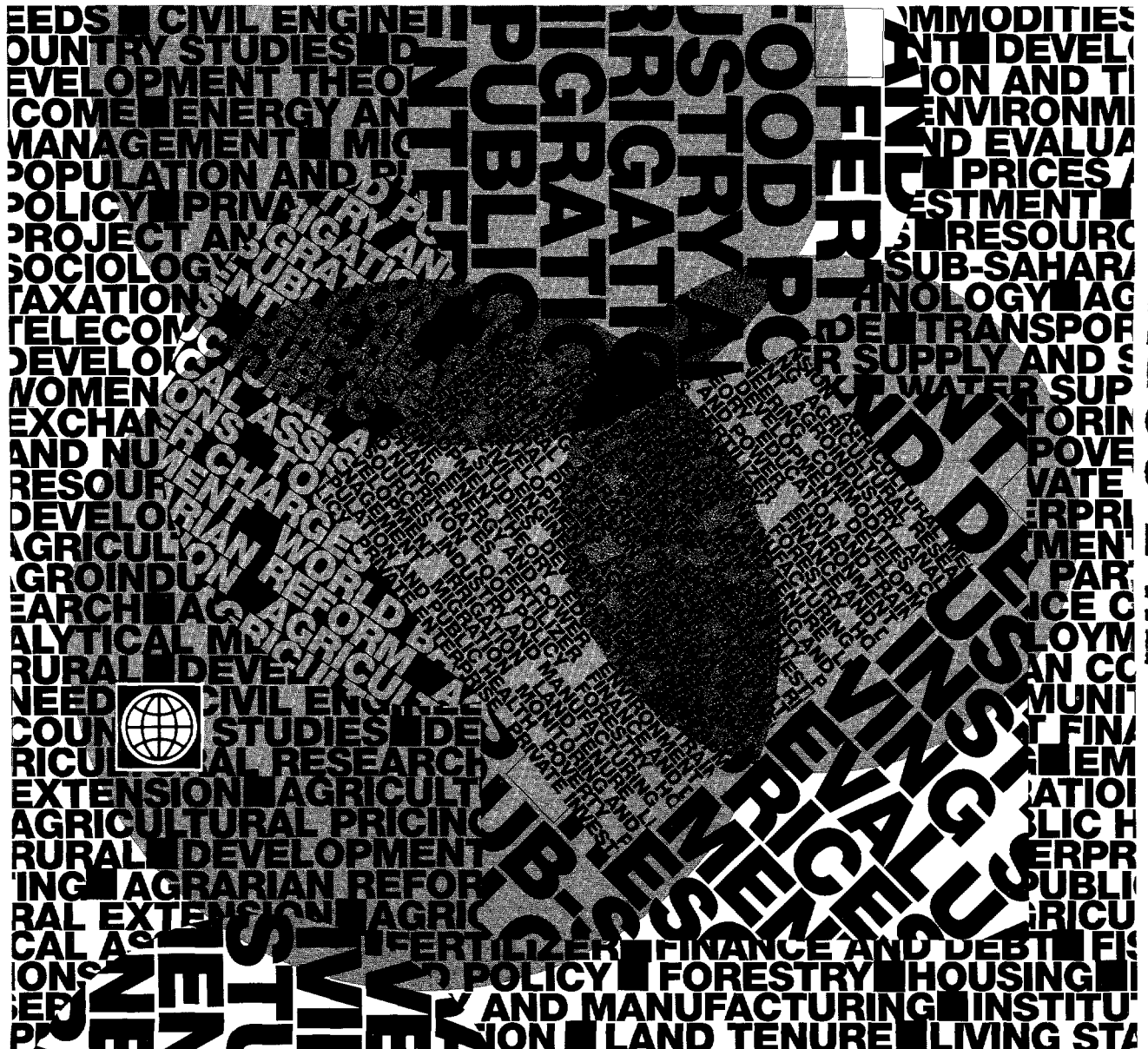WTP- 132

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Farmers' Estimations as a Source of Production Data

Methodological Guidelines for Cereals in Africa

Josette Murphy, Dennis J. Casley, and John J. Curry

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The World Bank
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ABSTRACT

The reliability and timeliness of agricultural production data are insufficient to meet information needs in many African countries. The use of simple data collection methods well adapted to the irregular plots of African traditional agriculture would help improve this situation. This paper, based on recent evidence comparing the standard crop-cut method and the method based on farmers' estimations, respectively, with the actual weight of harvest, discusses the types of information needs for which the farmers' estimations provide a valid source of production data. It analyzes the advantages, limitations, and requirements of using the farmers' estimations method; and provides guidelines for collecting, analyzing and interpreting production data from the farmers concerned.

The paper is intended for management and technical staff in line ministries and agricultural services agencies, as well as for survey specialists. It can also be used during training sessions on data collection methodologies. The purpose of the paper is twofold:

(1)   to inform management and technical staff of the validity and limitations of the farmers' estimations of cereal production as a data source for some information needs, and

(2)   to provide technical staff and survey specialists with detailed guidelines on the organization, design, and implementation of data collection, as well as on the verification, interpretation, and utilization of the results in the broader agro-ecological, economic, and cultural context of the country.

The document begins with a review of the diversity of information needs regarding cereal production among agricultural and rural development agencies. Chapter 2 provides a summary of evidence regarding the relative validity, advantages, and limitations of using the farmers' estimates of production, compared with the standard crop-cutting method. Chapter 3 reviews the key issues which influence data collection and analysis, Chapter 4 elaborates on the step-by-step organization and implementation of a survey, and Chapter 5 emphasizes the necessity of interpreting the results in light of data from other sources and of various agro-ecological, economic and behavioral indicators. Chapter 6 is an annotated bibliography for the various categories of methodologies in use for estimating cereal production; it covers methodological guidelines as well as case studies of actual field measurement which include sufficient information on the method used to be of interest to technical staff.

ACKNOWLEDGEMENTS

FOREWORD

Good management cannot occur without good information. The report Sub-Saharan Africa--from Crisis to Sustainable Growth (World Bank 1989) calls attention to the lack of appropriate, rapid flow of information to decisionmakers. It emphasizes the urgent need to improve information systems in public institutions by helping them to better focus their information systems on decision-oriented indicators, and to give priority to simple, flexible, rapid methods of data collection. Regarding data on agricultural production, the report points out that the standard measurement (crop-cut) method is fraught with difficulties when applied to the irregular fields of traditional agriculture in Africa, and that a simpler approach would be helpful. The report calls for the systematic dissemination of recent evidence showing that farmers' estimations of their production may provide such an alternative. The objectives of this paper are to review the evidence and to discuss the advantages, limitations, and requirements of using the farmers' estimations as one source of production data for cereal crops. It is intended for management and technical staff in line ministries and in agricultural services agencies who need to obtain and use production data, as well as for survey specialists and trainers.

In 1987, the World Bank, the United Nations Food and Agriculture Organization (FAO), and the United Nations International Children's Emergency Fund (UNICEF) collaborated with local institutions in Benin, the Central African Republic, Kenya, Niger, and Zimbabwe to compare crop estimation methods under controlled conditions. The objective of this study was to test the hypothesis that African farmers are capable of estimating the volume of their cereal production at a level of accuracy compatible with many information requirements in agricultural agencies. The study showed that the aggregate estimates of cereal production provided by farmers were sufficiently close to those obtained by total weighing of the harvest to be used for planning and management decisions; the results achieved by using the standard measurement method of crop-cuts were disappointing.

The ability of African farmers to estimate the cereal output achieved on their plots should not come as a surprise. Historical documents from many cultures show that literate farmers maintained detailed records of their production estimates through the ages. Illiterate farmers share the same capacity to estimate, if not to record. At a time when men and women in Africa are recognized as active partners in development, it is fitting that agricultural services agencies draw from their skills and knowledge. If used with adequate care and interpreted in context, the farmers' estimates method presents strong advantages and provides a relatively simple, rapid, and statistically efficient source of production data.

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CHAPTER 1

Estimating Crop Production for
Monitoring and Evaluation Needs in Africa

A. Introduction

Agricultural statistics, and especially production data, are an absolute information need in all countries. Data on crops are necessary during the crop season, as a forecast of likely production, and after harvest, as a quantified estimate of actual outputs. Such data are essential for a broad array of planning and management decisions by agricultural and rural development agencies, as well as for national accounts. They are also difficult to obtain and process on a timely basis and at reasonable cost in parts of the world where agricultural production is undertaken on a small scale by many rural households and where there are no written records or cadastral information on land use. This is particularly true for dryland agriculture in Africa, where small fields of irregular shape, uneven crop stands and intercropping remain prevalent.

Discrepancies in estimates of crop outputs have been widely reported (David 1989; World Bank 1989; Chander 1990). In recent years concerns about data deficiencies with regard to smallholder crop production in Africa have been raised repeatedly in international meetings (see Food and Agriculture Organization, 1986 for a good summary of issues). A recent report by the World Bank states:

"...most analysts and decisionmakers believe that available estimates of agricultural output are unreliable and grossly inadequate. The need for prompt and more reliable production statistics has been reaffirmed at the national, regional, and global levels. Sectoral policy analysis, early warning systems, assessment of food requirements, and the study of nutritional standards all demand basic agricultural production data. And given the size and contribution of agriculture in GDP, production estimates are critical for preparing macro-economic accounts as well." (World Bank 1989, 209)

This serious problem also inhibits in-country public and private institutions in designing, implementing, monitoring, and evaluating agricultural services adapted to farmers' needs. A brief summary of the development of statistics in Africa helps to explain this situation.

The statistical offices in Africa achieved an identity that went beyond merely collating government records in the 1950s and 1960s, when the first population censuses that provided fully documented lists of administrative locations were conducted. This was a necessary first step if the statistics offices were to develop a data collection program around some form of sampling plan, using administrative areas as primary units. But such programs were slow to develop: the infrastructure for carrying out survey programs in the field was not available, and sufficient staff at the junior, and senior levels did not exist.

Besides, there were some key statistics that were available on the basis of complete, or nearly so, enumeration and were thought to be of reasonable quality. For example, statistics on the import and export of crops were generally available from documents submitted to and summarized by customs departments and marketing boards. There were good grounds for believing that the limited statistical resources could make a wider and more immediate impact by exploiting sources of this kind rather than focusing on primary data collection. This expectation was also justified in terms of influencing the policymakers. Most of the senior officials concerned still took a critical, albeit uninformed, view of sample surveys, but were much less skeptical about information derived from administrative sources.

Perhaps the most decisive factor at this time was the importance attached to national accounts--above all to the calculation of estimates of the gross domestic product (GDP), in which agricultural output figured prominently. The general method of calculation relied on administrative statistics of external trade and public finance; agricultural department estimates of crop and livestock production, supplemented by marketing board reports; population data, and specially collected estimates of employment and earnings in a sector usually designated as "modern" or "monetary." The GDP calculation has retained its priority status, and much effort has been devoted to its extension and improvement. The importance of agricultural production data in such calculations is reflected in table 1.1, which traces the evolution of the share of agriculture in the GDP of selected countries. Agricultural exports as a share of total exports are presented in table 1.2.

The important transactions and interrelationships occurring in the mass of the population working in agriculture or in informal activities have been neglected and in many countries continue to be neglected, except for small ad hoc specialized studies. Surveys on the agriculture population often involve poor standards of data collection. This leads to indifferent results, often after long delays, and consequent lack of support for this type of inquiry.

The collection of agricultural statistics is an expensive undertaking because of the perceived necessity for frequent measurements and observations over an extended time period. Furthermore, the methodology required to collect statistics of the production, marketed volume, and consumption of home-grown crops is by no means well defined. The consequence has been a comparative neglect of agricultural statistics at the national level, even when such statistics are of prime importance to the national economy. In some countries, the ministry or department responsible for agriculture, in the absence of a regular flow of data from the Statistics Department, has relied on its own estimates, produced in a subjective and informal manner by agriculture field staff such as the extension service. Such estimates are often heavily biased (mostly upward) because reporting is done by field staff responsible for agricultural development in particular areas. In other countries of the region, the agriculture ministry/department has been responsible for the generation of official agriculture data. In these countries, area and yield surveys have been instituted, but in most cases the methodology is faulty and survey management inadequate.

Table 1.1. Agriculture as percentage of gross domestic product by country, 1960-1989

Country	1960	1970	1980	1987	1988	1989
Angola	48.2	41.7	34.7	-	-	-
Benin	56.6	44.5	43.4	37.6	40.8	43.4
Botswana	54.4	33.1	11.7	3.4	2.9	-
Burkina Faso	37.7	29.9	27.9	30.4	31.6	30.5
Burundi	-	65.3	57.8	50.9	48.9	-
Cameroon	-	31.4	27.9	24.4	25.3	27.0
Cape Verde	-	-	18.7	15.0	14.6	14.4
Central African Rep.	50.5	33.4	37.6	39.2	40.2	40.1
Chad	46.3	43.3	53.4	36.9	41.1	35.8
Comoros	-	-	-	35.8	-	-
Congo, People's Rep. of the	23.2	17.9	11.7	11.9	13.7	13.7
Côte d'Ivoire	48.0	31.9	26.9	31.1	33.4	35.4
Djibouti	-	-	-	2.4	2.4	2.4
Equatorial Guinea	-	-	-	58.3	59.2	58.7
Ethiopia	61.5	52.2	45.6	38.6	37.5	38.7
Gabon	32.5	17.5	7.2	11.0	11.3	-
Gambia, The	32.3	28.5	27.3	28.9	26.6	26.6
Ghana	40.8	46.5	57.9	50.6	49.3	50.2
Guinea	-	-	-	29.4	29.1	29.5
Guinea-Bissau	-	47.5	44.3	47.4	45.7	47.0
Kenya	35.3	30.2	27.6	26.9	26.3	-
Lesotho	69.2	31.8	20.4	15.7	19.4	-
Liberia	-	22.3	32.2	-	-	-
Madagascar	30.1	21.9	26.7	29.3	29.3	28.2
Malawi	48.4	41.0	33.3	32.8	32.3	31.5
Mali	-	61.3	58.4	48.7	49.0	49.6
Mauritania	43.1	27.5	28.5	33.1	33.8	33.7
Mauritius	12.5	13.5	10.5	12.3	10.8	10.6
Mozambique	-	-	47.1	57.8	57.2	55.1
Niger	75.3	64.9	42.6	33.7	39.0	35.4
Nigeria	58.1	37.3	25.3	29.1	33.7	30.0
Rwanda	79.7	61.6	45.8	38.1	37.8	37.1
Sao Tome and Principe	-	32.4	38.7	29.4	28.9	28.9
Senegal	24.3	24.1	18.8	21.8	22.1	22.0
Seychelles	-	-	6.8	6.0	-	-
Sierra Leone	-	25.4	30.4	40.0	37.3	43.5
Somalia	64.4	52.7	64.4	60.4	62.9	62.2
Sudan	-	37.6	31.0	33.4	29.4	34.7
Swaziland	28.4	26.8	21.4	-	20.3	-
Tanzania	52.9	36.9	39.5	55.2	57.2	-
Togo	54.9	33.8	27.5	33.6	33.9	33.9
Uganda	50.1	48.5	70.5	67.5	67.1	-
Zaire	7.0	4.0	27.6	29.9	28.4	29.6
Zambia	11.5	10.7	14.2	11.2	14.2	-
Zimbabwe	16.5	14.2	13.1	10.7	12.2	11.1

Source: World Bank economic and social database.

Table 1.2. Agricultural exports as percentage of total exports by country, 1965-88

Country	1965	1970	1975	1980	1985	1988
Benin	93.7	89.2	84.8	45.1	42.7	38.2
Botswana	78.0	61.4	41.9	9.0	18.7	28.7
Burkina Faso	94.4	95.1	93.4	89.1	82.7	98.0
Burundi	93.5	94.8	95.8	92.3	92.1	83.3
Cameroon	77.2	82.0	82.5	60.0	30.1	35.0
Central African Rep.	44.7	55.4	76.2	73.6	70.7	59.6
Congo, People's Rep. of the	32.2	67.0	13.4	5.9	10.1	17.1
Côte d'Ivoire	93.0	92.4	81.9	84.3	82.1	84.7
Ethiopia	98.2	93.1	87.8	92.2	92.0	96.0
Gabon	39.4	32.9	8.5	7.5	13.0	27.1
Gambia, The	99.7	98.5	98.1	95.5	94.9	93.3
Ghana	84.6	85.0	86.5	67.2	68.0	64.6
Kenya	81.0	74.1	64.9	50.4	69.3	63.3
Lesotho	91.3	93.3	79.4	75.5	77.1	69.7
Liberia	24.8	23.2	18.7	37.8	31.5	44.4
Madagascar	90.5	83.8	80.9	84.8	80.0	70.0
Malawi	98.8	85.5	87.4	88.8	92.8	82.7
Mali	96.1	88.7	88.0	83.2	78.7	70.3
Mauritania	5.1	10.8	8.1	22.5	59.1	65.4
Mauritius	99.6	97.0	87.7	70.9	56.1	38.6
Niger	95.3	96.0	30.4	12.0	9.7	20.2
Nigeria	65.3	36.3	5.7	3.5	2.1	9.6
Rwanda	59.6	63.9	58.0	62.8	88.7	90.3
Senegal	88.1	68.9	54.0	46.1	52.0	50.3
Seychelles	85.1	68.1	31.9	22.8	10.7	23.8
Sierra Leone	14.3	16.7	25.4	31.2	24.8	20.5
Somalia	79.8	93.7	96.8	94.4	98.5	94.9
Sudan	97.6	98.3	94.3	96.0	86.4	79.5
Tanzania	82.6	79.0	80.8	74.4	76.3	75.3
Togo	47.6	55.7	25.3	16.2	28.0	22.6
Uganda	85.5	89.9	95.9	96.6	96.9	95.6
Zaire	20.0	15.2	21.1	34.6	36.3	29.1
Zambia	3.0	0.7	1.5	1.3	0.7	3.1
Zimbabwe	40.1	36.6	48.4	49.2	44.7	47.0

Note: Includes food crops, livestock and nonfood agricultural production.

Source: World Bank economic and social database.

Interest in statistics at the farm level has been more evident. Agricultural economists have been active in conducting small-scale surveys, particularly farm management surveys, with the stated objective to "diagnose the problems confronting the farmer and devise more economic ways of using available resources" (de Wilde 1967, 94). But, in the view of Collinson (1972), the results of these surveys were rarely used in decisionmaking, because they had not been designed in a systematic manner to fulfill clearly identified information needs. In the 1970s, the collection of data similar to that included in the classical farm management survey was undertaken as a means of monitoring and evaluating agriculture and rural development projects. This was an inappropriate choice and proved as disappointing for this purpose as in earlier years. During this period, however, Collinson and others pioneered a more informal probing system for collecting farm system data, and this system proved more successful in individual applications on a limited scale. Over time, a school of thought has emerged that stresses rapid data collection techniques for rural appraisal (see Chambers 1988). These techniques have the advantages of rapidity and relative simplicity, although they have sometimes been achieved at the cost of scale and sampling rigor. Most importantly, they encourage the inclusion of qualitative information from farmers as an essential element of data collection.

