Measuring Area, Yield and Production of Vegetable Crops

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DOI: 10.1481/icasVII.2016.g44d

ABSTRACT

The horticulture subsector is among the fastest growing agricultural sub-sectors in most Sub-Saharan African countries. Compared to traditional field crops, horticultural crops (or vegetable crops) exhibit several advantages that make them attractive to farmers, both commercial and subsistence. Vegetable crops contribute significantly to food security and income generation for a large segment of the population, particularly women. The growth of this sector can also contribute to the reduction of rising unemployment levels in both urban and rural sectors. In recent years, the horticulture industry has become a noticeable earner of foreign exchange; in fact, some of the horticultural crops provide a viable option for diversification hence widening a country's export base.

However, despite this importance, vegetable crop cultivation has been one of the least statistically explored sectors in many African countries. The quantity of vegetable crops produced each year is largely unknown in most countries. There are a number of country experiences or

isolated studies and surveys on the estimation of vegetables and fruits, but since vegetable crops are often outside of the traditional scope of agricultural surveys and censuses, there is no consolidated and internationally validated estimation methodology.

The survey approach for the estimation of area and production is a challenge due to the large variety of vegetable crops. Issues to be taken into account in horticulture crop production estimate methodologies include (iii) Plant phenology, cultivation and harvesting techniques, (iv) implying crop area and yield measurement issues (i) no normalised concepts and definitions for horticulture crops; (ii) Sampling frame and sampling design.

Therefore, there is a need to develop adequate methodologies to estimate vegetables crops areas, yields and production. The purpose of this paper is to propose a consolidated methodology for estimating vegetable crops area, yield and production addressing the main methodological issues and taking into account lessons learnt from past experiences, from country practices and analysis of data from case studies in pilot countries in the context of African countries. The paper will build on a technical paper prepared in the framework of the Research Programme of the Global Strategy to Improve Agricultural and Rural Statistics.

Keywords: Vegetables, Production, Estimates.

1. Background

Accurate statistics on vegetable crop area and yield and production regularly released and communicated to the public must play an important role in planning and allocating resources for the development of the agriculture sector and food security in Africa. Reliable and timely information on vegetable cultivation is of vital importance to planners and policy makers including governments for planning the development of the sector, private companies for important decision-making related to products purchase, storage, distribution, import, export and other related issues.

The challenges for getting accurate estimates on vegetable crop production are not the same for different regions and countries around the world. In developed countries where vegetable holdings are keeping management records and area planted, production, yield, input are registered, the survey or census for estimating vegetable production remain sampling issues, the variable to be recorded are easy to get from the holders. In countries where value chain is well organized and the bulk of vegetable crop production are commercialised through a well-known limited number of markets, the estimates can be obtained through administrative sources related to market data. Expert assessment is also used for vegetable crop production estimates in some countries. The experiences of some countries below illustrate the different methods:

Some countries like Malta and Mexico are collecting vegetable crop data using administrative records and sources of vegetable crop estimates.

The Mexican agricultural statistics program uses administrative registers to obtain vegetable crop data. In particular, the agriculture information includes the sown area, harvested area, damaged area, observed and estimated harvests, etc. The Ministry of Agriculture (SAGARPA) state offices combine advanced reports on sown and harvested areas during the first ten days of each month and

continue to capture this information in order to include the cumulated data in the next month's report. The central office of Ministry of Agriculture provides the rules and the information system for processing the data.

In Malta, to do away with expert advice the Agriculture and Fisheries Unit decided to embark, with the support of European Union, on a survey project using scientific methods in order to provide solid foundations for present and future vegetable crop production estimates (TAPAS project).

Interviewing was carried out during a twelve-week period extending from March to May 2005 and the information collected referred to harvested crop production for the calendar year 2004. The households in the sample were informed individually by mail explaining the scope of the survey and the information it was about to collect. Each farmer was asked to prepare area and production figures for the year 2004.

