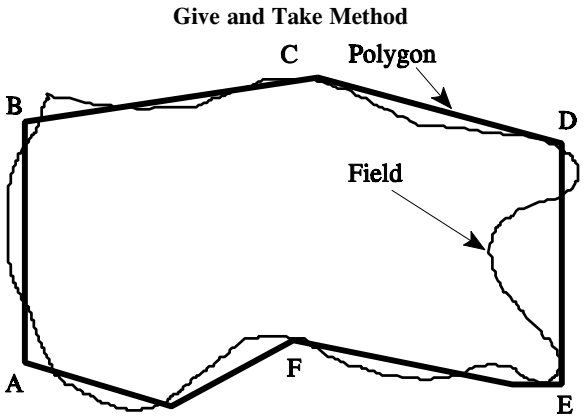
Objective measurements: In many countries, reliable data on crop area and yield can only be obtained through objective (physical) area and yield measurement.

Area measurement: Of the objective methods used, the FAO recommended method is the best. It consists of:

- identifying the boundaries of the field to be measured;
- determining the shape of the field which is usually irregular and reducing the field to an *equivalent polygon* using the *"give and take method"* (see figure below);
- taking compass bearings of each side of the polygon with respect to the North;
- measuring the lengths of each side of the polygon; and
- using a programmable calculator to calculate both the area of the field and *error of closure*; the latter is used as a measure of how well the field has been measured.

The method provides reliable area estimates when judiciously applied. However, it is expensive and cumbersome to apply.

In addition, effective application of the method requires a cadre of well trained, conscientious and well supervised field staff. Such staff are in short supply in many countries. Indeed area and yield data are still collected using the method of farmer interview in many countries.



Production measurement: Through objective measurement, crop production is obtained as a product of area and yield. Yield measurement is done using the crop-cutting method. This method, pioneered in India and now used worldwide, is regarded as the most reliable method for measuring crop yield. The method involves crop-cutting from small yield sub-plots (YSPs) of specified shape and size randomly placed in the field, and subsequent threshing, drying and weighing of the harvest for the purpose of estimating yield.

Different shapes and sizes of yield sub-plots are used for yield measurement. The main shapes of yield sub-plots which have been used in the past are squares (Malawi, Sierra Leone, Nigeria, Kenya, etc.) and circles (Lesotho, Tanzania, Zambia, etc.)

Crop-cutting is very involved and is only used to estimate yield for a few important crops, and even then only on a subsample of the sample used for area measurement.

3.9.3 Non-response

Total non-response rates among small holders are invariably very low and where they occur, are mainly due to deaths or out-migration of sampled households after the census has started, and not due to refusal to cooperate. However, occasionally, item non-responses occur.

3.10 Data Processing

Data processing has been the main cause of delays in releasing census results. Until recently, many countries lacked in-house computing facilities and qualified, experienced data processing personnel to process census data. Consequently, it often took several months to a couple of years to produce some results. However, with the increased use of microcomputers for data processing, there has been notable improvement in the timeliness of census results.

3.11 Data Analysis and Reporting

Data organizers carry out primary analysis based on generated basic tables. Occasionally, more definitive analysis has been done by university researchers. Data analysis and reporting have also improved, thanks to many user friendly packages which are readily available on the market.

3.12 Dissemination

Census reports are the most commonly used dissemination medium. A number of census reports are printed and distributed (free) to main data users. Some copies are usually sold at nominal price (non-cost recovery basis). Usually the reports are sent to user institutions, a list of which is maintained by data producers.

In some countries, dissemination seminars have been held for major data users to inform them about available data, their quality and how they can be accessed.

3.13 Data Quality Assurance

The following are some procedures which are usually put in place to ensure census data quality:

- *extensive publicity* of the census programme using different methods;
- *pre-testing* survey instruments — listing forms, questionnaires, and data processing systems including application programmes;
- use of mainly *pre-coded questions*;
- institution of strict *operational control* of the document flow;
- *training* of all staff engaged in the census programme;
- setting up *field organization* with defined functions;
- carrying out *close supervision* of staff at every level;
- doing both *manual and screen editing* of questionnaires — sometimes on 100 percent basis; and
- *checking tabulation* consistency.

3.14 Some Organizational, Operational and Technical Problems

The following are some of the organizational, operational and technical problems of varying degrees of severity faced in implementing the census of agriculture in the African region.

3.14.1 Organizational and Operational Problems

Timing of the census: Some countries in drought prone areas of Africa have had problems when the reference period for the census was a drought year. If the reference period is a drought year, it is difficult to collect benchmark data. Two countries solved the problem by collecting census data in two (consecutive) agricultural seasons. Tanzania repeated its census in the 1994/95 season having carried out the census in 1993/94, a drought year. Zambia spread its 1990/92 census over two agricultural seasons of which one (1992/93) was a drought year, so it too could collect benchmark data from the census programme.

High cost and complexity: The census is a very expensive and complex operation. The high cost and complexity are due to the subsistence nature of the agriculture sector and the underdeveloped socioeconomic infrastructure in most African countries. For these reasons, the census is usually carried out at intervals of 10 years and even then on a sample basis. There are, however, a number of countries which could only manage to repeat the census after 20 years.

Limited technical skills and experience: Technical skills required to manage all aspects of the census programme are not always available. Areas where expertise has been lacking include census management, sampling design, data processing, data analysis and reporting. Where this deficiency has been identified in time, technical assistance has been sought from international organizations.

The time interval between censuses is so long that experience from the previous census is usually not ploughed back into the new census programme because it is either lost or its relevance will have been eroded by the passage of time.

Equipment: In many countries, the census programme has had start-up problems caused mainly by delays in procurement of equipment for the census. Also in some countries, inappropriate equipment has been bought, which is too fragile for the rough field conditions.