In the 1980s, the World Bank encouraged a different focus for monitoring agriculture projects, one which emphasized farmers' reactions as reflected by indicators such as adoption rates. This focus is central to joint publications by the World Bank, the International Fund of Agricultural Development (IFAD), and the Food and Agriculture Organization of the United Nations (FAO) (Casley and Kumar 1987, 1988), as well as to related guidelines for agricultural services agencies (Murphy and Marchant 1988). This shift in focus lessened emphasis on formal crop area and yield surveys as a routine part of monitoring and evaluation systems, but it highlighted the issue of whether the farmers' estimates of their own production could be a credible source of data.

B. Need for Crop Production Estimates
by Agricultural Services Agencies

For national planning purposes, the need for accurate crop statistics by geographical areas and at the national level is great, but these statistics are not sufficient to fill the information needs of managers in agencies responsible for extension and related agricultural services. The danger for such agencies is to attempt to provide valid estimates of regional or national crop statistics, even though this requires a survey capability that is usually inappropriate for, and unattainable by, the available resources. The result of such attempts, in countries as widely different as Nigeria and Malawi, is a failure to provide valid aggregate estimates as well as to meet the needs of the agencies' manager.

As always in data collection, the appropriate focus and methods are determined by the use that is going to be made of the results. Several uses of crop data are discussed here.

Crop response to specific inputs

If an agency is promoting, and arranging for, the supply of specific inputs such as a new crop variety or fertilizer, the field response is clearly of critical interest to management. In such a case, information probably exists regarding the biological response of the crop to the input: data should be available from research trials of the input conducted in controlled experiments on research stations. But analysts need to demonstrate that the response predicted from these results, or at least a substantial proportion of it, is achieved when the input is used by farmers using their regular farming practices and on their own lands. Often demonstration plots are maintained or supervised by local staff, even though they are dispersed through the target area, and so records of inputs and practices are kept. In such a case, these plots should be harvested under supervised and controlled conditions so that the yields are available, based on weighing the complete harvest. While many demonstration plots may be treated with this level of care, a key step is to institute a system for recording the results obtained from these demonstrations and to incorporate them in the information system of the project. Throughout Africa such data can be found in manual files in district offices, but the data are inaccessible for overall monitoring purposes.

If the input is tested by a first group of adopting farmers who apply the input to one of their plots or part of one of their fields, the harvesting should be undertaken under supervised conditions so that the necessary drying, shelling, and so on is followed by careful weighing and recording of the output. Input levels and farming practices however may not be known in sufficient details to warrant a sophisticated analysis.

The important methodological issue in both these examples is the need to weigh the complete harvest when the crop is in an appropriate postharvest condition. To estimate a response curve showing the relationship of yield to input or comparing the yield of one subplot using a new variety with that of a paired subplot using the traditional variety, it is not sufficient to use sub-sampling techniques (the random crop-cut, described in the next chapter) or the farmers' estimates. Estimating the response relationship requires considerable accuracy in recording the input and the yield. Even strong advocates of the crop-cutting method do not claim that random cuts provide accurate estimates of *individual* plots, only that a sufficient number of cuts in a sufficient number of fields provides a valid estimate of *average* yields. Similarly, advocates of farmers' estimates accept that there is considerable variation in the accuracy of estimates by individual farmers. Such variations are not acceptable for meeting this particular data use, but given the demonstration nature of the test plots, and therefore their relatively small numbers, there is no reason why recording of complete harvests should be impracticable.

Crop production forecasts

In many circumstances, a reasonable forecast of production from a specific geographic area will be of great value to managers responsible for arranging marketing or other postharvest services. This is an almost diametrically opposite data need from the one just discussed in terms of data collection methodology. Here accuracy of individual plot or farm estimates is not the requirement, nor is the level of accuracy required exacting. An approximate estimate of the likely production is what is needed. The estimate, however, should be derived from a

widely dispersed sample so that all microclimatic or cultivation system variations are adequately represented.

For many crops (including cocoa, cotton, and maize) there is an extensive literature on yield estimation methods involving the random selection of subplots, plant rows or blocks of trees, with a count of heads, pods, bolls, and so on in each sample segment together with the measurement of a crucial parameter such as length of cob or circumference of pod. Regression estimates based on previous experience allow for an extrapolation of estimated yield at full maturity. Crucial to the efficacy of this method is the randomization of the sample and careful control over the demarcation of the sample units (areas, rows, or blocks). Large biases are likely when rigorous survey management is not exercised. For many project monitoring purposes, speed is the primary requirement, and the resources for conducting such a formal survey quickly are unlikely to be present.

The alternative is to base the aggregate forecast on individual farmers' forecasts. Again, it is important that the sample of farmers be selected according to randomization principles and that the sample be well dispersed, minimizing clustering as far as possible. This is likely to be simple and practical when there is an extensive network of extension agents or other staff who can each conduct a few interviews to obtain farmers' estimates of their likely production. Evidence regarding the ability of farmers to make such forecasts is presented in a later section.

Production by identified farmers for specified harvest

If the monitoring system includes, as it should, a regular flow of data on the penetration of the agency's program in terms of who receives the services offered (extension advice, credit, input supply, and so on) much of the information required by management will be available in terms of adoption rates and repeat adoption rates (Casley and Kumar 1987, chap. 4). Nevertheless, most managers will seek on occasion an estimate of production of specific crops in a particular season. This requirement is distinct from the establishment of a time-series of production estimates over a span of years, which is discussed in the next subsection. What we are discussing here is an estimate of production for each of certain identified groups of farmers; the groups being based on those groups that the agency is targeting (for example, smallholders below a certain farm size level, classified further by, say, first-time adopters, repeat adopters, and nonadopters). Because the purpose is to monitor relative performance, it is obviously necessary to visit individual sample farmers, conduct a brief interview in order to determine to which group the farmer belongs, and then obtain an estimate of harvested production of the crops of interest.

If the monitoring system is already based on a sample of farmers who are being targeted, the same sample will be appropriate for the harvest estimate for this targeted survey involving intergroup comparisons. We stress, again, that this is a distinct purpose from that of producing unbiased estimates of production for a specified area, where the need for every farmer in the area to have a known probability of selection is paramount.

Once at the farm, there are essentially two options for estimating the harvested production. One is for the staff to harvest randomized subplots and retain the harvest for processing and weighing; the other is to rely on farmer reports of their production using a structured

interview format. The relative merits of these options are discussed in a later section, but a few points need to be emphasized here.

. It is not reasonable to assume that farmers do *not* know their production.

. It is not reasonable to assume that if the farmers know their production, their answers will, as a rule, be biased or evasive.

. Farmers associated with development program are not likely to be suspicious regarding the intent of interview questions, if they are properly introduced and phrased. Indeed, there is a vast pool of experience that demonstrates the openness of African smallholders if approached in a proper manner.

. Crop-cutting surveys are more exacting than surveys based on farmers' estimates; they require both area and yield to be measured, so the team must visit the selected fields early during the crop season and again on the very day of harvest. This creates difficult logistical problems for both enumerators and farmers. Interviews of farmers, on the other hand, can be conducted over a period of several weeks after the harvest. If only production data is required, they do not require that the area be measured.

. Because of these limitations, crop-cutting surveys require clustered samples; farmer interviews can be more widely dispersed, a considerable advantage given the high intraclass correlations of crop yields when plots are clustered.

Crop production for a given area

Valid estimates of aggregate production for a given district, region, or project area are required for several purposes. For extension and other services agencies, they are one of the measures of improved efficiency and productivity of agricultural outputs. For marketing and food aid agencies, they, together with estimate forecasts, are key data in assessing the food situation in the area. Estimates of aggregate production offer a varied menu of options. It is likely that the management need is for a time-series of production estimates over the lifespan of a given program, so that its emerging impact can be evaluated. Establishing trends in production is much more difficult to do with any reasonable level of statistical confidence than is commonly supposed (Casley and Kumar 1987, chap. 8), but many managers will feel it advisable to establish such a series.

The choice of data collection methodology when the requirement is only for an *aggregate* estimate of production, not disaggregated by type of farmers, will largely depend on the crop to be estimated. Four major types can be distinguished:

(a) Cash crops for which the total production is marketed through known outlets. Production estimates can most efficiently be obtained by accessing the purchasing records of these outlets, either on the basis of complete coverage or by selecting a sample of outlets using an appropriate sample design (including stratification by size of outlet). There may be a problem of leakages in this marketing system, which

must be assessed according to local circumstances, but the need to identify the seller is not present, which obviates some of the difficulties.

(b)   Annual seasonal crops--mainly cereals--harvested within a limited period, only part of which may be marketed through regular outlets. Estimates of cereal production may be high on the management's priority list, and to meet this need a well-designed sample of farmers to be interviewed about the total harvest from the holding may be the optimum design. The sample must fairly represent all farmers in the area, irrespective of their participation status in terms of available services. If, on the other hand, only marketed production is of interest, or if movements in the volume marketed can be used as a proxy for *changes* in the total harvest, then a survey of rural markets and rural traders may be feasible.

(c)   Roots and tubers that may remain in the ground for extended periods of time and that are normally harvested in a piecemeal fashion. This is the most intractable problem facing a survey designer. There may be no alternative to adopting a casestudy approach to estimating yield in which agreement is reached with a small sample of cooperative farmers to harvest the plot at an agreed time when the crop is mature, even though this may not be the farmers' preference. (Some compensation in cash or in kind may be needed for this interference in the normal practice--a rare instance when intervention may be justifiable.) Average yields obtained from these casestudies are multiplied by an estimate of the number of plots, obtained during normal monitoring interviews with a more rigorously selected sample of farmers to give a proxy estimate of production in the region (but not a true aggregate estimate of production).

(d)   Minor crops that are important to the service agency because they are a source of cash, provide variety in diet or needed nutrients, or improve soil-carrying capacity. *Minor* in this context means either that they are grown by a small minority of farmers, or that the plots are extremely small even though the crop is commonly grown. In the former case, a random sample may not pick up a sufficient number of growers to allow an estimate to be made. However, many minor high-value crops are cash crops so they can be covered through the marketing outlets as discussed above. Alternatively, a frame of growers of such rare but relevant crops should be available in the agency's records, and a sample could be selected from this frame. In the case of commonly cultivated but low-value crops grown in minuscule plots and kitchen gardens, management should not need aggregate estimates of production. Precise estimates will be impossible unless very large samples with objective yield measurements are undertaken. This is not likely to be a valid monitoring and evaluation exercise.

Nearly all requirements for crop production data by agricultural services agencies will fall into one of the few categories just outlined: crop response, crop forecast, comparative production estimates across farmer groups, or aggregate area estimates. The last, as we have indicated, should be reserved for inquiries that can access marketed supply data. Otherwise, the need for large, randomized surveys, cannot be avoided and a national survey agency must be involved. Crop response is a research need that requires weighing the totality of harvest at plot level. For the two remaining categories of data requirements--for crop forecast and

comparative production estimates across identified farmer groups--the farmers' own estimates represent a valid, efficient source of data that should be used more systematically than they have been. The purpose of this document is to review the advantages and limitations of the farmers' estimate methods, and to provide guidelines on survey organization and interpretation.

CHAPTER 2

The Accuracy of Farmers' Estimates

In the late 1940s, a method for estimating crop yields based on sampling small subplots within cultivated fields was developed in India by eminent pioneers in sampling and survey design, notably Sukhatme (1947), and Mahalanobis and Sengupta (1951). The method involves the random location prior to harvest of a small subplot, usually a square or a triangle, within each plot included in a sample of plots. At the time of harvest, the subplot is harvested by the survey enumerator, the crop is dried and processed, and then it is weighed. Since the subplot area is known, the yield per hectare is a matter of simple calculation. If the area of the entire plot is measured, then the total production of the plot can be calculated.

This method has been widely applied in many countries since the 1950s, and it has been the standard method recommended in survey manuals. In recent years, however, questions have been raised regarding the size of the upward bias in the estimates produced by this method. The early papers of Sukhatme and Mahalanobis report biases of modest size depending on the size of the subplot. When the method is used on small, irregularly shaped fields in which planting density is uneven, the biases are often substantial, according to evidence that began to emerge in the 1980s.

Parallel to this debate, the ability and willingness of small farmers to report field production estimates within reasonable error margins have been discussed. Clearly, if farmers can and will give valid estimates of production, this would be the survey method of choice: savings can be made in time and money for a given sample size, and more efficient sample design can be proposed (see section D). Evidence reported prior to 1985 was hampered by a common problem: the only estimates were those based on interviews with farmers and those based on the crop-cut. Differences between the two were attributed to farmer error. In other words, it was assumed that the crop-cut estimate was unbiased. Recent studies, mainly in Africa, have thrown light on this issue by comparing, at the aggregate level, the farmer estimate and the crop-cut estimate with an objectively recorded weight of the harvest from the entire plot. The results of these studies are summarized in this chapter, and the implications for survey design are considered.

A. Comparison of Farmers' Estimates and Crop-Cut Estimates of Production

In Nigeria, farmer and crop-cut estimates of sorghum and millet production in a small controlled survey had an average 14 percent bias when compared to measured production of the entire field (Casley and Kumar 1988, 105). Evidence from Zimbabwe showed crop-cut estimates of maize yields that were considerably higher than farmer estimates, which in turn were close to production estimates reported by the national extension and marketing agency (Casley and Kumar 1988, 105-6). A further study in Bangladesh reported crop-cut estimates

of rice that exceeded total production by approximately 20 percent. In this case, no farmer estimates were available (Casley and Kumar 1988, 106-7).

In 1987 a specialized study cosponsored by the World Bank, FAO, and UNICEF was conducted in five African countries (Benin, Central African Republic, Kenya, Niger, and Zimbabwe). The study team leaders reported and discussed the findings in two papers from which this section draws heavily (Scott, Marchant, and Verma 1989; Verma, Marchant, and Scott 1988). The study compared farmer estimates (pre- and post-harvest) and the estimates from crop-cuts (two randomly located sub-plots in each sample plot) with the production estimate obtained by weighing the harvest from the entire plot, and this for a sample of plots. The study was limited to maize, the main cereal crop in each country except in Niger, where the crop studied was millet. In each country two or three regions were selected, and within these a two-stage sample of enumeration areas and plots was randomly selected. The total sample size in each country was 100 to 120 plots. The plots were small (usually well below one hectare in area) except in Niger, where they were considerably larger (median 1.7 ha). The majority of the plots contained a mixture of the crop chosen for the study with one or more other crops.

In all countries except Kenya, the methodology for measuring the plots and for randomly locating the placement of the crop-cuts was based on the country's current practices. Kenya alone uses a system based on farmers' estimates, and therefore it was not using crop-cuts in its routine data collection. In general, each selected plot was measured (length of each side and bearing) and the area calculated using a preprogrammed hand-held calculator. If the closing error exceeded 2 percent of the perimeter, the area was remeasured. Two crop-cut squares, each 5 square meters in size, were randomly located within the plot. At the time of harvest each square was harvested by the enumerator. The produce was weighed immediately after harvest and then again after drying while the grain was still on the cob. Finally, the grain was weighed after shelling.

Farmers' estimates of production for the entire plot were obtained twice, once two to four weeks before harvest and once postharvest (immediately after harvest in Kenya and Zimbabwe; two to three weeks after harvest in the other countries). The entire plot was harvested by the farmers, with the weighing of the harvest being carried out by the enumerators, usually at the same time as the weighing of the dried grain from the subplots. To avoid influencing the farmers' estimates, care was taken to prevent the farmers from becoming aware of the results of the weighing of the entire harvest. Concern about contamination in Niger led to the exclusion of the farmers' postharvest estimates in that country. In Kenya and Zimbabwe, the local unit used was a standard bag that holds 90 kgs. In the francophone countries, a variety of local units was used by farmers, so conversion factors were estimated by conducting test weighings of the local unit in the locality.

In most of the countries, the study was carried out by the national agency responsible for collecting national agricultural production data. However, training and supervision were carried out at more intensive and exacting levels than commonly possible because of the limited size and scope of the survey and of the efforts of the consultants who coordinated the study. Therefore, the precision of both estimates (farmer and crop-cut) should be better than those likely to be obtained from a full-scale survey.

The overall results from the study are summarized in table 2.1.

Table 2.1. Percentage of production over- and underestimation by country and data collection method

Country	Crop-Cut 5mx5m	Farmers' estimate Pre-harvest	Post-harvest
Benin	25	19	-8
Central African Rep.	31	-27	7
Kenya	38	2	1
Niger	32	20	n.a.
Zimbabwe	14	43	7
All	34	9 a/	3

a/ excluding Niger.
n.a. not available
Source: Adapted from Verma, Marchant, and Scott (1988, 16).

In each country the crop-cut method resulted in serious overestimates of production compared with the measured production from the entire field. Only in Zimbabwe was the error as low as 14 percent, the figure previously reported from the Nigeria study. In the other four countries, the overestimation was in the range of 25 to 38 percent.

In contrast, farmers' estimates were much closer to the measured production. Preharvest estimates varied widely. Large errors were common, although the overall estimate was less than 10 percent in error. More impressively, the postharvest estimate by farmers in each country was within 10 percent of the measured production, with an overall combined error of only 3 percent. The mean estimates not only were closer to the actual recorded production, but they also displayed considerably smaller variances.

These results are more differentiated than expected. The margin by which farmers "outperformed" the crop-cut enumerator harvested method is far greater than even the advocates of farmer interviews had imagined, and the size of the biases in the crop-cut method was, in general, much higher than previously supposed.

B. Sources of Error in Crop-Cut Estimates

The method for locating the subplots, and for dealing with cases where the random location cuts the border of the field, was based on the standard procedure recommended by FAO (1982). The authors of the study reviewed the various sources of error in a paper to the 1989 Meeting of the International Statistics Institute (Scott, Marchant, and Verma 1989). A summary of their conclusions follows.

(a) **Focusing effect.** The probability of the random location being closer to the center than the relative area occupied by the center was illustrated in a worse-case scenario by the authors. They demonstrated a significant bias due to this effect. It could be as high as 10 percent, but in most cases would not exceed 5 percent.

(b) **Border bias.** Methods to place the subplot completely inside the plot (when the random coordinates show part of the subplot lying outside the field) usually result in a lower than required sampling probability for a band just inside the perimeter of the field, where yields are often lower. This bias can be large when the fields are small and thin. The authors estimate that the average should be less than 5 percent.

(c) **Underrepresentation of protruding corners.** If bits of the field jut out from the main area, these portions may have a very low or zero chance of being selected as a site for the subplot. If yields are relatively low in these protruding areas, another bias is introduced.

(d) **Nonrandom location of subplot.** Even a well-trained enumerator may tend to move the subplot if it falls on an infertile piece of the field containing no crop. Yet such bare pieces are common and are included in the measurement of crop areas. Since there is no tendency to avoid very fertile portions, no counterbalancing of biases occurs. It is the belief of most practitioners that this bias can be very substantial because enumerators want to measure output.

(e) **Edge effect.** The string marking the edges of the subplot may not lie flush on the ground, leading to ambiguity as to whether a particular plant falls within the subplot or not. In dubious cases, enumerators tend to include the plant rather than exclude it. This source should not account for more than a 2 to 3 percent upward bias.

(f) **Overthorough harvesting of subplot.** The crop-cut, since it is limited in size, is likely to be harvested conscientiously with little wastage. Such is not the case when harvesting complete plots: many studies have shown that some grains remain on the ground. In effect, the subplot yield approximates the "biological" rather than the "economic" yield, that is, it is close to the actual harvest produced by the plants rather than to the produce available to farmers for sale or consumption.