The final results from the TAPAS Project gave a total crop production of 106,922 tonnes in 2004, with a percentage error of 4.3 given a 68 per cent level of confidence. This production was significantly higher than the volume which passed through organized markets which stood at 44,513 tonnes during the same period. The primary aim of the survey was to establish the level of production which by-passes the market. Table 4.1 shows the percentage comparison between the total production from the survey, and the volume of produce that can be collected directly from administrative sources. It can safely be concluded that there are no direct sales for tomatoes, carrots and vegetable marrows and also administrative sources are very reliable. As for beans and onions this is absolutely the opposite as only a small percentage pass through the official markets. On the other hand, the production of beans and onions are mainly grown by part time farmers and are either consumed on the holding or sold directly. A substantial volume of certain crops, namely sugar melons, water melons, cabbages and cauliflowers are sold directly by the holding and by-pass the official market (TAPAS, 2005).

Table 4.1 Comparison between estimated total crop production (t) and crop production (t) from

administrative sources

	Production (t) TAPAS survey	**Total production (t) from administrative sources**	**%**
Tomatoes	15,047	15,051	100
Onions	5,276	2,254	42,7
Beans	1,990	467	23,5
Vegetables Marrow	3,083	3,046	98,8
Water melons	5,148	4,400	85,5
Sugar melons	4,172	2,871	68,8
Cauliflowers	5,065	3,186	62,9
Cabbages	3,482	2,634	75,6
Lettuce	2,720	2,237	82,2
Carrots	1,612	1,648	102,2

Sources: Fruit and vegetable production/Final report (TAPAS, 2005).

Some countries do not implement a specific sample survey or census for vegetable crops. Accordingly, vegetable crop data are collected together within the framework of an existing agricultural survey or census. Therefore, data on vegetable crops are collected together with other crops like cereals, fruits, etc. In many Europeans countries, the Survey on Agricultural Production

Methods, abbreviated as SAPM, was a survey carried out in 2010 to collect data at farm level on agri-environmental measures in the EU. European Union (EU) Member States could choose whether to carry out the SAPM as a sample survey or as a census survey. The SAPM covered all agricultural holdings (including vegetable crops holdings).

In the case of Africa and Asia, due to the diversity situations of vegetable crops cultivation, it is difficult to collect vegetable data production together with traditional crops.

Some vegetable holdings are usually located in specific areas. In developing countries, they are located in the neighbouring of cities, where it is easy to access markets to sell produce due to perishability of these types of crops. In many countries, most of the vegetable crop plots are located in specific sites, generally near water points in rural areas where water is available for irrigation (AFRISTAT & DNSI, 2004). Therefore, a sample used to estimate the production of a set of crops (including traditional and vegetable crops) is not able to capture in an efficient manner the production of the latter. Sampling bias error could be large considering vegetable crops holdings are not spread enough and could be considered as rare crops. Specific surveys with specific sample designs are necessary for the vegetable crop estimate survey.

The specific case of Africa

The practice of growing vegetable crops is prevalent in almost all African counties. Horticultural crops, especially vegetable crops, serve a dual function as both cash and food crops. The methods and techniques employed by producers for growing and harvesting these crops vary from region to region, according to peculiarities of vegetable crops. Furthermore, the specificity of vegetable crops such as continuous harvesting, successive harvesting, staggered harvesting, the different methods of cultivation and marketing strategies adopted by holders including timing and frequency of harvest for staggered crops pose certain statistical challenges (area and yield measurement) that are not present in traditional crops (cereal and root crops).

One particular challenge is that the growing cycle is often short for vegetable crops compared to traditional ones and vary considerably from one vegetable crop to another. This allows several planning and harvesting occurrences for the same vegetable during a single growing season and different crops rotation during the same growing season. As a result, different crops are often sown and harvested on the same piece of land during the agricultural year. This practice is the main characteristic of vegetable growing. In developing countries, another characteristic is that the farmers are typically small holders and are located near wet zones and big cities due to the perishability of these crops and the lack of storage facilities, and close proximity to major markets.