Unreliable power supply: Some countries experienced problems with electricity supply which has adversely affected data processing activities. Some countries solved this problem by installing standby generators.

3.14.2 Technical Problems

The main technical problems faced relate to construction of sampling frames as well as area and yield measurement. The following are some of the problems which have been experienced.

Problems of constructing sampling frames of PSUs: Where the NMS does not exist, frames of PSUs have had to be created using data from the most recent population census. In a number of countries, however, the agricultural census was carried out long after the population census. In these cases, available population census data (e.g. size and boundaries of EAs) are out of date and have to be updated. This is neither easy nor cheap to do.

Problems of constructing sampling frames of SSUs: The main problem associated with construction of sampling frames of SSUs include appreciation and application of the concept of *household* as distinct from the concept of *family* with which most people, including field staff, are more familiar.

Sample selection: It has been mentioned that the sample used in the census is usually a household-based multi-stage design. The estimate of the population total based on a two-stage PPS sample design is given by:

$$\hat{Y}_{PPS} = \frac{1}{a} \sum_{1}^{a} \frac{y_i}{P_i}$$

where a is the number of selected PSUs, y_i is the total for study variable y, P_i is the selection probability of the ith PSU. This estimate is precise if the study variable y and the measure of size x are proportional. So to the extent that household numbers used as measures of size to select the PPS sample are proportional to the study variable, the PPS estimates are precise. It is, however, known that some important agricultural variables are not related to population numbers. Such variables include livestock. Indeed estimates of livestock numbers in censuses of agriculture in many African countries are not estimated with a high degree of precision and are open to dispute.

Measurement: A number of measurement problems have been experienced. These include approximating the field with equivalent polygon, area measurement in complex cropping systems and yield measurement.

Area measurement: The quality of measurements of crop areas using the FAO recommended method depends on two factors:

- how well the "give and take method" has been applied to approximate the field with an equivalent polygon; and
- how well the equivalent polygon has been measured as per magnitude of the error of closure.

Unfortunately the first factor is not emphasized sufficiently in the literature or even during training of field staff, so that the impression is created that a low error of closure means that the field area has been well measured. It is possible to realize a low error of closure when the area of the field has been badly measured. This happens if enumerators measure well an inappropriately constructed polygon.

Problems of area measurement are often compounded by the complexity of cropping systems which often involve mixed cropping, continuous planting and harvesting, etc. For instance, mixed cropping is a common feature of subsistence agriculture in many African countries. In Tanzania, it was estimated that on average, 47 percent of all planted area in the 1994/95 season consisted of mixtures. The practice of planting crops in mixtures makes it difficult to properly measure the area under crops in the mixture, particularly when there are no established norms or information to apportion area to constituent crops in mixtures. Usually, subjective methods are used to apportion area under mixed crops and this does not inspire confidence in area estimates.

Yield measurement: There are technical problems associated with placing of the yield sub-plots in crop plots. In general, there is inherent bias in placing yield sub-plots in favour of areas towards the centre of the field (plot) and this partly accounts for the overestimation that accompanies the crop-cutting method. A detailed review of these problems is given by Scot [1989].

3.15 Major Weaknesses of the Census

The following are some of the major weaknesses of censuses carried out in Africa.

3.15.1 Lack of Coordination with Population Census

As pointed out earlier, coordination between the agricultural and population censuses has been limited or nonexistent. This has made the agricultural census more expensive and difficult.

3.15.2 Reporting and Documentation

Reporting and documentation of field experiences is usually not done systematically, if at all. While staff are often required to note down their experiences and the problems they face, the reports are either not made and where they are made are not processed and collated or consolidated. What is more, the field staff are usually not given uniform guidelines and formats for documenting experiences and problems. As a result, documentation of experiences is usually unsatisfactory.

3.15.3 Large Non-sampling Errors

The scale of the operation is such that more people are employed in the field than can be adequately trained and supervised. In addition, the underdeveloped infrastructure makes transport and communication into and out of villages difficult. Often there are problems in providing accurate responses on items such as planted area, crop production, number of livestock owned, etc. All of these

have been identified as sources of non-sampling errors, which in extreme cases have been so large as to vitiate the census results.

3.15.4 Data Disaggregation

Generally, the census gives results at national and regional/provincial levels only. The size of the sample used is usually not large enough to provide small area statistics — sub-regional estimates. The need for small area statistics, however, is becoming greater, with sub-regional administrative units becoming the focus for development efforts as more and more governments in Africa decentralize administration, devolving planning and related functions to these levels.

3.15.5 Dissemination of Census Results

Apart from production of census reports, there usually are no comprehensive programmes to disseminate and promote the use of the census data and results. Such programmes are essential to ensure that funds are appropriately budgeted for census dissemination activities and also to ensure that census data which are collected at high cost to the country are put to optimum use.

Enhanced data user-producer coordination and development of on-line computerized databases will go a long way in promoting the use of census and other agricultural data in Africa.

4. Future Outlook

From the foregoing, it is clear that the census of agriculture programme has not been terribly successful in the African region and the future outlook for the programme is not bright. Yet, census-like data are in real demand. As a way forward, it is proposed that countries in the region establish a *census programme* that will collect both agricultural and population data, not necessarily in one field operation. The census programme will, among other things, allow for maximum coordination in collection and handling of data on population and agriculture, make it easier to source funds for collecting agricultural data, and provide some small area statistics. However, as a stopgap measure, it is proposed that the scope of the current agricultural surveys which most countries are carrying out on an annual basis should be expanded to include those indicators which are usually monitored by the census of agriculture programme. Census data items could be surveyed every three or four years.

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