(g) **Bias in area measurement.** When measuring the lengths and bearings of an irregular perimeter, the enumerators approximate curving and wiggly lines with straight lines. In doing this, they tend to minimize the exclusion of plants and so include a series of minor bits and pieces that do not properly belong to the field. This would not matter

if the placement of the subplot uses the same notional boundaries, but in practice the enumerator adopts a more conservative image of the field in this latter exercise to avoid the "bare patches" on the perimeter. This relative bias in field boundaries in the two stages of the exercise may account for a bias as high as 5 percent.

All these sources of bias are in an upward direction. Therefore, it is not surprising that a combination of these errors can produce an overall bias reaching the alarming sizes reported in the five-country study when field sizes and shapes are small and irregular, and crops are unevenly planted.

C. Sources of Error in Farmers' Estimates

There are also several sources of error in estimates obtained by interviewing farmers:

(a) **Conscious or subconscious bias in reporting.** Farmers may understate or overstate their production depending on the benefit they perceive from doing so (see chapter 3). Farmers also may be subconsciously pessimistic or optimistic, depending on their state of mind or cultural traditions. These sources of bias will depend on the circumstances prevailing at the time of the survey. All that the five-country study demonstrated was the farmers' ability to make reasonable estimates in conditions that they recognized to be somewhat experimental. Nevertheless, this is an important finding since in many circumstances farmers have been shown to be well-motivated toward project-related inquiries or surveys.

(b) **Calibration of informal units.** Some local units used by farmers in the study were extremely variable in size when test measurements were made. This was true particularly for two units reported in Benin and three units in the Central African Republic, all of which had coefficients of variation over 13 percent. Units such as these are likely to lead to substantial errors in calibrating farmers' reports and should be avoided as far as possible.

(c) **Rounding of calibrated unit weight.** Some standard units such as the 90kg bag are so large that an estimate of "three bags," which may imply anything from 2.5 to 3.5 bags, could involve a large error in rounding up or down. Farmers tended to avoid reporting in fractions of a bag.

(d) **State of the crop.** Obviously, the farmers' subjectively assess the condition of the grain they are visualizing in order to provide an estimate of grain equivalents. For example, they will assume a given moisture level, depending on their normal marketing practice. Unlike the local retailers with more flexible standards, a marketing agency might buy only grain that is below a certain moisture content. It is certainly necessary to ask farmers for a grain equivalent, since reporting in terms of an unshelled or unthreshed status leaves too much uncertainty in converting to a grain equivalent. However, even in the Central African Republic where farmers reports were given in terms of unshelled status, the farmers' estimates were accurate enough to be used in monitoring reports and planning.

These limitations in using farmers' estimates are important. Nevertheless, the findings are clear: if farmers are motivated to make their best estimates, they can do so with impressive results. When the necessary presurvey explanations are made and normal courtesies are observed, small farmers are generally very responsive. In many circumstances, the farmer interview method will be the method of choice. The alternative, given the problems in using the crop-cut method on small fields of irregular shapes with variable planting densities, is to arrange for weighing of the total harvested output.

The crop-cut method provides a direct estimate of yield, which together with area can be used to calculate production (at the aggregate level, not at the field level). The farmer's estimate provides a direct estimate of production, which for a variety of uses is all that is needed. Indeed, information on food availability, marketing forecasts, and trends in overall area production or in overall production by identified groups of farmers require only production data. In those cases, area need not be measured (thus avoiding what is a major task, as a rule).

If yields are needed, then areas must be measured. One should consider, however, the possibility of weighing the total crop to provide enough precision for analysis of the impact of various practices on yields under farmers' conditions. This is one application where anything short of weighing the total crop is likely to involve a margin of error that is too high. We will therefore assume in this paper that the information needed is production data.

D. Benefits of Using Farmers' Estimates in Terms of Sample Design and Costs

Given the practicality of using farmers' estimates of production, certain major benefits can be achieved in terms of sampling efficiency, survey timing, and costs. Comments on each of these areas are given below.

(a) **Sampling efficiency.** The crop-cut method requires the enumerator to handle a clustered sample of fields, close enough to allow for easy access, given the likelihood that harvesting will occur almost simultaneously within a given district. The standard sample design, therefore, is for each enumerator to be allocated one or at most two clusters (enumeration areas) with a sample of 30 to 60 fields per cluster. For measurement of yield or production, this is a very inefficient design because of the phenomenon of intraclass correlation--the tendency of yields from fields close to each other to be more alike than the yields of fields that are some farther apart. Intraclass correlation reduces the efficiency of a sample estimate for a given sample size and is particularly damaging for variables such as crop yields where the correlation is often high.

The loss of sampling efficiency is calculated using the formula

$$Z = 1 + (\bar{m}-1)\ \delta$$

where Z indicates the proportionate increase in the sample size n needed to obtain the same sampling error margin as a random sample; $\bar{m}$ is the average number of plots selected per cluster, and δ is the intraclass correlation coefficient.

Values of δ for crop yields have been reported in the range 0.1 to 0.4. Taking a figure of $\delta = 0.25$ and a $\bar{m}$ of say 30 (a sample size lower than 30 would create other problems)

$$Z = 1 + (29). \ 0.25$$
$$= 8.25$$

In other words, such a clustered sample would need to be eight times larger than a random sample to achieve the same error margin. Even a $\delta = 0.1$ would give a $Z = 3.9$ using a $\bar{m}$ of 30. The highly clustered nature of crop-cut samples imposes a major loss of sampling efficiency. To justify this, the nonsampling errors would need to be reduced very dramatically. As we have seen these reductions may not occur the biases may indeed be very large.

To minimize Z for a given value of δ requires a very low figure for $\bar{m}$. If clustering can be reduced by allowing the enumerator to cover a wider area, substantial sampling efficiency gains can be made. If $\bar{m} = 5$, for example, the values of Z for δ values of 0.25 and 0.1 as used above would be 2.0 and 1.4 respectively--a major improvement on the values of 8 and 4 that apply when $\bar{m} = 30$.

If farmer interviews are used to obtain production estimates, reducing the clustering effect becomes a practical possibility. It is no longer essential for the enumerator to be present at the precise time of the harvest, so it is not essential for the sample plots to be so closely clustered around his base. Moreover, since a farmer interview is quicker than the process of enumerator harvesting of subplots, the sample size can be increased to compensate for any residual clustering effect. In the example above if $\bar{m} = 5$, a 40 percent increase in the number of interviews per enumerator may be practical, whereas a major increase in the number of plots to be subsampled may result in the enumerator failing to be at the plot before the farmer proceeds with harvesting it, thus resulting in the loss of the previously demarcated subplots.

(b) **Survey timing.** With the crop-cut method the enumerator must be at each sample plot immediately prior to harvesting by the farmer, in order to harvest the subplots. Relying on an interview with each sample farmer reduces these constraints so that the survey can be phased over a week or two around the harvest period. The incidence of missing data will be reduced: arriving two hours late may mean the chance of harvesting the subplot has been lost, but it is not too late to conduct the interview, which could even be postponed for a few days. Such flexibility makes possible a more efficient organization of the enumerators' sampling design. It is also likely to be appreciated by the farmers. From their point of view, crop-cuts directly interfere with the harvesting process, since the plot cannot be harvested until after the enumerator harvests the subplots. An interview can be scheduled at the farmer's convenience.

(c) **Survey costs.** The crop-cut method requires a preliminary visit before harvest to locate and demarcate the subplots and measure the plots, and a second visit to conduct the subplot harvest. To achieve the latter, the enumerator is often resident in the cluster for some days prior to harvest awaiting the signal from the farmers that the crop is ready for harvest. A period of relative inactivity is followed by a frenetic period when the enumerator attempts to visit all the sample plots in a very short time. This is a costly and inefficient use of survey manpower. Using farmers' interviews as the method of choice may obviate the necessity of a preliminary visit and may enable the enumerator to use his time almost entirely for productive interviews, thus lowering the cost per sample unit substantially. This may be partly offset by the increased travel costs of an enumerator covering a wider area in order to disperse the sample, but the net effect is likely to be a reduction in overall enumeration costs per sample unit.

These benefits are, of course, interrelated. Use of farmer interviews can enable the survey designer to adopt a methodology that allows for a larger, more dispersed sample that can be enumerated for the same cost as a smaller, more highly clustered sample if the crop-cut method were chosen. The sampling error will be smaller without any increase (indeed a possible reduction) in the nonsampling errors.

CHAPTER 3

General Guidelines on Obtaining
Production Data from Farmers

Cereal production estimates provided at the plot level by the farmers themselves are precise enough for use in estimating cereal production. As with all data collection, however, the method is not without pitfalls, and it must be used with care and discipline: this and the following two chapters provide guidelines for staff who design, implement, and interpret production surveys. In these surveys, as in all survey work, it is especially important that the staff demonstrate common sense, a good knowledge of the social realities of the area, and attention to qualitative information.

This chapter discusses several issues that commonly arise when using the farmers' own estimates of production, regardless of the purpose of the data collection. First, the question must be asked of the person most likely to have an interest in knowing the answer, and this is not necessarily the head of the household or the owner of the plot. Second, the fact that experienced people are able to estimate the production level of a plot does not mean that they will give their true estimate whenever asked. Third, farmers will answer in traditional measurement units, which will need to be converted into the metric system. Fourth, the distinction between the production on individual plots and total production of the holding needs discussion, as well as the issue of area and yield versus total production. These various issues and resulting guidelines apply especially to the collection of farmers' estimates for forecasting purposes or after harvest.

A. Identifying the Appropriate Respondent

Many surveys have been designed with the head of household as the respondent, usually the oldest man. This is not necessarily appropriate for two reasons. First, individuals are likely to be better informed, and to have made a more accurate estimate, for plots that they see often and are directly working on. The division of labor and responsibilities within the household is therefore relevant to the choice of respondent, since in many African countries there is a clear distinction between household plots and those under the autonomous control of individuals, especially women and young adults. Second, more and more often the men may spend extended periods of time away from the compound, and the day-to-day responsibility for farming is taken up by the women. The question of absentee owners also arises in some areas.

Questions on the estimated production of specific plots should be directed to the person who works that plot. To identify that person and make sure that he or she will be available for an interview may require additional preparation. When a woman is to be interviewed, cultural mores must be respected. Perhaps the purpose of the interview should be explained first to the male head of household. Male enumerators may need to avoid visiting women

alone in their compounds. In any case, as we will see below, the interview should take place at the plot being discussed.

Efforts to ensure privacy and veracity can create difficulties: the presence of family members and neighbors during the interview can be disruptive and can prevent the respondent from giving his or her real estimate, but it would be counterproductive to insist on privacy. This problem is less likely if the enumerators are known to the villagers and have visited the area on other occasions (thus their presence is not unusual, and if proper care has been taken to obtain the approval of local authorities and to explain beforehand the purpose of the visit.

B. Veracity of Farmers' Response

The accumulated evidence on the use of farmers' estimates shows only that farmers are capable of estimating their production. It does not signify that they will say what their true estimate is to anyone who asks. There may be obvious reasons why farmers knowingly underestimate production. Farmers may believe some food aid is forthcoming, or that taxes will be levied, or a quota of production is to be sold at a low price to a marketing agency.

While objections on the basis of fear of taxes are often raised by survey practitioners, this fear seems exaggerated in African countries where small farmers are subject to a head tax and possibly to a tax on export crops, but not to a tax based on food crop production or on income. Why should they worry about a tax they have never experienced? Of course, in countries with such a tax, the survey organizers must assure the farmers that the raw data will never be made available to tax collectors (*and the organizers must keep that promise*).

The link between crop reporting and distribution of food aid may present a significant difficulty at a time when production is well below normal, in those areas where food aid has been provided in the past. Marketing quotas could also be a source of difficulty if farmers are required to sell the totality of their production, or a set percentage, to a marketing agency. From a data collection point of view, if these regulations were respected, the problem would disappear since marketing data would be a perfect estimate of actual production. However, this is unlikely with food crops, since part of the production will be kept for home consumption, and an informal market, whether recognized by the authorities or not, is likely to thrive.

In any case, as for all data collection, the quality of the findings will depend on the design of the survey, on the courtesy and thoroughness with which the survey is introduced to the farmers and local officials, and on the care with which the data are checked and corroborated through direct observation, spot checks by actual weighing, and other data. The problem of refusal or false response should be minimal when the survey is conducted, for example, by monitoring staff in an extension agency because a rapport has already been established between staff and farmers. This is particularly true when the survey is conducted on a sample of farmers who have already been exposed to this type of data collection. They can easily see how the questions on cereal production are a logical part of a continuous process that they understand and support.

Candid responses will be more difficult to obtain if the survey is conducted by an outside group that has not had previous contacts with the villagers and local authorities. In that case, after agreement has been reached with the central authorities, a trip to the local authorities in the area and villages included in the sample is absolutely necessary. The purpose and organization of the survey can then be explained, the sampling frame can be verified, and any unusual factors in the area that could affect the survey or analysis of the findings can be identified.

As a rule, it is best to inform local officials and farmers at the beginning of the season that they will be asked to provide information on their crop. Doing so before anyone knows if the harvest will be good, bad, or average separates the survey from crop condition at harvest time. When the survey becomes an annual event, it is likely to lose its frightening aspect. It is not necessarily the same individuals who are interviewed every year, but the word spreads quickly through the villages. There will always be the odd coincidence in some areas, where a farmer who participated in the survey seems to be rewarded or punished through some unexpected circumstances, but this is the case with all data collection and has to be dealt with as it arises.

The problem of "eagerness to please the interviewer" can be avoided if the enumerator interviews the farmer at the plot being discussed, so that obviously incorrect answers are spotted right away by an experienced enumerator (see chapter 4 for a discussion of training and supervision of staff). This should be a basic rule in the use of farmers' estimates. When the data are being collected just before or at harvest time, the interview should be done on the plot, where misrepresentation of the correct estimate is limited by the very fact that the production is being observed by both the enumerator and the farmer. When the data are being collected after harvest, the estimate should be compared with corroborating factors at the farm level (such as the number of granaries on the compound and the amount stored) as well as with more general data on sales on the local market and various behavioral indicators. (See chapter 5 for a more complete review of corroborating sources of data; for methodological guidelines on qualitative data collection, see Casley and Kumar 1988; Cernea 1985; Chambers 1988; Salmen 1987).

Cooperation will be facilitated if the interviewer asks very clear questions that are understood by all respondents in the same way; the usual rules for clarity and specificity of survey questions apply (Casley and Kumar 1987; Murphy and Sprey 1982; Patton 1986). A key point is to provide feedback to the farmers on the results of the survey (for example, by organizing group discussions of whether results are plausible and then to explain them. This would fulfill three objectives: (1) to find out from the farmers whether the results make sense to them and discuss any possible trend, (2) to obtain their ideas on explanatory factors that influenced production results, and (3) to provide feedback to farmers, as a courtesy and an incentive for future cooperation. The group discussions would include a comparison with previous years and with other areas, with tentative explanations of the variations observed and any discernible trends (see chapter 4, section D, for a discussion of group interviews.)

Whatever care is given to the design and implementation of field work, the fact remains that there are psychological and cultural factors involved in discussing one's field production (just like income), and it is likely that they operate differently in different countries and for different ethnic and religious groups. On the positive side, farmers everywhere are keenly

interested in the size of their crop, they compare it with that of their neighbors, and they make private or public comparisons with results achieved in previous years. Whether literate or not, all farmers have an extensive memory of good and bad crops over many years, and they can place their estimate of a particular crop in the broader context of production in the area. The pride of a job well done may encourage a farmer with a plentiful harvest to be quite articulate about it, although in some cultures an obviously good crop might be downplayed. In areas where social or ethnic groups compete for resources, it may be difficult for the farmers to be candid.

C. Conversion of Traditional Measurement Units

In most cases, the farmers will estimate their production in a traditional unit (usually of volume rather than weight) or in number of bags or containers (usually in whatever type of bag is sufficiently ubiquitous in the area to have become a standard measure). A conversion factor will have to be established to convert the results to the metric system. This is a key technical problem with the method, especially in regions where there is a great diversity in traditional units even within short distances. Table 3.1 presents some of the units mentioned in recent reports together with their value.

When using farmers' estimates the traditional units in the area must be ascertained, and their conversion factors actually measured, by weighing a sample of five filled units to calculate an average weight by unit and to calculate the coefficient of variation (or standard deviation). If there is a high degree of variability between different measures of the same unit, then it is not a suitable unit to use.

For units with an acceptable level of consistency, the conversion factor must take three characteristics into account: the size of the traditional unit when it is considered full, whether it is filled before or after threshing the grain, and the moisture content of the crop at that time.

In terms of physical measurement, traditional units used for cereal crops seem to fall into two main categories: the container or the bundle. The bundle, by definition, uses grain on the stalk. Its size can be defined by the number of stalk in a bundle, or by the bundle size that one can comfortably hold in one hand. More frequent is the use of a container as a unit, usually some type of tin pot or can, or a standard basket or bag. Tradition dictates whether the crop is stored before or after threshing, and how the container is filled in order to be considered "good measure." The pot or basket may be filled only to the top of the container, or into a heap ("until any addition falls to the side"). In either case, there will be a right way (all local people agree) to fill the container.

In many countries, commercial jute bags of various sizes are reused, and they have become a standard unit of measurement. They have the advantage of being truly standard in sizes within each category, so that full bags are nearly identical in weight for a given crop. However, the largest of the bags are big; a full-sized bag filled with maize, for example, weighs about 90 kg. This causes difficulties with expressing and recording "parts" of bags, with a

possibly large error for smaller volumes due to the round off in full bags. Scott, Marchant, and Verma (1989) report the problem for small plots in Kenya.

Table 3.1. Examples of local units and conversion factors

Country/Region	Crop	Name of unit	Mean weight (kgs.)	Standard deviation
Benin/Zou	a/ maize	Benin	0.86	4.82
Central African Rep./ Bambari	a/ maize	cuvette	27.80	1.50
Burkina Faso	b/ sorghum	basket	17.50	n.a.
Kenya	a/ maize	bag	90.00	n.a.
Zaire	a/ maize	basin	19.74	6.46

Note: Not to be used without field verification.

a/ unshelled.
b/ grain.
n.a. not available.

Sources: For Benin, Central African Republic and Kenya, Scott, Marchant, and Verma (1989); for Burkina Faso, Murphy and Sprey (1983); for Zaire, Rep. du Zaire (1989).

Finally, the influence of the moisture content on the weight of the sample unit can be quite significant; Tollens, for example, reports that the same basin weighs 19.74 kg on average when filled with fresh maize, but 13.50 kg after drying (Republique du Zaire 1989, 7). What matters in a production estimate is that the conversion factor be established with a moisture content identical to that present at the time of estimate of production by the farmers, with a correction factor if necessary across sites, so that the data can be aggregated. While the moisture content at harvest time can be as high as 20 or 25 percent, the recommended moisture content at the time of storage is about 10 percent (see table 3.2).

Table 3.2. Moisture content (MC) in selected crops (percent)

Crop	Moisture Content	
	At harvest	Recommended for storage
Maize	n.a.	8
Millet	n.a.	10
Rice	18 - 25	13 - 14
Sorghum	20 - 25	10
Wheat	n.a.	10

n.a. not available.
Source: USAID (1974).