Another challenge is the application of technology such as fertilizers and irrigation to vegetable crops that affects yield and the number of harvests.

Due to heterogeneity among cultivation techniques, and frequency of harvest, choosing the appropriate observational method for a particular crop can be difficult. The observational method should be chosen based on the crop and cultivation technique including necessity for periodical monitoring. For the purposes of this study, vegetable crops are divided into 5 types with regard to the nature of crop (leaf, root, fruit) and the methods of harvest (single, staggered) requiring a specific method for yield estimation:

1) Leafy vegetables with staggered crop harvest;

2) Leafy vegetables with single harvest;

3) Root vegetables with single harvest;

4) Fruit vegetables with single harvest;

5) Fruit vegetables with staggered harvest.

In these cases, staggered harvest crops refer to crops for which fruits or products do not mature at the same time and for which multiple harvests are required and spread over a period of time. Examples include tomatoes, okra etc. On the other hand, single crop harvest refers to crops that are completely harvested upon maturity and destroyed thereafter. These include pumpkins, cabbage, lettuce, carrot, etc.

2. Objectives

Considering the issues of having a sound methodology for vegetable crops production estimate, the Global strategy to improve agricultural and rural statistics added this domain to the list of research topics to be explored in the research plan. A literature review has been prepared to review the methods used in different countries and regions to produce vegetable crop production estimates and to prepare and implement Field Test Protocol (FTP) and a guideline to support countries. The FTP targeted development countries where technical issues are more acute. Among all existing sources (administrative, expert assessment, census, survey) the FTP targeted to conceive and implement survey methodology in order to assess the technical choices and the results and gather elements to prepare a methodological guideline. The FTP has tried to explore all aspects to have a good survey providing accurate estimating of interested parameters including:

- Necessary adaptation of concepts and definitions for vegetable crop survey
- Appropriate sample frame for vegetable crop holdings:
- Appropriate sample design for effective sample selection for the survey aiming at having accurate harvested area and yield estimates for all significant crops including rare and cash crops
- Appropriate methods for harvested area and yield data collection considering the challenges identified for this kind of crop (continuous planting/harvesting, staggered harvest crop)

The FTP has been applied in Ghana and this paper will try to summarize the methodology adopted for measuring vegetable crop area, yield and production based on a sample survey. The paper will address the primary challenges associated with measuring vegetable crop production. More specifically the pilot has addressed the issue of sample frame and sample design and the issues of having easy and accurate measurement methods for production parameters estimates (area harvested, yield). The FTP puts emphasis on:

- The method for choosing or developing an appropriate frame of vegetable crop holdings, and specific variables to be collected during PSUs constitution and listing of vegetable crop holding as a final sampling unit;
- Considering different measurement methods including farmer inquiry and objective measurement for harvested area and yield estimation for various vegetables;
- Considering yield variability over time for staggered harvested crops and the feasibility for using monitoring method and farmer recall to collect data for yield estimate;
- The use of beds for vegetable cultivation allows to pilot other methods for harvested area and yield data collection in addition to the crop-cutting method;

3. Methodological Approach

3.1. The Scope of the Pilot Survey

The administrative sub-division of Ghana is at first level 10 Regions and at second level 216 districts. The scope of the field test is limited to two districts in two close regions. The scope a the pilot survey is two districts. The district target should be the ones where vegetables growing constitutes an important activity and convenient for testing various aspects of the methodology. The Ada West District in the Greater Accra Region and Keta Municipal District in the Volta Region were chosen. by Statistics Research and Information Directorate (SRID) of the Ministry of Food and Agriculture (MOFA) and are known to be sheltering a large number of diverse types of vegetable holders growing a large number of vegetable crops.

3.2. Methodology of Data Collection

Data could be collected through a sample survey. The absence of a sampling frame for vegetable crops (list of vegetable crop holdings) requires a prior listing operation to constitute an exhaustive list of gardeners. Once this has happened, a sample of vegetable holders will be drawn.
The survey will be implemented in several steps:

- Step 1: Listing of vegetable crop growing areas.

The first step is to list all the horticultural sites. Each site will be enumerated with important variables like geographic position, number of vegetable holders, types of vegetable crops grown. This listing will allow establishing a sampling frame for vegetable sites as PSU. The sample of PSU will be drawn from this frame.

- Step 2: Listing of vegetable holdings and the identification of holders.

A full listing of vegetable holdings will be obtained for each sample of vegetable crop areas. This list will be the Secondary Sampling Unit (SSU) frame. During the listing, information will be collected on farmer name, crops on each parcel and specific date of harvest. The latter is very important: the enumerator will record the exact date of the harvest. A return visit will be done on that date in order to collect information on yield.

- Step 3: First visit

In the second step, the main part of the questionnaire is filled. Data are collected on socio-demographic characteristics of farmers, economic characteristics of the farm including labour, land (size and number of plots, number of beds under cultivation, average size of beds by crop, equipment, production costs, etc.). During this visit, we will identify the beds by crop type and a few beds by crops will be measured to get an idea of their average size.

- Step 4: The Yield Survey

The production of a selected sample of plot will be collected and weighed. In some cases, the enumerator will collect and weigh the total production of a bed or count the number of its plants, calculate the average weight of a plant from a few harvested plants and compute the weight of the production of a bed. In other cases, (for staggered harvest crops), he/she will estimate the production

of a bed in a number of measurement units and weigh the contents in order to compute the weight of the bed.

In the large majority of countries (developed and developing countries), a proper system to collect area data on vegetable crops does not exist. Some countries, mostly developing countries, rely on Census of Agriculture to collect these data. Some developed countries use administrative data or expert assessment. Very few countries conduct surveys or censuses for collecting vegetable crops area. It is important to examine which method applies to which country and under which conditions. For instance, in Africa, the vegetable plot has often the form of the bed and since some vegetables are staggered harvest crops, one option is to rely on the statement of the holder to have area and production estimates and that requires a significant effort of memory recall from holders.

If the collection of data on vegetable crops is done within a more comprehensive survey/census, it is possible that the questionnaire design and the general techniques of measurement of area and production for "traditional" could not fit the peculiarities of vegetable crops.

The use of administrative data from different sources, that is to say data which were not collect primarily for statistical purposes, can be difficult when reconciling them to obtain statistical data. This can be more difficult for countries where administrative data are outdated. Global Strategy is elaborating a guideline on how to improve and integrate administrative data in the agricultural statistical system (Global Strategy, 2015).

Due to the large species of vegetable crops, the measurement of yield depends on the type of vegetables. Onetime enumeration is not meaningful for some vegetable crops, since they have several growing seasons within a year. It is important to evaluate the best option between: 1) Providing necessary tools and capacity building to the holder and relying on his statement or 2) Follow-up by several visits, with the physical presence of enumerators. In this last case, it is important to determine with the holder, the exact date for crop harvesting. Some crops are left in the field by the holders and harvested when needed.

The yield depends also to the seed varieties. Only information collected from the field could give clear indication on the yield. Administrative data should be extremely detailed to give all these information, for each crop. Therefore, the use of administrative data to identify yield rate could be a daunting task. However, administrative files could be used to assess the production.

The use of a specific seed can be different within a year; the yield rate also can vary considerably during this period of time. For crops which are grown several times during a year period, if the yield estimates for one growing season is used for another one, the results could be inaccurate.

The main challenge for this kind of survey on horticulture crop is to find the best observation methods giving right and accurate measurements of the key parameter for production estimate (area harvested, yield). It is how to find the easiest, the simplest and most user-friendly method for respondents and enumerators, which are fast to implement and are cost-effective that is a challenge.