The level of moisture present in the crop is measured with an hygrometer, an instrument that should be available from colleagues in the extension or research services.

Before the survey is undertaken, the survey manager must ascertain not only what container is used, but also how it is normally filled, and arrange for the enumerators to weight at least "fillings" of each type of container used in the area, so that the weight equivalent of an average filling can be calculated. The full process of how to measure a unit has to be elucidated, and the work done by, or in front of, the enumerator. Detailed instructions must be written down and given to all enumerators, so that they weigh the traditional containers in comparable situations - that is, threshed or not threshed, at a standard moisture content, and in strictly identical conditions.

This can best be done just before the actual survey. A preliminary visit can be a good time to explain the objective and use of the data collection, but only if the survey will be done at or just after harvest time. If the survey is being conducted outside the harvest season, grain from the previous harvest could be used, but its moisture content will be low. It is suggested that a monitoring and evaluation unit whose work program will include data collection on production should build up its own set of standard equivalencies over time, with yearly checks for new or evolving measurement units.

In some cases, survey organizers avoid the problem of traditional units by providing participating households with a standard container, both as a gift for their participation, and so that household members can actually count the number of fillings of that container used to bring the harvest to the compound (DeJaegher 1988; Republique du Zaire 1989). This method is especially appropriate for crops that are harvested a little at a time (maize, beans, peanuts).

D. From Plot to Holding

Producers know how to estimate the production of a single plot, whether of a single or mixed crop. Most of the plots in the five-country study described in chapter 2 are of the latter sort. But producers know how to estimate total production from all the plots under the same crop in their holding? This question is important, since almost all farms contain several plots of various cereal grains, often managed by different members of the household. For early warning systems and for resource management, the information of real interest is the total production of a given crop for the entire holding, not that of individual plots.

Experience in a number of countries seems to indicate that producers can provide a valid estimate of their total grain production. Kenya, for example, uses the method with satisfaction. The farmers in southern Africa, where maize is often planted in narrow strips close to each other, harvested, and brought back to the compound all together, should have an easy job of shifting from individual plots to total holding when estimating production. (This was confirmed for Swaziland by Curry, personal communication). The situation may be more difficult in the Sahel, where household and individual plots can be scattered over a fairly broad area.

In any case, the interviewer must be very specific to be sure that the answers cover all the plots cultivated by the family, including the separate plots of the women and young people. It will therefore be necessary to question several family members, and if at all possible to go to each of the plots with them; this is particularly important for forecasting.

When the estimate is obtained just after harvest, the global estimate can be made easier if all household production has been brought to the compound and stored in a few granaries. The key here is to make sure that the respondents understand clearly that the question pertains to all grain produced, including what may have been sold immediately, and just on what has been stored.

E. Farmers' Own Records

Experience has shown that recordkeeping by the people themselves, or by their school age children, can be used as a source of data on agricultural practices, petty trade, social forestry, or livestock activities. Illiterate farmers or herders have been successful in recording their activities on forms with pictorial headings, and illiterate women have been trained to maintain health and immunization records on similar forms (see Rugh 1986 for an example of recording by illiterate individuals).

For production data, there is anecdotal evidence of experiments with recording by farmers, but more systematic efforts to test the approach would be desirable. To obtain estimates at the holding level, one could conceive of a system in which the farmer notes his or her estimate of production for each plot as it is being harvested, for example by crossing out the appropriate number of drawings of the appropriate local container. Dejaegher (1988) reports such an attempt for a variety of crops (beans, root crops, cereals); the farmers were provided

with a standard size bucket that they could use in daily harvesting of beans and root crops, and extension supervisors visited frequently to assist and verify in filling out a pictorial questionnaire. Even though the data would be aggregated at holding level, a difficulty with such a method would be the identification of individual plots, to avoid double counting or missing data, in areas where each household may cultivate a great number of small plots with the same crop. Another source of difficulty may be the reluctance of individuals in the household to openly estimate the production of their individual plot. The relative privacy of a short interview on an individual's own plot is lost when physical records are maintained at home for all to see.

In any case, verification by an enumerator or supervisor would be essential. During a preliminary phase, this should include the actual presence of the enumerator at harvest time, to assist the farmer in filling out the form if necessary. Should a test comparing the farmers' records and the actual weight of total harvest be conclusive, only spot checks would be required for future crops. It would be highly desirable that any agency or non-governmental organization using the farmers' own records take time to write down the details of the methodology used and lessons learned.

In summary, this chapter has identified a few specific issues that affect the quality of data in a survey using farmers' estimates. Chapter 4 will elaborate on general procedures for organizing, implementing, and verifying a crop production survey using farmers' estimates. Possible sources of corroborating data, both qualitative and quantitative, will be reviewed in chapter 5.

CHAPTER 4

Organization of a Survey to Collect
Farmers' Forecasts or Estimates

A. Basic Principles

Before specific plans can be made for any data collection, three sets of parameters must be clearly defined: who will use the results and for what purpose, when must the results be available to decisionmakers, and what is the population of concern. Farmers' estimates provide a valid source of information for planning for agricultural agencies that require an early forecast of production (early warning systems), and for those engaged in the marketing of crops or planning of inputs associated with grain production. The method also fulfills the information needs of agricultural agencies about the harvest actually achieved by a specific category of farmers (for example, those who took a short-term loan). For extension services, the method supplements other information on the rate of adoption of new techniques. Statistical and planning agencies reporting on production level in a given area can also use the farmers' estimates, but the sampling requirements will be different from those for a service agency.

The farmers' estimates are not an appropriate source of data for detailed studies at the farm level that seek to establish the yield response to particular production factors, or to record precise farm budgets: Such studies require a total weighing of the harvest as well as measurement of the plot.

The time at which analyzed and properly interpreted results must be available to decisionmakers varies with the users and the type of utilization foreseen. Forecasting information must be available very quickly, or it will be obsolete; actual production data may offer more flexibility, although it should be available soon enough to influence preparations for the next crop season by various service agencies.

Careful thought should be given to defining the universe (population) that must be surveyed in order for analytical results to fulfill the information needs of the intended users. Is the objective of the survey to estimate the production of all farmers in a given area, or of specific categories of farming households? Surveys are sometimes requested on farmers "who had access to extension advice." This is not a well-defined category of farmers: Does it mean only farmers who are official members of an extension contact group, any farmer who ever attended an extension demonstration that year, or any farmer who lives in a village where an extension agent is active? There is no absolute answer, but if the population is not rigorously defined so that it really corresponds to the hypothesis being tested by the survey, the conclusions will not be satisfactory.

When the population to be surveyed consists of one or several specific categories of households, the availability of an appropriate sampling frame should not be a problem. An agricultural services agency should have a list of all the households in the area it serves. (This

is a broader list than that of "contact" farmers, or farmers active in demonstration groups.) Normally, the listing is made by the extension agents themselves, with the technical help of the staff in the monitoring and evaluation unit. This provides the extension agents with an opportunity to introduce themselves on a more personal basis to individual households (after they have been introduced in each village by their supervisors). During the visit, the agents will inquire about household composition, farming equipment, and draught animals.

When the population consists of all holdings in the area, a sampling frame can be designed through the use of maps or aerial or satellite imagery. Data derived from satellite imagery, already analyzed and interpreted so it can be used by various agencies, are becoming more readily available from specialized units at the central level in many governments.

With regards to sample size, section D in chapter 2 demonstrated and quantified the sampling advantages of using farmers' estimates rather than the crop-cut method to estimate production. Since the enumerators only visit each village twice for a day or two each time during the survey, there is no need to cluster the sample around a few homebase villages; instead, work can proceed directly on a sample of farms more evenly distributed over the whole area to be covered. This reduces the problem of intraclass correlations within each cluster, making possible a reduction of sample size by a factor of about eight for the same error margin. A smaller sample size cuts the time and resources needed for data collection and analysis, and so more emphasis can be given to the quality and rapidity of the work. The nonsampling errors can thus be decreased.

In practice, one would rarely use a true randomized, one-stage random sample, since travel could be very inefficient and timeconsuming. A good compromise would be a two-stage sample, but covering more villages with only three or four sample holdings around each village. This greatly improves sampling efficiency compared with many sample holdings clustered around a few villages.

B. Survey Methodologies and Format

One should never rely on one source of data without verifying it through crosschecks and comparisons with information coming through other sources, covering physical evidence of crop conditions, economic indicators, behavioral evidence which show what the local population expect the food situation to be in coming months. Quantitative data should not be analyzed and interpreted in isolation; qualitative information from the farmers themselves, from local authorities and staff, and from other agents whose activities influence or are influenced by the size of harvest should always be part of a balanced analysis of the situation.

This means that a variety of data collection methodologies will be used in combination. The core of data collection should be a rapid survey to interview individual farmers in the appropriate sample. The findings and their interpretation should be discussed in group interviews of farmers and in individual interviews with local leaders and officials. Before the survey is designed, secondary sources (such as crop statistics reports, marketing data, farming systems studies) should be reviewed, and key informants interviewed, to determine the context within which the survey will be conducted, to identify key issues, and define the range of

results that can be expected. This preparatory work makes it possible to design a survey that is well focused, and therefore more effective.

Since there is no need for the enumerator to set up physical measurements in the sample of plots, or to be present exactly at harvest time (except perhaps for a subsample for which the total harvest will be weighted), visit dates for individual interviews can be flexible and the data can be obtained through a single visit to each farm at or shortly after harvest time. Enumerators need not live in the villages surveyed for part of the growing season. Rather, mobile teams of enumerators or supervisors can make short visits. In addition, the work can be staggered across villages, thus reducing the number of enumerators needed. Surveys teams of three to five members can be divided into teams of two or members can work on their own once they arrive in a village. Sometimes three people set off in a pick-up truck with one or two bicycles or mopeds. This enables them to visit a number of neighboring villages at the same time and to check with each other every evening.

Of course, for mobile teams to be effective, the enumerators must be able to move around without any difficulties when the time comes. This leads us to a consideration of practical questions of organization and resources. The cost of the mobile teams should compare well with that of enumerators living in the survey villages. Although the small teams have greater transportation expenses, the cost of building or renting suitable lodgings is avoided. The difficulties of settling families in somewhat remote areas with few services, and the problems of supervising and motivating isolated staff, are also avoided. It is likely that experienced, skilled staff can be made available for brief survey periods, which cuts down on the nonsampling errors that are often extremely high in data collection work. A small number of well-trained and motivated enumerators will produce fewer errors and less useless data. If, as ought to be the case, the analytical tables and the review and report stages have been prepared and tested in advance, the results can be made available very quickly.

To obtain both a forecast of production during the growing season and an estimate of the harvest actually obtained, the mobile teams will need to visit the same farmers twice. This approach entails more work, but it has a number of advantages. First, the conclusions drawn during the first visit can be confirmed or revised, and a comparison can be made with the first visit during the following season. Specifically, estimates that were very different from those for farmers in the same area can be identified and checked, and any explanatory factor noted.

Second, data can be obtained on anything that might have happened in between the two visits to explain changes in the prediction made during the growing season. It is particularly useful to distinguish between "accidents" (damage caused by fire or animals, for example) and biological developments resulting from natural causes such as unfavorable rainfall pattern, diseases, or pest infestations (see a discussion of the analytical implications in the next section).

Finally, the second visit allows for the useful verification measure of weighing the total harvest on the basis of a subsample. This will enable the validity of the results to be checked and will help to refine the method over the years.

Obtaining production data through a rapid survey by mobile teams can easily be linked to a monitoring survey, which would have to be undertaken anyway to provide feedback on

farmers' changing practices and adoption rates. Thus a diversified survey can be undertaken on a smaller sample, probably with fewer but better trained staff. The results should be available to decisionmakers quickly, a benefit that is difficult to measure but very real for the country.

In summary, to carry out a survey using small mobile teams requires good organization, including clear arrangements, with local authorities, detailed planning of the itinerary and work timetable, transportation at the right time, appropriate composition of the teams, and quality supervision, which enables most problems to be solved on the spot. This organization varies according to the geographic conditions; the key requirement is that the survey not be held up by lack of resources or access to transportation.

C. Survey Design and Preparation

As always, the manner in which the survey is prepared and introduced to the population and authorities plays a key role in determining its validity. It is essential to work with the local authorities to ensure their cooperation, and to inform local institutions such as the local extension office. They should be informed of the purpose of the survey and told clearly who is responsible for it, which staff will be conducting it, how the results will be utilized, and what precautions will be taken to prevent the respondents from being penalized (or favored) in any way. The level of precaution needed to introduce this particular type of data collection depends in part on previous contacts in the area. Interviews by survey staff already familiar to the farmers would not need the same level of introduction as those conducted by strangers.

Because the data collection for production per se requires only a few questions, it is possible to link it to another survey if the samples are compatible. For example, in an extension agency, the farmers' estimates of their cereal production can be tagged on the periodic monitoring survey, whose primary focus is exposure to extension activities and evidence of adoption of recommendations. The two surveys are concerned with the same population, and they share a common framework in terms of timing (shortly before or at harvest) and approach (talking to the farmers in their fields). Little time need be added to the monitoring survey since the interview will focus on the history and results of the crop season anyway. Since the survey is being repeated at regular intervals each year, it is logical to inquire about the production relative to that of previous seasons. Over time, as these estimates are being corroborated by evidence obtained after harvest, past estimates become firmer, and the estimation of current harvest should become more reliable. The possible sources of corroborating evidence will be discussed in the last section of this chapter.

Data collection, verification, analysis, and interpretation (as well as report dissemination) should be a coherent system, with each step building on the previous one. The entire system, not just the data collection questionnaire, should be tested in a pilot survey. A first compilation of the raw data by village or groups of villages *must* be done right after data collection, so that estimates that are quite different (whether lower or higher than the bulk of the answers) can be identified and checked, and any explanatory factor noted. For example, a field may have been damaged because of flooding or other physical problems, or by wandering animals, or it may have been more or less affected by a pest attack than were neighboring

fields. Usually, accidents will be limited to a few contiguous plots; they may have a serious impact on the households concerned, but hardly on the overall area of production. On the contrary, most cereal plots in a given area will be hit in the same way by natural phenomena such as pest or diseases, strong rains at the time of flowering, or an early end to the rains. The resulting loss of production will be widespread.

It should be very clear to all enumerators how to handle this type of situation (that is, whether to keep all results in the compilation, however unusual or extreme). It should never be left to individual enumerators to decide that a plot in the sample is "too unrepresentative" to be kept in the survey. This first level of compilation can be handled by the enumerators themselves at the end of each day in the field, when the team gets together to compare notes and discuss progress.

There are two approaches to compilation of data at the village level. If the survey is complex enough to require a separate questionnaire for each respondent, then a separate compilation form will need to be used. On a compilation form key data from all respondents in a given geographical area (village, or district) are listed together in one table, making it easy to identify estimates which are very different--higher or lower--from the others at a glance, and to calculate means and coefficient of variation directly on the form. The two forms should be prepared together before data collection begins, to ensure complementarity between the individual respondent interview forms and the compilation form that combines their answers. Whenever the survey is limited to a few questions, a combination form can be used from the start, and the answers of several respondents who are interviewed by the same enumerator can be written directly on the compilation form. This has the advantage of avoiding one copying step, always a source of error and time-consuming. The forms filled out by enumerators in the same team should be kept together for comparison.

Either way, the data usually will be entered into a computer for further verification and analysis, providing another opportunity for verification of range and internal consistency as well as a source of delays and error. (See Ainsworth and Muñoz 1986 for an example of how this can be done in a highly decentralized, rapid fashion.) Two cautions are in order. First, in all analytical work, one should work out the entire process of verification and analysis with pen and paper, to make sure it is tailored to the information needs of users and that the format used at each step is efficient. Second, the analysis should be limited to what is really appropriate and needed on the basis of the data available.

Testing the entire set of procedures on a small number of farmers is an absolute necessity. The full process of data collection, compilation, and verification must be reviewed. Only then can the various forms be finalized, together with a written set of instructions for the enumerators. The test is not a waste of time; even experienced staff will find inconsistencies and problems in their draft questionnaires. They may also stumble on unforeseen situations in the field, for which instructions need to be developed. Finally, the test period serves as useful training for staff at all levels.

Proper training and supervision of the enumerators are essential since human errors during data collection can be great if staff are not well informed about the objectives and requirements of their work. Training should cover more than the simple mechanics of filling out forms accurately and cleanly. If the enumerators are encouraged to observe, to notice any

unusual situation, and to check one source of information against another, their work will become more interesting to them, and they can contribute much more than filled-out questionnaires. Each team should spend time at the end of each day comparing experiences and discussing what members have observed. The team leader should do some spot-checks and assist team members as needed. Depending on geographical constraints, the teams should meet for an in-depth discussion at the end of data collection and again as the first tabulations become available.

D. Survey Implementation and Data Verification

Since physical measurements are not necessary, each interview is fairly short. (We are referring here to collecting production data, not yields.) Notwithstanding the importance of explaining again the purpose of the survey (the reason for the survey will already have been explained to the local authorities) and of using the customary greetings, the interview will take only 30 to 45 minutes per interviewee. Some additional questions may well be put to the farmers in light of the user's needs, but this will not take much additional time since all the preliminaries remain the same.

The interview ought to take place on the plot for which data is being collected. This does not add much time to the overall survey in each village, if the plots are not unusually distant from each other. If the farmers have been informed in advance, an interviewer familiar with the village can meet them directly on their plots. When the question pertains to total holding production, ideally all plots should be visited. Should distances make this unrealistic, all enumerators should follow the same procedure: visit a randomly selected plot or, if working after harvest, conduct the interview at the compound where the granaries can be observed. Data verification and analysis should occur right after data collection so that return visits can be made quickly if necessary.

An alternate approach to obtaining the farmers' estimates of production at harvest time is to ask farmers to count the number of baskets or bags used when the crop is put into the household's granaries. This approach is easy for farmers to understand because it is a method they often use themselves (especially in Moslem households). Moreover, it takes place after the harvest is completed, either at the time when it is transported from the field to the compound or when it is transferred from its drying area to the granaries.

The length of time between the actual harvest and the transfer into the granary varies. To aggregate data it will be necessary to know the moisture content of the grain at the time it is measured, and correction factors may have to be used (see chapter 3, section C). The way the grain is stored varies (for example, on the cob or threshed). These differences will have to be taken into account.

In areas where cereals are stored after threshing in granaries of regular shape (rectangular or cylindrical), it may be possible to obtain a rough estimate of production by measuring the volume of the grain stocked in the granaries. Again this is to confirm the farmers' estimates, and need not be done for all farmers. Adjustments will need to be made for leftover crops stored from previous harvests, and for the share of production that was sold or distributed

immediately upon harvest. However, a simple observation of the number of obviously new (and full!) granaries, or of granaries empty after the harvest is completed should tell the analyst whether the data are plausible.