The vegetables grown in the region (lettuce, carrot, spinach, mint, celery, etc.) are characterised by short growing cycles (1-3 months) and generally non rain-fed crops allowing the practice of continuous planting/harvesting over the year. Certain vegetables like mint, parsley's main characteristic is that they are successive harvest crops and others like okra and tomatoes for which harvest is staggered can last 1 month or more. Hence measuring the harvest area and yield using objective measurement methods needs to monitor each planting/harvesting occurrence and also each harvest occurrence by the sampled holder for okra and tomatoes.

For the exercise, there was not enough budget and probably no national institution would accept to participate in a pilot survey covering one year in the field. The strategy used in this field test is to reduce the number of visits by the enumerators to the farmers at a minimum possible considering the short time allocated to data collection phase in the field (one month). For the recording of area harvested, the combination of objective measurement during the field visits and the farmer recalls allow to calculate estimates covering the reference period (one year). Considering the general cultivation practice of the vegetable growers using the bed as the principal technique for soil preparation and plant sowing, the bed is an area unit that can be used for harvest area measurement.

The questionnaire is designed to allow recording of a suite of variables needed in order to estimate the area and yield of each type of vegetable crops. The variables to be measured and the appropriate methods of measurement vary according to the type of crop, the mode of harvest (i.e. single harvest, staggered harvests, successive harvests), and cultivation techniques (on bed, full field). For yield measurement, two methods are tested, the random selection of a sample of beds to be harvested and the production weighted in the case the plot is sown using the beds and the use of traditional crop cutting method in case the plot is sown using full field. Table 1 below illustrates the proposed variables to be collected during this pilot by type of crop according to the mode of harvest, and cultivation technique.

Note that for root vegetables and fruit vegetables, the determination of the measurement unit is central to estimating production.

3.3. Sampling Frame

A sampling frame can be built using agricultural or population census frame. Some variables collected during these statistical operations allow to identify the vegetable growers. The use of administrative files of producers registered in official government agricultural support programs. It is an important storage of administrative records that allows, through in-office activities, to obtain enormous quantity of information about the vegetable growers.

The experience and knowledge of the field enumerators or technicians about the producers and plots land located in their work areas could make it easier to identify producers and their agricultural holdings.

Sometimes it is necessary to build a proper sampling frame. For instance, during the pilot test in Ghana, this option was used. In the absence of appropriate registers of vegetable holdings in Ghana, the better sample design is the two staged sample. The use of Enumeration Area (EA) of the Population and Housing Census 2010 was an option but due to the time-lag between the two operations (5-6 years), the risk of having obsolete and inappropriate information about vegetable growers of the EAs for drawing a sample of PSU was very high. In addition to that the need for having more information on the PSU for an effective sample selection required to have a step for the first stage sample frame preparation by the identification and listing of PSUs allowing the collection of important variables to support the sampling selection.

The first stage sampling frame was built by a complete listing of vegetable growing areas (sites) in each district. Variables such number of holdings operating in the site, the types of vegetables grown in the site were collected to be used for the sample selection.

Once the site is selected, then a complete listing of vegetable holdings is done. This list was the Secondary Sampling Unit (SSU) frame. For sample selection purposes, variables were collected on holder name and sex, type of vegetable grown and specific date of the next harvest, number of

employees, total acreage under cultivation. This additional information is used to perform effective holdings sample selection and also for operational use to ensure that the area and yield questionnaires are implemented at the right time particularly that yield data collection are planned during the right harvest time minimizing the survey personnel workload and costs of logistics.

During the listing of the PSUs, the following variables could be collected: a) Area Code b) Area Name c) Geographic Location-GPS Coordinates; e) Estimated Number of Vegetable Holders; f) Main water source; f) Types of vegetable crops grown.

The latter variable allows to build a sample, covering all the different crops. The estimated number of vegetable holders allow to calculate the probability of inclusion for the PSUs.

During the listing of SSUs, the following variables could be collected: a) Name of the Holder; b) Gender; c) the Total acreage under cultivation (acres); c) the number of beds (if applicable) d) The crop grown; e) the beginning of the period of harvest.

3.4. Sample Selection

The sample design could be the 2 stages sampling. At the first stage, the vegetable growing areas are selected with probability proportional to size (pps). The variable to be used for the pps sampling could be the number of vegetable growers in the area.

In the pilot test held in Ghana, 102 vegetable growing sites were identified and listed in the two districts (53 for Keta and 49 for Ada). 32 sample sites (PSU) were selected using PPS (16 for each district). The sample rate at first stage is 1/3. In the Ada District, one site was automatically selected since it was the only site where a specific crop, Zucchini, was recorded. The listing of vegetable crop holders in these 32 sites gave a total of 1814 holders. 10 sample holders were selected randomly in each of the 32 sites. The sample size for the field test was 320 holders. The workload of the enumerators and the budget limitation was taken into account in deciding on the sample size. A total of 16 enumerators were available for the field test.

4. Field Implementation and Innovation

The field implementation has allowed to identify several area of innovation:

- For staggered harvest crop, the enumerator can visit the field 3 times during the harvest period. Ideally, at the beginning, at the peak and at the end of the harvest. A harvest diary could be given to the farmer in order to record the production of the farm during the absence of the enumerator. The variables to be collected could be: a) the production on the bed/crop-cutting area in terms of number of measurement unit; b) Number of Harvested Beds; c) The date of the harvest. These variable should be kept simple as possible and well understandable by the farmer. Such collected would be useful to access the variability of the production within a single harvest period and to obtain better estimates of the production.
- The pilot test in Ghana has shown that, the growing of vegetable crops is not fairly distributed in various PSUs. For instance, zucchini was only cultivated in one PSU. During the sample selection, this PSU was automatically included in the sample. The estimation of the vegetable crop production grown in such production is done separately and then add to

the estimation on the remaining sample. This procedure allows avoiding the overestimation of the production for such "rare" crop.

- In order to assess the yield, a number of beds are randomly selected in the case the field is divided in beds. The enumerator will confine the field, whatever is its form, in a rectangle with sizes a and b. He will assign the four corners of the rectangle numbers from1 to 4. Using a calculator, he will select a number between 1 and 4. This number will correspond to a selected corner, which will be considered as an "origin point''. Then, he will select a random number between '0 and a' and between '0 and b', using a calculator. These selected numbers will be the coordinates (a, b) of a point in the field. When the point falls in a bed, this bed is selected. The operation is repeated until 3 beds are selected from this field. The sizes of the three beds will be recorded.
- Due to their correlation with the production, socio-economic variables, like availability of water supply, the demand, the equipment, etc. could be collected in other to assess the production. In the case of the pilot test, stratification was not necessary, since the listing of the SSU present a quite homogenous population. However, when stratifying the whole population of the farms the more recent information for each farm is used. It is therefore necessary, to keep update as possible all the information related to the farms. The listing is highly useful in this case.

5. Concluding remarks

Methodologies for measuring area and production for vegetable crop are under development. For instance, Remote Sensing Data are also used to estimate agricultural production; but their use is still at an early stage. Even in developed countries the use of remote sensing data in horticulture is scarce. However, some studies have been done on its implementation in horticultural census/survey (Avtar & Kamlesh, 2012 and Trout et al., 2008). Apart to the fact that it can be used to assess the area, it could be used to identify the harvest period and provide information on the growth status of crop. This information will facilitate the data collection work (Lee et al., 2014).

The pilot test survey in Ghana is currently under implementation, the result will allow to assess the various methodologies to measure area and production (farmer inquiry vs. objective measurement). It will also allow to access the variability of the production for staggered harvest crop.

However, the field implementation in Ghana done so far has allow to confirm what identified in the literature review about the use of bed for vegetable crop production and the use of a measurement unit for the measurement of the production by the farmer.

An adequate sample design has been also developed in order to estimate in an accurate manner the production. The data collected in the Keta district, will be compare with existing data on the vegetable production in order to assess the methodology.