Yet another means of verification is to obtain estimates from agriculture staff. Experienced agriculturalists and extension staff should be as able as farmers to make an "eye estimate" of a plot's production, although not of production at the farm level since they cannot be expected to be familiar with the details of every plot cultivated by a given household. Their estimate, like the farmers', can be influenced by other factors, if their performance is measured by how their reported estimates match production targets. It is essential to disassociate the data reported by staff from any performance evaluation of the staff. One solution is to send staff outside the area where they normally work, so that they interview farmers and make their estimates in villages where they have not been professionally involved. Staff employed purely as enumerators are not expected to influence production by the quality of their work, and so should be less subject to overly optimistic estimates. They may, however, have less field experience in estimating production than do extension supervisors or researchers who have received more training in agronomy.

Whenever staff estimates are used, they must be obtained from a proper (randomized) sample within the correct population of farmers. Too often, staff base their estimates on what they see as they circulate in the area and observe the plots along the road, or as they visit individual farmers purposely selected for having agreed to set up a demonstration plot on their land. Such observations can never form the basis for quantified estimates of production either for a given geographic area or for a set of farmers. It is incorrect to draw *quantitative* conclusions from these impressions, which would reflect the condition of plots close to transportation (and therefore services) or belonging to the more progressive farmers. A correct estimate would be obtained through systematic firsthand observation of a randomly selected sample of plots, properly recorded, by staff who do not have a personal stake in the outcome. This is quite different from asking the extension agents to report on the plots of the farmers they work with (since the farmers may be under pressure to be optimistic) or from relying on the conclusions drawn by extension managers during their supervisory travels to the rural areas.

While marketing data can provide adequate estimates of production for many cash crops that are sold through a limited number of marketing channels, this is not the case with cereal crops. Part of the harvest will be kept for household consumption and part may be sold; even the marketed production may be difficult to estimate since numerous small sales may be made over time at the farm and at the local market, as well as through traders. Part of the harvest also may be bartered or given in payment to casual farm laborers. Nevertheless, marketing data (or data on volumes transported) can be useful to confirm and verify trends, regional differences, and the flow of goods.

Finally, if the extra funds and time are available, the farmers' estimates can be verified by comparing them with those obtained on a small subsample of plots by actually weighing the total production of those plots.

In all cases, it is important with the first compiled results to go back to some of the key informants and farmers who had been interviewed, and to ask them to verify and interpret the

findings. This would be done mostly through group interviews, separately for local officials for staff, and for farmers (see Kumar 1987 for a review of the methodology). Group interviews would make it possible to confirm whether the results (aggregated for the group, not given for individual farmers) seem plausible, to obtain the participants' views on the factors that explain these results, and to get them to discuss trends and patterns as they have observed them.

For group interviews with farmers, attention should be given to the composition of the group; young or poor farmers may not feel free to speak up in front of their elders. Separate interviews with a group of women farmers may be advisable. In any case, with group interviews taking place outdoor. It may not be possible to keep other farmers out of the discussion. The interviewers will need to make mental note of those participants who hesitate to speak up, and talk to them informally afterwards.

Second interviews with some key informants, once the preliminary results are available, are essential. As a courtesy, local staff and officials should be informed of the preliminary findings and given a chance to correct any obvious errors. Second interviews also have analytical importance, since the informants are asked how they explain what the results show. This can reveal to the survey staff a line of explanation they had not yet identified.

E. Data Analysis

Once the data have been verified, the analysis can proceed but always as a function of the needs of users. The level of analysis should not be more complex than is warranted by the data quality. A first phase of exploratory analysis (such as simple tabulations and ordering of data, graphic representations, distribution, and dispersion) will provide key summaries of findings and identify possible patterns for more detailed analysis. Often this is all that will be needed. The reader can refer to any standard publication on basic data analysis and simple statistical analyses for further details on methods (for example, Casley and Kumar 1987, 1988; Casley and Lury 1987; Murphy and Sprey 1982). The next chapter will discuss indicators that the analyst should assess to understand and interpret production data in a broader context.

CHAPTER 5

Interpretation of Production Estimates

Once the farmers' production estimates have been collected, verified, tabulated, and analyzed, the results should be interpreted in the light of information from various sources. The analyst needs to assess and explain the results in the broader context of production data from previous years, differences in results among reporting agents, and evidence from other sectors of the economy. Although the results will have been discussed with technical staff in a preliminary form, formal oral presentations and final written reports to the intended users should include a discussion of the context in which the results must be interpreted.

This final phase of the survey calls for much experience and a broad understanding of the physical, economic and social dimensions of agricultural production. Discussions of the results with experienced staff within the agency and with farmers and traders are of course essential. However, it will be desirable to discuss the findings and their possible interpretation with analysts outside the agency who are particularly familiar with relevant sources of meteorological and related data, with trade data, and with the overall socio-economic situation in the area. This corroboration is specially important in unusual years. The interpretation of production forecasts requires particular attention to other sources of evidence, since one is trying to predict a production that is influenced by a variety of on-going factors.

A. Categories of Corroborating Information

Three categories of corroborating data are likely to be used: physical parameters that influence production, market information on the supply and demand of food and other goods, and social and behavioral information. In other words, are the results plausible in light of other physical factors that would influence the crop? What was the meteorological situation throughout the crop season? Were there any report of pest infestation, or diseases, or any extraneous factors that could lower production? If this first review confirms that an area seems to be in a clear deficit or surplus situation, what are the signals from storage, agro-processing and marketing data? What is the trend for official and informal prices? What view of the future do farmers, traders, and other people express through their behavior regarding food storage, trade activities, other income-producing activities, temporary migration? Do those activities corroborate the physical evidence of production?

Physical parameters to be considered include first the most simple observations of meteorological and agronomic data throughout the crop season. The experience of the agency's agricultural and research staff in the area will be of great help, as will the data on previous years, which should be available from archives and previous reports.

In addition to this first level of interpretation, expected yields can be forecast through modeling analysis on the basis of agro-meteorological data, such as rainfall amount and pattern,

if appropriate groundproofing and calibration data (that is, yield measurements on the ground) are obtained. Such analyses are likely to be beyond the scope of work of an agricultural services agency, but the analyst may be able to draw on the work of a local research institute, the national statistical office, and the meteorological service. This will provide the agency with an independent source of corroborative information within which it can interpret its own production estimates. Much of the needed physical data for recent years are likely to be available from national, regional, and international sources, although problems may arise for longer time series. However, the availability of detailed time-series of meteorological and vegetation data is increasing, in part because of recent breakthroughs in the utilization of remote sensing data. A discussion of this data source is beyond the scope of this paper; the reader is referred to recent publications for a review of the utilization of remote sensing data in agricultural projects (Gastellu-Etchegorry 1990) and for a discussion of the institutional issues involved (Falloux 1989). The annotated bibliography in this paper (section C in chapter 6) summarizes reports on the use of remote sensing data for production forecasts.

The level of production in a given area is of course reflected in subsequent trade patterns and prices, not only for the cereals produced but also for other goods. Marketing and prices information useful to forecasters include the supply and sales of agricultural inputs to farmers; food demand; amount of food likely to be procured by the government and other agencies; fluctuations and trends of domestic food prices; existing stocks of food, and the logistics of food movement (see FAO 1989 for a useful discussion of the use of marketing information in early warning systems). Since the type, timing and quantities of the agricultural inputs used on a crop have a strong impact on yields, forecasters should be sensitive to the quantities of seed and fertilizer available to specific areas, to the credit available to farmers to purchase these inputs, and to data on actual purchases. Factors which affect food demand and therefore may need to be monitored at the local level include retail prices, production levels, and seasonality of supply and prices.

At and after harvest, the analyst will take in consideration evidence on storage capacity, volume of sales, and prices for the cereals studied. Monitoring the behavior of local traders can provide a useful source of information on the food situation. It is important to know not only how much traders are buying compared with previous years, but also whether more or fewer traders are handling more or less of the total crop. Other market-related information that can be gathered locally to assist forecasting includes estimates of food stocks held by traders and farmers, reports of incidence of pest outbreak to help estimate food losses, and knowledge of availability of transport and storage facilities to help determine the logistics of food movement into the local area. However, the analyst should not focus only on cereal trade, since the level of cereal production will influence a chain reaction in the economic and social decisions of the households.

No interpretation of production results can be complete without observation of social and behavioral indicators for the farming households. It is helpful to distinguish between normal situations and food shortage situations, because behavioral patterns at harvest time will reflect the farmers' prediction of future conditions. Examples of relevant behavior include gifts and exchanges, and selling and buying decisions regarding goods and services.

Harvest time is traditionally a time for gifts and exchanges among household members, and between neighbors and related households. This normal pattern of exchanges can take place

over an extensive area, especially in areas where migration of some household members has taken place. Harvest time is also a time when cash is needed, to pay casual laborers or for school fees, and so it is a time when trade increases. The appearance of new bicycles and radios shortly after harvest, repairs and additions to village houses, and highly active markets for cattle and small ruminants are all signs of a good harvest. The population feels confident that it can sell part of the crop and use the proceeds for savings (cattle) or for consumption goods, as well as cover basic expenses and food requirements.

During food shortages, a pattern of coping mechanisms, which individuals and households activate in stages as their access to food becomes more difficult, has been identified across countries and cultures. Fairly simple indicators make it possible to identify which stage of coping mechanisms has been reached by a population, thus verifying whether the production forecast seems plausible in the context of past history. For example, Corbett (1988) describes three stages of coping mechanisms and indicators for various activities at each stage (table 5.1).

Sources of data for the indicators presented in table 5.1 fall into two categories: those that should be available on a routine basis from various agencies (such as prices, market availability, and wages), and those that are not likely to be available routinely (such as changes in cropping systems, consumption patterns regarding wild food, informal credit activities, or level of current food consumption and nutritional status). The analyst will need to draw upon information from other agencies, such as public and private marketing institutions, health organizations, aid agencies, non-governmental agencies. It may also be necessary to perform an additional rapid verification survey at the farm, community, and market levels in those situations where the qualitative evidence obtained during the original data collection is inconclusive.

As for all survey work, it is not enough to analyze and interpret production data. It is essential that the conclusions be made available to the agency's managers in a form that is easy to follow and well tailored to the users' needs. This may require oral briefings for senior managers and for technical staff. Written reports should be prepared in a format that highlights key findings, making use of visual aids as appropriate, and that is well adapted to the information needs of decision-makers. The reader is referred to Casley and Kumar 1987 or Murphy and Marchant 1988 for a discussion of how to disseminate survey findings.

B. Conclusion

This paper provides evidence regarding the validity of farmers' estimations of production as one source of data, and general advice and guidance on their utilization by agricultural services agencies. However, each survey is different in terms of the specific needs of its users, the socioeconomic and agricultural situations of the households of interest, and the specific factors under observation. The analyst in charge of providing production estimates will need to cooperate closely with his or her managers and technical colleagues, with colleagues in other agencies who work on related topics, with field level staff, and with farmers.

Table 5.1. Three stages of coping strategies during food insecurity and relevant indicators

Stage	Activity	Indicator
I. Insurance mechanisms	Changes in cropping and planting practices	Actual practices
	Sale of small stock	Prices
	Reduction of consumption levels	Number of meals-day Nutritional indic.
	Collection of wild foods	Consumption pattern
	Interhousehold transfers or loans	Occurences
	Increased nonagricultural production (crafts)	Market availability
	Migration for wage labor	Level wages Household presence
	Sales possessions/jewelry	Market availability
II. Disposal of productive assets	Sale livestock	Prices
	Sale agricultural implements	Prices
	Sale or mortgaging of land	Prices
	Credit from merchants/money lenders	Qualitative info.
	Reduction of consumption levels	Number of meals/day Nutritional status
III. Destitution	Distress migration	Number of households

Source: Adapted from Corbett (1988, 1107).

At a time when a participatory approach to development is being recognized as essential for effectiveness and sustainability, using the farmers' estimates of production whenever appropriate to the information needs of the decision-makers makes sense from both an efficiency and a developmental point of view. In terms of efficiency, the method provides advantages of rapidity, flexibility, and increased sample dispersion. In term of sustainable development, it strengthen people's participation in programs and services which affect their lives.

The next chapter provides an annotated bibliography of methodological publications and field reports that discuss data collection on agricultural production. However, this topic is continuously evolving, and agricultural agencies are encouraged to refine their methodology for obtaining production estimates from farmers. They also are encouraged to take the time to write down in detail the methodology they used, the quality of the results they achieved, and the lessons they learned. As more field experiences become available, the overall quality and timeliness of production data should improve throughout Africa.

CHAPTER 6

Annotated Bibliography on Innovative Methods for Forecasting and Measuring Cereal Crop Production In Sub-Saharan Africa

A. Introduction

National governments and donor agencies in Africa have long recognized the importance of reliable data on agricultural production for policy formulation. Recently, there has been keen interest in many African countries in improving systems that assess agricultural performance and that forecast the food situation. This interest has resulted in the establishment of a number of crop forecasting and early warning systems, particularly in the Sahel and Southern Africa. Many of these systems derive their forecasts of the national harvest and grain reserves from a combination of crop modeling techniques using agroclimatic data, and of evaluating the actual crop situation during the growing season.

The data used for the latter estimates can be obtained by a variety of techniques. These can originate from the air, (i.e., aerial photographs and satellite imagery to estimate area under cultivation and vegetation cover), and on the ground in the form of survey data. Ground methods are often characterized as either "objective", or "subjective" in nature. "Objective" methods consist of either counts and /or weights of plants or fruits from harvest plots laid out in agricultural experiments or in farmers' fields. However, as Scott et al. (1989) show, these methods entail a degree of subjectivity in their applications and are best referred to as physical measurement methods. "Subjective" methods include eye estimates of yield or production by agricultural staff and farmers, obtained by asking them their evaluation of crop output either before or after the harvest.

Agricultural surveys have relied mostly upon physical measurement methods for estimates of crop area and yield. In the past, most agricultural statisticians (viz., Idaikkadar 1979; Zarkovich 1966) recommended physical measurements, particularly crop cutting, for providing statistically sound estimates. Zarkovich, among others, has noted numerous advantages that crop cuts have over subjective methods. These include protection against inaccurate response (for reasons of taxation, etc), and against the tendency for the estimator to be conservative in the estimate (Zarkovich 1966: 332). While often giving higher estimates than do farmers' statement methods, measurement techniques at least permit the investigator to estimate the sample error and sources of possible bias.

Long considered more accurate than eye appraisal or farmers' responses, measurement methods are not without their theoretical and practical problems. The size and shape of the sample plot--by no means standard--can effect the effect the direction and the magnitude of bias in the estimate. Bias from smaller plot size selection can be introduced depending on the precision of the crop-cutting instruments, the use of balances, or errors in judgement of the part of the investigator (Zarkovich 1966: 346). Other biases can result from the shape of the plot, the (subjective) placement of sample plots in the field, and from border effects in

irregularly shaped fields. A practical consideration is that crop cutting methods are often very costly in terms of time, personnel, and resources, making it an impractical method for large sample surveys in developing countries.

Less costly alternatives to crop cutting are measurement methods in which the cob, grain head, or even the plant itself is counted in the test plot to derive yields. Alternatively, the number of bundles or baskets removed from the fields and/or placed in granaries at harvest are counted as an estimate of total household production. The researcher converts these counts to yields using coefficients derived from weighing a sample of bundles, baskets, or cob/heads from either the same or the previous year. Coefficients derived from the previous years' harvest may reflect a different set of agroclimatic conditions. Careful monitoring of the harvest, and threshing and weighing can be nearly as costly and time-consuming as crop cutting. These and other problems are discussed in several of the general books on agricultural statistics and in specific studies contained in the bibliography.

The expense of crop cutting methods has recently prompted agricultural survey managers to seek accurate, but less costly and time consuming methods of collecting production data. This is particularly the case with crop forecasting and early warning systems, where the goal is to furnish timely information on the crop situation to decision makers. Pre-harvest estimates, which can be analyzed in the context of agroclimatic data, are most commonly based on either eye appraisal in the field by agricultural officers for their areas, or on farmers' estimates of expected harvest. These are usually confirmed by either measured or reported estimates of production after the harvest has been completed.

Estimation methods possess certain advantages over measurement methods in that they can be considerably less costly when incorporated into a existing survey or the normal work routine of agricultural field staff. Disadvantages which are often cited by critics of the method include the inability of the researcher to estimate the accuracy of response, or the magnitude and direction of the bias introduced by the estimator.

Several of the studies included in the bibliography illustrate the use of estimation methods in early warning systems, and agricultural surveys. A recent study by the World Bank, the Food and Agriculture Organization (FAO), and the United Nations International Childrens' Emergency Fund (UNICEF) has compared measurement and farmers' estimate methods of crop yield estimation in five African countries. The study found that the measurement (crop cut) method used significantly overestimated yields when compared to complete harvest. Farmers' responses gave closer estimates with lower sample variances. In several papers cited in the bibliography, the authors (Marchant, Scott, and Verma) conclude that farmers' estimates can, under the proper circumstances, provide reliable results that are cost-effective. These findings have profound implications for agricultural data collection in Sub-Saharan Africa, and have already generated considerable debate among agricultural scientists and statisticians.

B. Organization of the Bibliography

This bibliography contains source material relevant to Subsaharan Africa on agricultural statistics, crop forecasting and early warning systems, and methods of estimating agricultural area and crop yields. The bibliography has been arranged by topic to facilitate the reader's search of sources of interest. A particular reference may occur under more than one heading, if it is of interest to more than one topic, or contains descriptions of several methods. There are citations in both English and French.

Part C consists of general works on agricultural surveys, methods, and statistics. Nearly all treat objective methods. Both Collinson (1983) and Huddleston (1978) discuss use of farmers' estimates. Zarkovich (1966) gives an excellent discussion of problems of determining sources of error in agricultural data. The treatment of yield estimation problems is very useful.

Part D contains references on crop forecasting and early warning systems. These are intended to provide the reader with an overview of the design of crop forecasting models and early warning systems, and are mostly found in several documents by the Food and Agriculture Organization. Reports and evaluations of early warning system projects from several African countries are included to give the reader an idea of the range of activities and systems in place in the region.

Part E, on remote sensing and satellite data, is the first section to deal with specific methods. Given the technical complexity of these methods, this section is meant only as a very first introduction for readers with no previous knowledge in the subject. Allan's (1986) paper gives an introduction to the agricultural uses of satellite imagery. In his paper, Mwanda (1989) argues that aerial survey has several advantages over ground surveys for estimating crop areas and yields. This would appear to be the case only in countries where the civil aviation sector is sufficiently developed.

The final three sections of the bibliography are concerned with measurement and estimation methods of ground collection of crop area and yield data. Part F contains sources on the various methods employed, as well as numerous examples of crop cutting methods in use. Part G is concerned with studies in which the cob or head was counted and converted to grain weights. Examples are provided of the various methods used in Chad (Van Hasten & Buresi 1986), Kenya (Hesselmark 1978; Murage 1989), Mali (Van Hasten & White 1986), and Swaziland (Ministry of Agriculture and Cooperatives n.d.; Low 1984).

Part H covers estimation methods. There are several reports on the results of the World Bank, FAO, UNICEF study in French and English by the authors Marchant, Scott, and Verma. There are also several examples of the use of these methods in surveys and early warning systems. While several studies report positive results with the method, others met with difficulties. Thomas (1988) reports in his study from Senegal that farmers were unwilling to give accurate estimates of yields for a variety of reasons. In these circumstances, the crop cut estimates were more accurate. Thomas' study serves as a reminder that no single method will give accurate estimates in all circumstances, and that uncritical use of any method will produce undesirable results.

C. Agricultural Surveys, Methods and Statistics

Casley, Dennis J. and Krishna Kumar. 1988.
The Collection, Analysis, and Use of Monitoring and Evaluation Data. A joint publication of the World Bank, IFAD, and FAO. Baltimore, Maryland, USA: The Johns Hopkins University Press. 175p.

A general treatment on survey design, execution, and analysis for agricultural monitoring and evaluation programs. Includes qualitative and quantitative methods. Chapters on crop area and yield measurements are updates from Poate and Casley (1983).

Collinson, Michael. 1983.
Farm Management in Peasant Agriculture. Boulder, Colorado, USA: Westview Press. A Westview encore edition. Originally published in 1972 by Praeger Publishers.

A classic work in the farming systems literature, this book contains extensive discussions of survey techniques appropriate to peasant agriculture. Discusses various methods of area and yield estimation. Principal qualitative techniques for yield estimation are eye estimation and farmers' reports. The former require much training and experience on the part of the estimator. Collinson contends that, in general, farmers have difficulty providing reliable production estimates of standing crops because of the difficulty in finding a unit of measure for estimation (p. 283). Quantifying the quality of the harvest will be more successful in terms of the farmers' storage capacity. The book contains a discussion of crop cut methods and has very useful tables presenting data on the efficiency of different sized test plots and number of cuttings.

Downing, Thomas E., Kangethe W. Gitu, and Crispen M. Kamau. 1989.
Coping with Drought in Kenya: National and Local Strategies. New York, USA: Lynn Rienner Publishers, In cooperation with National Environment Secretariat, Clark University, Ford Foundation and the National Center for Atmospheric Research. 700pp.

The book is a collection with various aspects of coping with drought and famine in Kenya during the 1984/85 drought. Section II is concerned with drought forecasting and monitoring, and contains several papers which discuss use of aerial photography to estimate yields (Mendwa), and techniques of yield data collection for the monitoring surveys of the Central Bureau of Statistics (Maganda), the Ministry of Agriculture (Mwanjila), and the National Cereals and Produce Board (Murage). The Tanzanian crop monitoring system is also described (Kashasha). (See listings by author in this bibliography for more details of techniques of crop yield estimation contained in the papers).

Dubois, Jean-Luc. 1989.
Innovatives Techniques pour la Collecte et l'Analyse d'Informations Statistiques. Paris: AMIRA. 61pp.

This paper presents a general discussion of the present and future state of household data collection and analysis in Subsaharan Africa. The author reviews and challenges many of the assumptions that have guided previous efforts at data collection. He argues planners

have tended to simplify or downright ignore the complex nature of socioeconomic reality. They have also failed to grasp the fact that the rationality(ies) which govern economic actors (e.g., farmers, migrants, etc.) are based on assumptions quite different from those which planners use. He offers a program for data collection which would better address these complexities. His stimulating thoughts on complexity and differing realities are useful for one who would use farmers' responses and would assess their value. There is, however, no discussion of any specific methods, objective or subjective, of crop area and yield estimation (also available in English).

Food and Agriculture Organization of the United Nations (FAO). 1975.
National Methods of Collecting Agricultural Statistics, Vol. II. African, Latin American, and Near East regions. Rome, Italy: Food and Agriculture Organization of the United Nations. 234p.

Provides country summaries of the agencies which collect agricultural statistics, the surveys conducted, and the methods used, as of 1975. Nearly all African countries reported using objective methods to estimate crop areas and yields.

Food and Agriculture Organization of the United Nations (FAO). Statistics Division. 1982.
Estimation of Crop Areas and Yields in Agricultural Statistics. Rome, Italy: Food and Agriculture Organization of the United Nations Economic and Social Development Paper no. 22. 1982.

Provides a good overview to "objective" methods of crop area and yield estimation, and to sample surveys for early warning systems. Some of these methods (e.g., holding-wise direct crop reporting systems that use mailed questionnaires) are unsuitable for developing countries. No specific treatment of issues concerning use of farmers' estimates. Includes a bibliography and discussion of assessments in current agricultural statistics for developing countries.

Huddleston, Harold F. 1978.
Sampling Techniques for Measuring and Forecasting Crop Yields. Washington, DC, USA: United States Department of Agriculture, Economics, Statistics, and Cooperatives Service. Vol. 193p.

A basic source for techniques of yield estimation, it contains a useful discussion of fundamental issues and methods. There is a section on the use of reported yields, and a case study of using farmers'reports to estimate dry bean production. All of the information is US-based.

Idaikkadar, N. M. 1979.
Agricultural Statistics. A Handbook for Developing Countries. New York, New York, USA: Pergamon Press. 139p.

A good, basic introduction to the collection and analysis of agricultural statistics for agricultural scientists in developing countries. Advocates use of crop cutting and surveying methods to estimate yield and area. Chapters 4 & 5 discuss these methods.

Murphy, Josette. 1989.
L'Utilisation d'une Méthode Légère pour l'Estimation des Récoltes Céréalières. Paper presented at the Association Internationale des Statisticiens d'Enquête (AISE) and the Institut National de Démographie et des Etudes Economiques (INSEE) seminar on adequacy between supply and demand of statistical data in developing countries, Lomé, Togo, October, 1989.

The author identifies the various types of uses to which agricultural statistical information is put, discusses the advantages and disadvantages of using farmers' estimates as yield data, and describes the resources and organization required for an extensive survey using farmers' estimates. The uses to which clients put agricultural information can be conveniently classified into three categories: warning systems at harvest, resource management, and improvement of the technical level of producers. Each purpose requires a different level of resolution for the data. Farmers' estimates may serve the purposes of warning systems and resource management, but may not be appropriate for technical improvement studies. The advantages of the farmers' estimates over crop cutting methods are that they require fewer visits, that a small, dispersed sample can be used, and that enumerators are not required to be there at the moment of harvest. Disadvantages are: difficulty in assessing the truth of farmers' responses, difficulties in converting local measures to standard weights, and the necessity to visit the field in order to obtain an accurate estimate. The paper presents a useful, general discussion of the issues concerning the use of farmers' estimates in crop yield assessment.

Murphy, Josette, and Tim Marchant. 1988.
Monitoring and Evaluation in Extension Agencies. World Bank Technical Paper No. 79, Monitoring and Evaluation Series. Washington, DC, USA: The World Bank. 81pp. Also available in French.

A general discussion of the role of monitoring and evaluation in extension agencies, this report contains sections on problems with estimating agricultural production, crop forecasting, and comparison of productive outcomes of different agricultural technologies. Treats the types of production data available to monitoring and evaluation units (research station plot vs. surveys conducted by extension workers) and their shortcomings. Although it contains no in-depth treatment of production methods, the paper offers a useful discussion of the role of extension monitoring units in collecting such information for a variety of purposes.

Murphy, Josette, and Leendert H. Sprey. 1982.
Monitoring and Evaluation of Agricultural Change. Wageningen, The Netherlands: International Institute for Land Reclamation and Improvement. Publication No. 32. 314pp. Also available in French.

This book is a general training guide for monitoring and evaluation staff in rural survey techniques. The section on estimating agricultural production covers both crop area and yield estimation. Describes a practical method for obtaining yield from crop cut plots in field surveys. Methods for estimating total household production described are granary evaluations and the basket method used by the authors in Burkina Faso. The authors discuss the advantages and drawbacks of each method from a very practical standpoint.

Office Statistique des Communautés Européennes. 1988.
  Statistiques de Base. Agriculture, Elevage. Bamako, Mali: Office Statistique des
  Communautés Européennes.

  Describes data gathering methods for statistical sections of the Malien Direction Nationale
  de l'Agriculture (DNA) and the Direction Nationale de la Statistique et de l'Informatique
  (DNSI). The DNA, facing limitations of means and personnel, uses a variety of methods
  to produce estimates which, the authors state, are, "very subjective and which do not rest
  upon scientific methodologies, (..des estimations très subjectives et ne reposant en général
  pas sur des méthodologies scientifiques)" (p.5). The DNSI, better funded than DNA, uses
  classical methods of estimating crop areas and yields--area measurements, and crop cutting
  of yield plots--with a sample of about 2,000 households to produce its estimates. The Mali
  case provides an example of how choice of method is often dictated by financial, and
  other, considerations.

Poate, C. D., and D. L. Casley. 1985.
  Estimating Crop Production in Development Projects. Methods and their Limitations.
  Washington, D.C., The World Bank. A technical supplement to: Dennis J. Casley and D.
  A. Lury, Monitoring and Evaluation of Agriculture and Rural Development Projects.

  A useful discussion of the major points of issues concerning estimation of areas and yields.
  This includes treatment of advantages and disadvantages of farmers' estimates of output.
  Lack of bibliography is frustrating.

Simbashizweko, Astere. 1989.
  Le Système Permanent d'Enquêtes Agricoles au Burundi. Paper presented at Association
  Internationale des Statisticiens d'Enquête (AISE) and the Institut National de Démographie
  et des Etudes Economiques (INSEE) seminar on adequacy between supply and demand of
  statistical data in developing countries, Lomé, Togo, October, 1989. 25pp.

  The paper gives details concerning the "agro-socio-economic" surveys conducted by the
  Service National Economique et Statistique (SNES) in Burundi. The Service conducts
  agricultural surveys for the Ministry of Planning and the Ministry of Agriculture and
  Livestock. These surveys collect data on: area devoted to crops, crop yields, numbers of
  animals, household demographic composition, and household consumption. The author lists
  the different survey forms used to collect these data, and provides examples of some of
  them in the annexes. The agricultural survey consists of three visits, at the beginning of
  the growing season, at the first weeding, and at the harvest. Fields are measured during
  the first visit, and harvests are weighed during the third. No details of any of the methods
  are given.

Stallings, James L. 1985.
  Data Collection in Subsistence Farming Systems. A Handbook. Auburn University
  Department of Agricultural Economics and Rural Sociology Agricultural Economics Series
  no. 38. 52p.

  A general discussion of issues in household-level surveys for farming systems projects.
  Topics include: survey planning, determining crops grown and crop area, determining crop

production, consumption, and sales, and enumerating livestock numbers and production. Covers subjective and objective methods of area estimation. Output measures include asking the farmer, eye judgement, crop sampling, weigh or count harvest units, and utilization tables. Although he presents no comparative discussion, the author concludes that weighing or counting production at harvest is the best approach for production estimation in subsistence farming.

Zarkovich, S. S. 1966.
> Quality of Statistical Data. Rome, Italy: Food and Agriculture Organization of the United Nations. 395 p.

A very valuable source of information on methods for checking the quality of data. Includes chapters on procedures for assessing data quality, for estimating bias, for discovering errors (Type I & II), for handling missing data, for avoiding problems with enumerator and respondent error, and for checking the quality of data processing. The author devotes an entire chapter to problems of error and bias in yield statistics. The subheadings include: selection of fields, border bias, location of plots within fields, plot size, bias due to plot shape, missing crop, cutting date, yield surveys in small fields, cutting procedure, estimation biases, and assessing yield data quality through multiple cutting. While favoring objective methods, the author admits that use of farmers' estimates can produce accurate results. This is illustrated with data from a crop cutting experiment in Sweden. However, the author warns that eye estimates are "..unpredictable and variable... as long as they (eye estimates) are used, statistics on yields cannot be controlled, and it is very difficult to assess how biased the relevant data should be." (p. 333). Thus, more objective methods are to be preferred. The chapters on the respondent are useful for evaluating the quality of farmers' estimates.

D. Crop Forecasting and Early Warning Systems

Acquaah, B. P. 1977.
> Report to the Government of Tanzania of an Early Warning System on Basic Food Supplies with Particular Reference to Crop Forecasting. Rome, Italy: Food and Agriculture Organization of the United Nations. May, 1977. 15p.

Describes the then-current situation of agricultural data collection in Tanzania, and proposes a three-staged plan for a pre-harvest forecasting system. The Ministry of Agriculture collects data on crop area and yield estimates. District Agricultural Development Officers (ADO's) provide crop production information on an ad hoc basis on demand. The field officers visit villages and interview farmers in the course of their respective duties. From these interviews, likely production is categorized as above average, average, or below average. ADO's estimate area by eye, and by pacing. The lack of rigorous information on areas results in only very approximate production estimates. The author recommends in the proposed forecast system that field estimates of yield be calibrated by crop-cut experiments for the area to determine "average yield". Author recommends use of compass and chain to improve area estimates. No information on data

reliability is given, but this system serves as an example of the use of indirect methods of crop assessment in early forecast systems.

Chaudry, S. C. 1981.
Report to the Government of Zambia on the Development of an Early Warning System on Basic Food Supplies with Particular Reference to Crop Forecasting. Rome: Food and Agriculture Organization of the United Nations, July, 1981. 13p.

Describes the need for an early warning system for Zambia, gives background of country and an outline of the proposed system. The Central Statistics Office (CSO) conducts surveys on an ad hoc basis. The 1969/70 Census of Agriculture used both "estimated" and "measured" methods to estimate crop areas and yield. Estimates obtained from field measurements with compass and chain, and by crop cutting were twice those reported by farmers during interviews. The Crop Forecasting and the Agricultural and Livestock Production Surveys furnish "expected" and "reported" estimates respectively from a select sample of farmers in the commercial sector, without any physical verification. Five sets of subjective production estimates are available. The amount of error of these estimates is unknown and difficult to ascertain. Differences among the estimates are large. No estimates of actual production are available. The author proposes that objective measurement techniques be used for area and yield estimates, the latter employing crop cutting on a random sample basis. These can be linked in future with agrometeorological data for forecasting purposes.

----------. 1986.
Manual on Early Warning and Crop Forecasting Methodology for Adoption by Agricultural Officers. Lusaka, Zambia: Food and Agriculture Organization of the United Nations document no. FAO-AGO-GCPS/ZAM/019/METH. Nov., 1986. 35p. [An earlier version of a similar document with the same author and title can be found as document no. FAO-AGO-GCPS/ZAM/METH. Nov., 1983].

The author discusses methods used in the early warning system developed in Zambia. Producers' estimates are used to determine production levels in this system. There is no attempt to cross-check these estimates through use on direct methods. Nevertheless, the Zambia system serves as a case in which an farmers' estimates have been used.

Club du Sahel. 1987.
Evaluation des Systèmes d'Alerte Précoce Mis en Oeuvre dans le Sahel. Paris, France: Club du Sahel, Oct, 1987.

In its evaluation of early warning systems in the Sahel, this paper discusses two methods which have been utilized (earhead counts of staple grains and farmers' estimates) and the problems associated with each (pp. 51-56). Pre-harvest estimates based upon counts of cobs or panicles may be inaccurate, since the weight conversion coefficient must be calculated using samples from the previous year's harvest. Grain heads will be lighter in drought years, heavier in years of abundant rainfall. The veracity of farmers' estimates rests upon the validity of three hypotheses: a) the farmer is capable of accurate estimation; b) the farmer is capable of accurate prediction; c) the farmer is willing to give

the enumerator a truthful prediction (p. 53). The authors refer to the study in Kaya, Burkina Faso (Comité...1987f), which sought to verify these methods.

Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS). 1987a. Test d'un Système d'Alerte Précoce dans l'O.R.D. de Kaya. Bilan méthodologique. Ouagadougou, Burkina Faso: Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel. Projet Diagnostic Permanent. Mars 1987. 26pp. plus annexes.

Presents results of the test of the early warning system held in Kaya, Burkina Faso. Major elements of the methodology were: simultaneous monitoring of several relevant indicators; combined use of quantitative and qualitative indicators to produce "synthetic" indicators; data collection involving objective measurements and interviews with farmers; and systematic use of personnel and existing national staff. There were several conclusions vis à vis crop and area estimation methods. First, correlation of basically qualitative data on well-targeted parameters would suffice for the purpose of establishing an early warning. Agroclimatic, crop monitoring, and levels of national cereal stocks are the principal indicators for this system. Second, quantification of cropping indicators is possible, particularly through use of earhead counts converted to weight by a coefficient obtained the previous year. It was not possible, however, to quantify production in absolute values, since the study found farmers' estimates (presumably of area under crops) to be unreliable. The study offers no data to support this conclusion nor to indicate the direction of bias. Third, farmers, however, gave a reliable assessment of their reserve stocks. The authors suggest that such estimations be taken biannually. They also report that farmers gave a good qualitative assessment of the trend of cultivated acreages and the overall situation of harvest, but such estimates, when used in quantifying the latter, were underestimates and were not reliable. This was due either to genuine anticipation of a poor harvest, or to anticipation of food aid. The authors conclude that earhead counts in test plots in farmers' fields are the only reliable method of obtaining reliable estimates.

----------. 1987b.
Follow-up/Evaluation of Agricultural Survey Designs for the 1986-1987 Cropping Season and Proposed Improvements for the Forthcoming Season (Note by the CILSS Diagnostic Permanent). Rome, Italy: Aug, 1987. 19p. Workshop on strengthening national early warning and food information systems in the CILSS countries, Niamey, Niger 28 Sep-1 Oct, 1987. Food and Agriculture Organization of the United Nations document no. FAO-ESC--CILSS-WINES/3(B).

Lists the recent experiences of member states with crop forecasting surveys. Information includes: general background, resources utilized, organization and execution of the survey, overall evaluation assessments of results, and prospects. Nearly all countries used objective field measurements and yield plots. Information on Cap Verde was too scanty to determine the system in use. Niger, Senegal, and Chad collected both earhead counts and crop cuts from the plots. The survey in Mali also used the sample plots to collect phenological data. The paper gives a useful summary of methods in use in several West African countries.

--------. 1987c.

Contribution of Strengthened Agricultural Statistics Services to Harvest Forecasting (CILSS document on the early warning aspect of so-called classic survey systems for season monitoring and harvest forecasting). Rome, Italy: Sep, 1987. 5p.

Workshop on strengthening national early warning and food information systems in the CILSS countries, Niamey, Niger 28 Sep-1 Oct, 1987. Food and Agriculture Organization document no. FAO-ESC--CILSS-WINES/3(C). The paper addresses the issue of incorporating data obtained from yearly agricultural surveys into crop forecasting/early warning systems. Nearly all surveys in the member states produce estimates of number of farms, area sown to various crops, numbers of farm workers, levels of equipment and input use on farms, and yields. This information can be used to construct forecast yields and production estimates as part of an early warning system. The authors advocate the use of "standard methods" to determine theoretical yields for the system without describing or evaluating these methods.

--------. 1987d.

Methodological assessment of the early warning system test of Kaya (Burkina Faso). (Document prepared by Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel - Diagnostic Permanent). Rome, Italy: Sep, 1987. 17p. Workshop on (strengthening national early warning and food information systems in the CILSS countries, Niamey, Niger 28 Sep-1 Oct, 1987. Food and Agriculture Organization document no. FAO-ESC--CILSS-WINES/3(D).