CROP	Divided in Beds		NOT Divided in Beds	
	Area	**Production**	**Area**	**Production**
Leafy with single harvest • Lettuce • Cabbage • Cauliflower	Randomly select beds and: • Area by inquiry • Area by objective measure (GPS) • Simple geometric calculations for small beds • Number of beds harvested by inquiry over the last 12 months	Randomly select beds and: • Harvest bed, and weigh Or • Count plants • Randomly select plants, harvest and weigh • Production by farmer inquiry • Estimate yield of each harvest by farmer inquiry over the last12 months	• Area by inquiry • Area by objective measure (GPS)	Randomly select crop cutting area • Harvest and weigh • Production by farmer inquiry • Estimate yield of each harvest by farmer inquiry over the last 12 months
Leafy with staggered harvest • Spinach • Mint • Parsley • Celery • Potato leaves	Randomly select beds and: • Area by farmer inquiry • Area by objective measure (GPS) • Simple geometric calculations for small beds • Number of beds harvested by inquiry over the last 12 months	Randomly select beds and: • Harvest bed, and weigh • Production by farmer inquiry • Estimate the number of harvest over the last 12 months by farmer inquiry • Estimate yield of each harvest by farmer inquiry over the last12 months	• Area by inquiry • Area by objective measure (GPS)	Randomly select crop cutting area • Harvest and weigh • Production by farmer inquiry • Estimate yield of each harvest by farmer inquiry over the last 12 months
Root vegetables with single harvest • Carrot • Beet • Turnip • Bulb onion • Shallot • Leek	Randomly select beds and: • Area by inquiry • Area by objective measure (GPS) • Simple geometric calculations for small beds • Number of beds harvested by inquiry over the last 12 months	Randomly select beds and: • Harvest bed, and weigh Or • Estimate number of measurement units • Harvest randomly selected plants, weight measurement unit • Production by farmer inquiry in measurement units • Estimate yield of each harvest by farmer inquiry over the last12 months	• Area by inquiry • Area by objective measure (GPS)	Randomly select crop cutting area • Harvest and weigh OR • Estimate production by farmer inquiry in measurement units • Estimate weight of measurement units by farmer inquiry

Fruit Vegetables with single harvest • Pumpkin	Randomly select beds and: • Area by inquiry • Area by objective measure (GPS) • Simple geometric calculations for small beds • Number of beds harvested by inquiry over the last 12 months	Randomly select beds and: • Harvest bed, and weigh Or • Estimate number of measurement units by farmer inquiry • Estimate weight of measurement unit by harvesting, filling, and weighing • Estimate yield of each harvest by farmer inquiry over the last12 months	• Area by inquiry • Area by objective measure (GPS)	Randomly select crop cutting area • Harvest, and weigh Or • Estimate number of measurement units by farmer inquiry • Estimate weight of measurement unit by harvesting, filling, and weighing • Estimate yield of each harvest by farmer inquiry over the last12 months
Fruit Vegetables with staggered harvest * • Cucumber • Eggplant • Pepper • Hot pepper • Tomato • Okra *Methods are same regardless of whether or not fruit vegetables are cultivated in beds.	Randomly select beds and: • Area by farmer inquiry • Area by objective measure (GPS) • Simple geometric calculations for small beds • Number of beds harvested by inquiry over the last 12 months	Using fruit vegetables already reaped that are present at holding. • Estimate number of measurement units by farmer inquiry • Estimate weight of measurement unit by harvesting, filling, and weighing • Estimate the number of harvest over the last 12 months by farmer inquiry • Estimate yield of each harvest by farmer inquiry over the last 12 months	• Area by inquiry • Area by objective measure (GPS)	Using fruit vegetables already reaped that are present at holding. • Estimate number of measurement units by farmer inquiry • Estimate weight of measurement unit by crop cutting, filling, and weighing • Estimate yield of each harvest by farmer inquiry over the last 12 months

Table 1: *Variables to Be Collected to Measure the Area and the Production According to Each Type of Crop*

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