Presents findings of the CILSS test of its early warning system at Kaya in Burkina Faso. Major elements of the methodology were: simultaneous monitoring of several relevant indicators; combined use of quantitative and qualitative indicators to produce "synthetic" indicators; data collection involving objective measurements and interviews with farmers; and systematic use of personnel and existing national staff. There were several conclusions. First, correlation of basically qualitative data on well-targeted parameters would suffice for the purpose of establishing an early warning. A "crop monitoring" indicator is essential. Second, quantification of cropping indicators is possible, particularly through use of earhead counts converted to weight by a coefficient obtained the previous year. It was not possible, however, to quantify production in absolute values, since the study found farmers' estimates (presumably of crop areas) to be unreliable. The study offers no data to support this conclusion nor to indicate the direction of bias. Third, " Farmers give a good qualitative assessment of the trend of cultivated acreages and the overall situation of harvest...But their estimations, to be used in quantifying the latter are not reliable" (p.6). Farmers' estimates of harvest were "tainted with gross under-estimations". This was due either to genuine anticipation of a poor harvest, or "a state of mind created by over a decade of food aid" (p.7). The authors conclude that earhead counts in test plots in farmers' fields are the only reliable method of obtaining yield estimates (for early warning systems).

Dequin, H. and P. White. 1986.

Global Information and Early Warning System on Food and Agriculture. Crop assessment mission to Sudan, Nov 1986. Rome, Italy: Food and Agriculture Organization of the United Nations. 1986. 31p.

Describes method in use in Sudan for producing preliminary crop estimates. Major sources appear to be available data at area headquarters and other subunits, interviews with "a number of experienced farmers, village heads, and experienced agriculturalists" (p. 26) and tours of areas by local staff. New United States Agency for International Development project will employ a stratified sampling strategy for ground verification of remote sensing imagery estimates to improve forecasts. No description of the methodology to be used on the ground is given.

Food and Agricultural Organization of the United Nations (FAO). 1975.
Programme Plan for Developing the Capability of Forecasting Crop Production. Rome, Italy: Food and Agriculture Organization of the United Nations document no. AGD-RS/2/75. 41p.

As the title indicates, this document provides an outline for developing a crop forecasting program for developing countries. No useful discussion of methods of crop yield estimation.

----------. 1978.
Crop Forecasting: a Statistical Aspect of a Global Information and Early Warning System. Accra, Ghana: African Commission on Agricultural Statistics - 8. Session 29 May, 1978. 15p.

This paper discusses the use of various methods of crop area and yield estimation in early warning systems. Subjective methods include eye estimation, reports by government officials and staff, voluntary reports by farmers and others, and mailed questionnaires. Objective methods of estimation relate to some diagnostic characteristic of the plant; e.g., plant height, number and thickness of cobs, diameter of branches, etc. No details on the various methods are given, but the paper is useful in placing the techniques mentioned in context vis à vis early warning systems.

----------. 1981.
Report on the Current Practices of Crop Forecasting. Lome, Togo: African Commission on Agricultural Statistics. 9. 19 Oct, 1981. Food and Agriculture Organization of the United Nations document no. FAO-ESS--AGS/AAF/9/81. 9 P.

Discusses various methods that can be used to make crop forecasts. Four unidentified countries were surveyed for their practices. All four estimate area to be harvested by different methods. These range from "objective" measurement to "subjective" estimation by field staff. Two countries use objective measures--cobhead counts or crop cuts--to assess yield. Three use eye appraisal, and one uses agrometeorological data. No country reported using farmers' estimates. There is obvious overlap in methods which would permit comparison of results of the various methods. No such attempts at comparison were reported, however.

----------. 1986.
Early Agrometeorological Crop Yield Assessment. Rome, Italy: Food and Agricultural Organization of the United Nations 1986. v, 150p.

A general discussion of the use of crop modeling and weather data for crop forecasting. No information on field methods for crop yield assessment, and, thus, not very useful for the problem at hand. Does provide an introduction to forecast modeling.

Food and Agricultural Organization of the United Nations (FAO). Statistics Division. 1983. Forecasting in Agricultural Statistics. Rome, Italy: Food and Agricultural Organization of the United Nations Statistical Techniques in Developing Countries no. 2. 1983. 23p.

Description of a time series forecasting model applied to Ethiopia. No discussion of crop estimation methods. Serves as an example of the application of forecast modeling to a variety of situations (e.g., crop forecasting, food supply and demand projections, etc.).

Food and Agricultural Organization of the United Nations (FAO), Commodities and Trade Division. 1986a.
Global Information and Early Warning System on Food and Agriculture. FAO crop assessment mission report. Mali. 20 September - 4 October, 1986. Rome, Italy: Food and Agricultural Organization of the United Nations Commodities and Trade Division, Dec, 1986. 20p.

Crop assessment team used a variety of techniques to estimate crop production on a country-wide scale. These included gathering already published data from a number of sources, interviews with ministry and field staff, and visual field inspection. No discussion of crop area and yield estimation techniques. Report serves as a reminder, however, that such assessments are often at the mercy of the data at hand.

----------. 1986b.
Global Information and Early Warning System on Food and Agriculture. FAO crop assessment mission report. Chad. 6-18 October, 1986. Rome, Italy: Food and Agriculture Organization of the United Nations, Commodities and Trade Division, Dec, 1986. 17p.

Crop assessment team used a variety of techniques to estimate crop production on a country-wide scale. These included gathering already published data from a number of sources, interviews with ministry and field staff, and visual field inspection. The team reported that one of the main difficulties encountered was the weakness of the agricultural statistics available, due, in part,".. to a shortage of adequately trained personnel and equipment in the relevant organizations," (p.1). No discussion of crop area and yield estimation techniques. Report serves as a reminder, however, that such assessments are often at the mercy of the data at hand.

----------. 1987a.
Contribution of Strengthened Agricultural Statistics Services to Crop Forecasting (FAO paper on current arrangements for agricultural statistics and crop forecasts in the CILSS countries). Rome, Italy: July, 1987. 9p. Workshop on strengthening national early warning and food information systems in the CILSS countries, Niamey, Niger 28 Sep-1 Oct, 1987. Food and Agricultural Organization of the United Nations document no. FAO-ESC--CILSS-WINES/3(A).

Discusses concepts of and data requirements for crop forecasting in the CILSS member states. In the Sahel, data on crop area and yield are collected by sample surveys. Crop area estimates, usually collected by objective measurement techniques at the beginning of the growing period, should be duplicated and sent to the CILSS Central Office to produce early production estimates based on last year's yields. CILSS' agrometeorological branch, AGRHYMET, uses qualitative data from member countries to forecast potential yield via the FAO agrometeorological model. The paper advocates regional collection of crop yield data by a permanent staff of enumerator/monitors using objective, quantitative techniques to improve forecasts. Such a system is in use in Mauritania. No details of area/yield estimation techniques are given, however.

---------. 1987b.
Operational Applications of the FAO Agrometeorological Rainfed Crop Monitoring and Yield Forecasting Model. Rome, Italy: July, 1987. 9p. Workshop on strengthening national early warning and food information systems in the CILSS countries, Niamey, Niger 28 Sep-1 Oct, 1987.

Describes the system by which the Sahelian regional organization for combating drought, CILSS, uses agrometeorological data for crop forecasting. No discussion of on-ground yield estimation methods. Food and Agriculture Organization of the United Nations (FAO), Commodities and Trade Division, 1987c. Preliminary assessment of 1987 cereal production in Western Africa. Global Information and Early Warning System on Food and Agriculture. Rome, Italy: Food and Agriculture Organization of the United Nations, Commodities and Trade Division, Nov, 1987. 13p. English and French. Describes agrometeorological situation for West Africa during 1986. No crop area and yield methods described.

Frere, M. and Popov, G. F. 1977.
A Programme for Monitoring Crop Conditions and Crop Forecasting in the Sahelian Region. Rome, Italy: Food and Agriculture Organization of the United Nations, Plant Production and Protection Division. Food and Agricultural Organization of the United Nations document no. FAO-AGP--ECOL/9 8p.

Provides a discussion of an application of crop forecasting models to the Sahel in 1976. Gives hypotheses and model assumptions. The study used the Penman method to calculate potential evapo-transpiration. The authors present crop coefficients by decade (ten-day period) for food crops with long and short vegetative cycles. Use of the model is illustrated by using rainfall data from N'Djamena for 1976. No methods of crop area and yield estimation are discussed. Useful as an example of application of crop forecast models to the Sahel.

---------. 1979.
Agrometeorological Crop Monitoring and Forecasting. Rome, Italy: Food and Agriculture Organization of the United Nations plant production and protection paper no. 17. 64p. published in English, French, Spanish, and Chinese.

Discussion of topic similar to publication on early meteorological crop yield assessment. Contains a discussion of various models and data sources used in crop forecasting. No useful treatment of farmers'reports or similar indirect techniques of yield assessment.

Hanus, H. 1977.
Forecasting of Yields from Weather Data (using non-remote sensing techniques). Rome, Italy: Food and Agriculture Organization of the United Nations pp. 50-64.

This is an outline of a lecture on the subject, and concerns itself primarily with specification and estimation of crop/weather models. Examples of model application are drawn from Europe. In comparing several yield estimation models, the author concludes that, "..these simplified models provide sometimes better results than the complete model..", and that "..yield predictions..were almost as good as later estimates made shortly before harvest" (p. 63). No discussion of other crop area and yield estimate methods is given.

Hervio, Gilles. 1987.
Evaluation des Systèmes d'Alerte Précoce Mis en Oeuvre dans le Sahel. Paris, France: Club du Sahel. 103pp.

In its evaluation of early warning systems in the CILSS member states, this paper discusses two methods which have been utilized to estimate staple grain yields--earhead counts of maize, millet and sorghum, and farmers' estimates--and the problems associated with each (pp.51-56). Preharvest earhead estimates may be inaccurate, since the weight conversion coefficient must be calculated using the previous harvest. Grain heads will be lighter in drought years, heavier in wet years. The veracity of farmers' estimates rests upon the validity of three hypotheses: (a) the farmer is capable of estimation; (b) the farmer is capable of prediction; (c) the farmer is willing to give the enumerator a truthful prediction (p. 53). The author refers to the study in Kaya, Burkina Faso, (see Comité ... 1987), which sought to verify these methods.

Huddleston, Harold F. 1978.
Sampling Techniques for Measuring and Forecasting Crop Yields. Washington, DC, USA: United States Department of Agriculture, Economics, Statistics, and Cooperatives Service, 1978. v, 193p.

A basic source for techniques of yield estimation, it contains a useful discussion of fundamental issues and methods. There is a section on the use of reported yields, and a case study of using farmers'reports to estimate dry bean production. All of the information is US-based.

Kashasha, D. A. R. 1989.
The Tanzanian crop monitoring and early warning system. In: Thomas E. Downing, K. W. Gitu, and C. M. Kamu, eds. Coping with Drought in Kenya: National and Local Strategies. New York, USA: Lynn Rienner Publishers, In cooperation with National Environment Secretariat, Clark University, Ford Foundation and the National Center for Atmospheric Research. pp. 262-272.

Describes the experiences of the Tanzanian Crop Monitoring and Early Warning Systems Project. Funded by the Food and Agriculture Organization of the United Nations, the project uses crop forecast techniques based on agroclimatic data. Observers are trained, and provided with equipment. They send data to the project via a prepaid supply service. A computer program, AGRO, written in BASIC, estimates yields with rainfall and temperature data. The model was calibrated with district (yield?) averages from district agricultural reports. Interim production estimates are obtained for each district by reports of District Agricultural Development Officers (presumably by eye estimation methods) and by crop specific soil/water balance calculations. No farmers' estimates or objective methods reported.

Lalau-Keraly, A. and G. Winter. 1988.
    Rapport de Mission d'Evaluation du Projet Système d'Alerte Précoce au Mali.
    Luxembourg: Centre Européen de Formation des Statisticiens Economistes des Pays en
    voie de Développement. Novembre, 1988. 23p. plus annexes. Report of the evaluation
    of the EEC-sponsored early warning system project in Mali.

Describes the organization and function of the project. Field activities are in three phases: first, a qualitative monitoring of crop conditions at the beginning of the agricultural campaign; second, monthly surveys of arrondissement development committees using a variety of socio-economic early warning indicators; third, a series of micro-nutritional studies which use anthropometric measures to determine nutritional status. The results are reported monthly by the project in a series of bulletins. The project appears to rely upon field reporting for production estimates, as no separate field survey of yields and crop areas is mentioned. Consequently, no estimation methods are discussed.

Lalau-Keraly, A. and L. Magos. 1989.
    Evaluation du Système d'Alerte Précoce (SAP) Financé par la Communauté Européenne
    au Tchad. (Projet de rapport). Luxembourg: Centre Européen de Formation des
    Statisticiens Economistes des Pays en voie de Développement. Janvier, 1989. 53p. plus
    annexes.

A more detailed discussion of the EEC early warning system project in Mali than Lalau-Keraly (1988). Socioeconomic indicators appear to focus on price movements of grain and livestock. No discussion of crop yield and area estimation methods presented.

Mwenjila, D. W. 1989.
    Food crop monitoring and reporting by the Ministry of Agriculture. In: Thomas E.
    Downing, K.W. Gitu, and C.M. Kamu, eds. Coping with Drought in Kenya: National and
    Local Strategies. New York, USA: Lynn Rienner Publishers, In cooperation with
    National Environment Secretariat, Clark University, Ford Foundation and the National
    Center for Atmospheric Research. pp. 239-242.

The Ministry of Agriculture in Kenya relies upon eye estimates by extension workers for data on crop conditions. No methods, subjective or objective, for estimating crop areas and yields are reported in this paper.

Sanderson, Fred H. 1954.

    Methods of Crop Forecasting. Cambridge, Massachusetts, USA: Harvard University Press. 259p.

A classic and thorough coverage of the topic from a US perspective. Chapters 4 & 5 discuss methods of area and yield estimation, including both subjective and objective methods. For application of these methods to the situations faced by developing countries, the discussion by Poate and Casley (1985) would be more appropriate.

Samba, Abdullah. 1989.

    Stratégies Alimentaires et Systèmes d'Alerte Précoce. Expérience du Sénégal. Paper presented at AISE-INSEE seminar on adequacy between supply and demand of statistical data in developing countries, Lome, Togo, October 1989. 18pp.

The early warning system in place in Senegal is described. The system uses a variety of data sources and analytical methods, including long-term weather data, agroclimatic indices, teledetection methods, geographic information systems, and harvest forecast techniques. A stratified sample of 3,800 fields/plots is used for the forecast. Fields are measured, presumably using objective methods. Some form (not described) of subjective estimation is used for a pre-harvest forecast. At harvest, the sample plots are presumably harvested using objective methods. No real discussion of methods is included, but the paper gives an overview of the forecast system in use in Senegal.

Zambia, Central Statistics Office, Ministry of Agriculture and Water Development. 1986.

    Interviewer's Manual for the Crop Forecasting Survey 1986-87. Lusaka, Zambia: Ministry of Agriculture and Water Development. Food and Agriculture Organization of the United Nations document no. FAO-AGO--GCP/ZAM/019/NET. 44p.

Contains very detailed instructions to enumerators for interviewing farmers during the crop forecasting survey. The document contains no details of methods for crop area and yield estimation for enumerator. These apparently were obtained solely through farmers' responses. Good source of ideas for training of enumerators for rural field surveys.

E. Remote Sensing and Aerial Photography

Allan, J. A. 1986.

    Remote sensing of agricultural and forest resources from space. Outlook on Agriculture, Vol. 15, no. 2 pp. 65-69.

Recent developments in satellite technology permit satellite platforms in space to collect high resolution data at 30 meters. Data on agricultural and forest land use can now be collected rapidly and repeatedly for use in research and planning. The author outlines the technical, economic, and political dimensions of remote sensing of agricultural and forest resources. While there is no discussion of specific analytical methods, the paper provides an interesting introduction to the topic.

Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS), Niamey, Centre AGRHYMET (Agro-hydro-meteo). 1987.

> Use of Remote Sensing Techniques for Crop Monitoring and Forecasting. Experience of the AGRHYMET Centre in 1986 (paper prepared by CILSS-AGRHYMET). Rome: Jul, 1987. 5p. Workshop on strengthening national early warning and food information systems in the CILSS countries, Niamey, Niger 28 Sep-1 Oct, 1987. Food and Agriculture Organization document no. FAO-ESC--CILSS-WINES/5(A).

General discussion of the use of remote sensing by the AGRHYMET center. No discussion of field methods.

Food and Agriculture Organization of the United Nations (FAO). 1977.
> Uses of Weather Satellite Data for the Improvement of Inputs to Crops. Rome, Italy: Food and Agriculture Organization of the United Nations document no. FAO-AGD--RS/10/77. Apr, 1977 p. 69-71.

A general discussion of the agricultural uses for weather satellite data.

----------. 1988.
> Applications of Remote Sensing to Agricultural Statistics. Eleventh UN/FAO International Training Course, Rome, Italy and Montpellier, France, 5-30 May, 1986.

The document includes a collection of training lectures and exercises on remote sensing techniques and their applications to agricultural statistics. The papers are written for readers with no previous knowledge of remote sensing principles. The papers include discussions of the principles of remote sensing, discuss how remote sensing data can be used to estimate areas under a certain crop, and two papers by Caponigro De Angelis describe a case study form Italy on the integrated use of remote sensing and ground collected data for forecasting what production as well as monitoring water resources. The potential yield forecasted 2 months before harvest from Landsat derived information (greenness value) was similar to that forecast by ground observation (eye estimates by farmers and agronomists, then actual weighing at harvest). Correlations between satellite data and the green vegetation cover measured on the ground were not significant. These articles are a good introduction to the complexity of ground proofing, a step without which satellite data cannot be interpreted.

Justice, C. O., ed. 1986.
> Monitoring the Grasslands of Semi-Arid Africa using NOAA-AVHRR Data. International Journal of Remote Sensing, 7(11): November 1986.

Although focussing on the use of satellite imagery to monitor grassland rather than measure crop production, this special issue includes examples of the steps involved in ground proofing of satellite data to determine a vegetation index on forecast drought conditions. A forthcoming issue of the International Journal of Remote Sensing will focus on agricultural production data.

Mwenda, H. 1989.
   Agricultural and Livestock Monitoring using Aerial Photography. In: Thomas E. Downing, K.W. Gitu, and C.M. Kamu, eds. Coping with Drought in Kenya: National and Local Strategies. New York, USA: Lynn Rienner Publishers, In cooperation with National Environment Secretariat, Clark University, Ford Foundation and the National Center for Atmospheric Research. pp. 189-215.

   The Department of Resource Surveys and Remote Sensing in Kenya's Ministry of Planning and National Development uses aerial photography to provide baseline data for planners. Included in the data inventory are agricultural yield estimates. The procedures include aerial photography to estimate area planted, and radiometry to estimate yields. This paper gives a general discussion of the survey and the analytical techniques used in the study. The author states that estimation using aerial photography permits inclusion of inaccessible areas in surveys, and is an inexpensive, yet effective method that can provide timely results. It would appear that, for situations other than Kenya, cost effectiveness of the method would be contingent upon the degree of civil aviation infrastructure extent in the country in which the survey is proposed.

Robertson, C. W. 1980.
   The Role of Agroclimatology in Agricultural Development and Investment Projects. Geneva: Secretariat of the World Meteorological Organization, 1980. Technical Note no. 168. 85p.

   Argues for the utility of weather-based crop-yield forecasting in agricultural planning. No discussion of methods of crop area and yield estimation.

F. Measurement Methods: Crop-cutting and Area Estimation

Black-Michaud, A. and F. Similane. 1982.
   Small Farms in the Central RDA (Rural Development Area). Malkerns, Swaziland: Malkerns Research Studies no. 1.

   This report contains case studies of twelve small farms in rural Swaziland. The authors describe crop area and yield estimation methods in annexes 2 & 3. The study relied upon objective measures of area (tape & wheel) of rectangular contour panels since farmers calculate area by plowing time. Three yield methods were evaluated at Malkerns Research Station prior to use in the field: the 'nine feet circle' used by the Central Statistics Office's agricultural census, the '5-pace plant row' used by the RDA project, and a 10 meter square frame developed at the station for easy conversion to kg per hectare. All three methods overestimated yields even with a 10% conversion factor included. The square method came closest to actual yields, was reported by researchers to be the easiest to use and to explain to farmers, and was consequently adopted for the study. However, in the case of small fields, the entire plot was harvested. The authors note that, " ..related to farmers' own estimates after threshing and bagging, the (square plot) samples over-estimated yields.(..after making appropriate calculations for deduction of cob cores and moisture loss)" (Annex 2).

Clay, Daniel C. 1983.
    The Perimeter Squared-area Method of Area Measurement. Contributed papers, American
    Statistical Association meetings, Toronto, Canada, August, 1983. Washington, DC, USA:
    Department of Commerce. Bureau of Census. pp. 65-81.

    This paper presents an alternative to the conventional methods for taking field and farm
    measurements in developing countries. The method, developed in Burundi, relies upon a
    rough sketch of the field made by enumerators after measuring the sides and interior
    angles of the parcel. The area and perimeter squared of the sketch are then determined
    and the ratio of perimeter squared to area is applied to the actual perimeter of the parcel
    to determine area. The technique can be applied in the field using a pocket calculator.
    The principal sources of error and methods for controlling errors are discussed. A
    hypothetical example of the methodology is provided.

The Gambia, Central Statistics Division. 1974.
    National Sample Survey of Agriculture 1973/74. Statistical Working Paper No. 13. Banjul,
    The Gambia: Central Statistics Division, the President's Office. May, 1974. 11p. with
    tables.

    This survey used objective methods to estimate crop areas and yields. Both statistical
    enumerators and extension field staff used crop cutting to collect yield data. The report
    notes differences in average yields collected by both groups. Possible explanations offered
    for this discrepancy include differences in sample size, and in field supervision. Extension
    workers, using client farmers for their sample frame, may have consciously or unconsciously
    chosen "better" farmers. The survey illustrates the potential subjectivity that can be
    introduced into "objective" methods of yield estimation.

Nigeria, Federal Office of Statistics. 1972.
    Rural Economic Survey of Nigeria. Methodological notes on rural sample surveys carried
    out by the Federal Office of Statistics. Lagos, Nigeria: Federal Office of Statistics.
    RES/1/1972. 21p.

    Describes methods of sample selection and data collection for sample agricultural survey in
    Nigeria. The survey used objective methods (i.e., compass and chain, crop cutting in test
    plots) to estimate crop area and yields. Techniques were chosen, "..because the great
    majority of the respondents being illiterate are unable to supply the required information
    otherwise," (p.10). Yield plots were usually circular. The shape and size of the test plot
    varied according to the crop being estimated.

Malawi Government. 1984.
    National Sample Survey of Agriculture 1980/81 (Customary land in rural areas only). Vol.
    3. Income and expenditure, crop storage, Livestock, Resources and Nutrition. Zomba:
    National Statistical Office. Printed by the Government Printer, Zomba, April, 1984. 41p.

    Reports methods and results of national agricultural survey in 1980/81. The survey
    measured all "gardens" belonging to sample households (N=6,880) during both wet and dry
    seasons. No method described, but one can assume it was some form of surveying

technique, since yield estimate plots were also laid out at time of measuring. Yields were estimated by a single-visit crop cut.

McIntire, John. 1981.
Crop Production Budgets in Two Villages of Central Upper Volta. Ouagadougou, Burkina Faso: International Crops Research Institute for the Semi-Arid Tropics West Africa Economics Program, village studies report no. 4, July 1981. 59p.

McIntire used direct methods to measure area and yield. Crop output was measured by crop cutting a sample of yield plots measuring 3 x 10 meters. The author reports no other methods, thereby precluding comparison.

Murphy, Josette, and Leendart H. Sprey. 1982.
Monitoring and Evaluation of Agricultural Change. Wageningen, The Netherlands: International Institute for Land Reclamation and Improvement. Publication No. 32. 314pp. Also available in French.

This book is a general training guide for monitoring and evaluation staff in rural survey techniques. The section on estimating agricultural production covers both crop area and yield estimation. Describes a practical method for obtaining yield from crop cut plots in field surveys. Methods for estimating total household production described are granary evaluations and the basket method used by the authors in Burkina Faso. The authors discuss the advantages and drawbacks of each method from a very practical standpoint.

Tanzania, Ministry of Financing, Planning, and Economic Affairs. 1988.
Agricultural Sample Survey of Tanzania Mainland, 1986/87. Vol. I: Technical Report. Dar-Es-Salaam, Tanzania: Ministry of Financing, Planning, and Economic Affairs. Bureau of Statistics. June, 1988.

Presents information on techniques used by survey team for estimating crop areas and yields. Fields were measured using compass, pegs, and tape. The team used a crop cut method for yield estimation. One field was chosen using a probability-proportional-to-size method. The 5 x 5 meter cutting plots were placed within the field orthogonally using points randomly selected along transects. This technique tends to reduce location bias introduced by enumerators.

Warren, Fred B. 1986.
Corn Yield Validation Studies, 1953-83. Washington, DC, USA: United States Department of Agriculture (USDA), Statistical Research Service, Statistical Research Division, SRS Staff Report Number YRB-86-07. 24pp.

Reviews the results of studies conducted by USDA over a thirty-year period to verify objective and subjective methods of yield estimation. The author summarizes each study and gives a general discussion and recommendations at the conclusion of the paper. The paper contains summaries of the methods used in many of the original studies. Studies of objective versus reported estimates conducted in the 1950's and 1960's reported that, with one exception (Southern farmers in 1964), farmers' estimates were lower than objective methods and total cutting. Studies conducted to examine relationships between objective

survey estimates and actual yield of corn showed an unexplained difference of between 2.0 to 4.8 percent. However, differences between the objective survey estimates and the final estimated yields for a region of 10 major states generally have been between 6 and 12 percent. A useful review of validation efforts in the United States by USDA.

G. Measurement Methods: Counting Cobs-heads and Other

Coulibaly, Oumar and Gilles Hervio. 1988.
 Analyse de la Première Expérience de Prévision Cérealière au Mali. Bamako, Mali: Office Statistique des Communautés Européenes. Représentation à Bamako, Mali. Informations statistiques pour le suivi des politiques alimentaires, No. 1. 45pp.

Discusses the first year's experience of an experimental crop forecasting system in Mali, the relationship of the project to the national agricultural survey, the underlying hypotheses of the exercise, and the analytical methods employed. The system relied in large measure on data collected by the national agricultural survey. Given the data collection schedule of the latter, two forecasts could be made. The first was based entirely upon farmers' pre-harvest estimates and was available to policy makers at the end of September. The second utilized objective measures and was only available towards the end of October or early November (p. 4). The latter method consisted of counting grain heads and weighing grains to obtain a conversion factor. Mean weights for grains by region are given, as are standard deviations and sample sizes. Problems with both the subjective and the objective methods used, and the possible sources of error are discussed. The authors conclude that the stratified sample (n=2,500) was sufficiently large and representative to provide reasonable forecasts for Mali. The estimation of the grain weight coefficient was a problem: it will require a long-term study to arrive at an accurate figure.

Hesselmark, Olof. 1978.
 An Agricultural Yield Survey System for Developing Countries. Design and experience from Kenya. Zeitschrift fur auslandische Landwirtschaft, 17, Jahrgang, Heft 1 Januar-Marz 1978, pp.46-60.

Describes a system for maize yield estimation designed for Kenya. Yields were estimated using cob measurements counts along ten meters of row space. The survey measured cob length and diameter. Two methods were used to estimate cob populations, depending upon whether or not the maize had been planted in rows. The enumerator asked questions of the farmer regarding cropping practices at the time of estimation. Sample sizes reported were 748 farmers in 1975 and 747 in 1976. The author provides an excellent example of the use of an objective, cost-effective, alternative method to crop cutting for yield estimation, and offers a useful outline for the implementation of a similar survey.

Low, Allan R. C. 1984.
 Rapid and non-destructive measurement of yields of cotton and maize. Farming Systems Newsletter. Nairobi, Kenya: International Maize and Wheat Improvement Centre (CIMMYT) East African Economics Programme. pp. 8-11.

Describes the cob/boll count method of yield estimation used by the Rural Development Areas Programme (RDAP) in Swaziland. Three steps are involved: first, choosing the farm; second, choosing the field for the estimate; third, choosing the sample plots for the estimate and recording the data required for yield calculation. The method has been used for several years by RDAP field staff and has been calibrated for local conditions. The author gives a straightforward description of the method, provides examples of data collection forms, and suggests how the formula and coefficients can be modified for local conditions. Unfortunately, the discussion is still not detailed enough to permit one to recalibrate the coefficients with ease. It is a useful and accessible discussion of the method, however.

Murage, F. G.   1989.
Agricultural yields, production and monitoring methods of the National Cereals and Produce Board. In: Thomas E. Downing, K. W. Gitu, and C. M. Kamu, eds. Coping with Drought in Kenya: National and Local Strategies. New York, USA: Lynn Rienner Publishers, In cooperation with National Environment Secretariat, Clark University, Ford Foundation and the National Center for Atmospheric Research. pp. 243-261.

Kenya's National Cereals and Produce Board conducts a yearly survey of maize yields, using a technique presumably based on the work of Hesselmark (1978). The survey consists of a randomly stratified cluster sample of 1,000 farmers. The field chosen for sampling must be at least a quarter of a hectare in size. A different sampling procedure is used for large farms. The team draws thirty cobs at random from the field, and measures the length and diameter. Two methods for estimating plant population are used, depending upon whether or not the maize was row planted. Yields are estimated by a formula of the square of the diameter times the length. Agricultural practices are obtained from the respondent farmer, and are regressed upon yield in another analysis. In addition, Bureau area managers provide estimates of the amount of produce they expect to purchase as another source of data for monitoring.

Swaziland, Ministry of Agriculture and Cooperatives, n.d. Agricultural Extension Services. Estimation of outputs (maize and cotton). Instructions for estimating output of maize or cotton. Mbabane, Swaziland: Ministry of Agriculture and Cooperatives.

This is a field manual/data collection sheet for maize and cotton yield estimates collected by extension workers for the Monitoring and Evaluation Unit of the Swaziland Ministry of Agriculture and Cooperatives. It contains detailed instructions for laying out five meter sampling rows, for taking plant and cob/boll counts, and for calculating plant populations, row spacing, and yields. Maize yield estimations are calculated by using different conversion coefficients according to the cob size observed in the field. The coefficients are not simple cob/grain weights, however, and probably take into account edge and other effects. Unfortunately, the developer of the method did not document how the coefficients were determined, making the method difficult to adapt to other countries and agricultural situations.

Van Hasten, T. and J. M. Buresi. 1986.
Global Information and Early Warning System on Food and Agriculture. FAO crop assessment mission report, Chad, (6-18 Oct 1986) Rome, Italy: Food and Agriculture Organization of the United Nations. 1986. 17p.

Outlines a proposed early warning system for Burkina Faso. Method of yield estimation proposed is counting number of panicles/heads in sample plots and multiplying by a conversion coefficient. The latter is obtained by threshing panicles/heads in two randomly-chosen plots per field and weighing and counting the grains. The grain weight is divided by the number of panicles/heads in the plot to obtain the average weight of grain per panicle/head. The method is described in detail in Annex II.

Van Hasten, T. and P. White. 1986.
Global Information and Early Warning System on Food and Agriculture. FAO crop assessment mission report, Mali, (20 Sep-4 Oct 1986) Rome, Italy: Food and Agriculture Organization of the United Nations. 1986. 21p.

Method of yield estimation proposed is counting number of panicles/heads in sample plots and multiplying by a conversion coefficient. The latter is obtained by threshing panicles/heads in two randomly-chosen plots per field and weighing and counting the grains. The grain weight is divided by the number of panicles/heads in the plot to obtain the average weight of grain per panicle/head. The method is described in detail in Annex II.

H. Estimation methods: Farmers' Estimates and Other

Black-Michaud, A. and F. Similane. 1982.
Small farms in the Central RDA (Rural Development Area). Malkerns, Swaziland: Malkerns Research Studies no. 1.

This report contains case studies of twelve small farms in rural Swaziland. The authors describe crop area and yield estimation methods in annexes 2 & 3. The study relied upon objective measures of area (tape & wheel) of rectangular contour panels since farmers calculate area by plowing time. Three yield methods were evaluated at Malkerns Research Station prior to use in the field: the 'nine feet circle' used by the Central Statistics Office's agricultural census, the '5-pace plant row' used by the RDA project, and a 10 meter square frame developed at the station for easy conversion to kg per hectare. All three methods overestimated yields even with a 10% conversion factor included. The square method came closest to actual yields, was reported by researchers to be the easiest to use and to explain to farmers, and was consequently adopted for the study. However, in the case of small fields, the entire plot was harvested. The authors note that, " ..related to farmers' own estimates after threshing and bagging, the (square plot) samples over-estimated yields.(..after making appropriate calculations for deduction of cob cores and moisture loss)" (Annex 2).

Chaudry, S. C. 1986.
Manual on Early Warning and Crop Forecasting Methodology for Adoption by Agricultural
Officers. Lusaka, Zambia: Food and Agriculture Organization of the United Nations
document no. FAO-AGO-GCPS/ZAM/019/METH. Nov., 1986. 35p. [An earlier version of
a similar document with the same author and title can be found as document no. FAO-
AGO-GCPS/ZAM/METH. Nov., 1983].

The author discusses methods used in the early warning system developed in Zambia.
Producers' estimates are used to determine production levels in this system. There is no
attempt to cross-check these estimates through use of direct methods. Nevertheless, the
Zambia system serves as a case in which an farmers' estimates have been used.

Club du Sahel. 1987.
Evaluation des Systèmes d'Alerte Précoce Mis en Oeuvre dans le Sahel. Paris, France:
Club du Sahel, Oct, 1987.

In its evaluation of early warning systems in the Sahel, this paper discusses two methods
which have been utilized (earhead counts of staple grains and farmers' estimates) and the
problems associated with each (pp. 51-56). Pre-harvest estimates based upon counts of
cobs or panicles may be inaccurate, since the weight conversion coefficient must be
calculated using samples from the previous year's harvest. Grain heads will be lighter in
drought years, heavier in years of abundant rainfall. The veracity of farmers' estimates rests
upon the validity of three hypotheses: a) the farmer is capable of accurate estimation; b)
the farmer is capable of accurate prediction; c) the farmer is willing to give the
enumerator a truthful prediction (p. 53). The authors refer to the study in Kaya, Burkina
Faso (Comité...1987f), which sought to verify these methods.

DeJaegher, Yvan. 1988.
Estimation de la Production par les Agriculteurs. Résultats d'une Enquête Menée au
Rwanda. Kigali, Rwanda: Service des Enquêtes et des Statistiques Agricoles (SESA),
Ministère de l'Agriculture, de l'Elevage, et des Forêts, République Rwandaise. Février,
1988. 26p.

The paper contains a discussion of the results of a survey to evaluate farmers' estimates of
crop yield. The survey used multiple interviews with a sample of 79 farmers during the
1986 and 1987 cropping seasons to obtain harvest estimates for sorghum, green beans, and
dry beans. Farmers reported harvests in standard units of measure (50 kg. bags for
sorghum, graded buckets for beans) which were converted to kilograms by enumerators.
These estimates were compared to harvest data obtained from plots. Farmers' estimates of
sorghum did not differ significantly from plot estimates for most seasons. Bean harvests
tended to be underestimated. The author provides a very useful discussion of possible
explanations for the results, and suggestions for future research on the topic.

Eddy, Edward D. 1979.
Prospects for the Development of Cattle Production in the Pastoral Zone of Niger: a
summary. In: K. H. Shapiro, ed. Livestock production and marketing in the entente
states of West Africa: summary report. Ann Arbor, Michigan, USA: Center for Research
on Economic Development, University of Michigan, pp. 228-322.

Presents the results of a household economic survey conducted in 1976 by Eddy among Hausa and Twareg cultivators in Kao, Central Niger. The investigators measured production plots using compass and tape. The survey obtained harvest reports from farmers in headloads of millet and sorghum, and converted these to kilograms with conversion coefficients calculated by threshing and weighing a random sample of headloads. No comparison with other methods is offered.

Huddleston, Harold F. 1978.
Sampling Techniques for Measuring and Forecasting Crop Yields. Washington, DC, USA: United States Department of Agriculture, Economics, Statistics, and Cooperatives Service, 1978. v, 193p.

A basic source for techniques of yield estimation, it contains a useful discussion of fundamental issues and methods. There is a section on the use of reported yields, and a case study of using farmers'reports to estimate dry bean production. All of the information is US-based.

Maganda, B.F. 1989.
Surveys and activities of the Central Bureau of Statistics related to food monitoring. In: Thomas E. Downing, K. W. Gitu, and C. M. Kamu, eds. Coping with Drought in Kenya: National and Local Strategies. New York, USA: Lynn Rienner Publishers, In cooperation with National Environment Secretariat, Clark University, Ford Foundation and the National Center for Atmospheric Research. pp 216-238.

Kenya's Central Bureau of Statistics has established a monitoring system that includes an agroclimatic crop yield model, data collected from crop forecast surveys, monitoring market prices, analysis of nutrition and health trends, and analysis of food flows as reported by the National Cereal and Produce Board. The Crop Forecast Survey relies upon farmers' estimates for area and household production. Household response rates are reported by district as being in the 80 to 90 percent range. Crop yields are estimated from these data. Another survey measures crop area. These results are supplemented by data from a survey of large farms. No objective methods are reported for monitoring activities. Also, no technique for verifying farmers' estimates is discussed.

Marchant, Tim. 1989.
Evaluation des Méthodes d'Estimation de la Production Céréalière Basées sur les Carrés de Rendement et les Déclarations des Exploitants. Paper presented at AISE-INSEE seminar on adequacy between supply and demand of statistical data in developing countries, Lomé, Togo, October, 1989. 23pp.

This paper presents data from the study sponsored by the World Bank, the Food and Agriculture Organization (FAO), and the United Nations International Children's Emergency Fund (UNICEF) which evaluated methods of physical measurement and farmers' statements as yield estimation methods in five Sub-Saharan African countries. Methods employed by the study are described in detail. Sources of error and bias are discussed. Results show that in all five countries the crop cut method which was used produced over-estimations on the order of 30%. By contrast, farmers' own statements, obtained shortly after the harvest, conformed in the average more closely to the

measurement based on complete harvest and weighing of the product. Sample variances of the farmers' estimates were substantially smaller (range= -8% to +7%) than those derived from crop cuts. The implications of the study are discussed.

Murphy, Josette. 1989.
L'utilisation d'une Méthode Légère pour l'Estimation des Récoltes Céréalières. Paper presented at AISE-INSEE seminar on adequacy between supply and demand of statistical data in developing countries, Lomé, Togo, October, 1989.

The author identifies the various types of uses to which agricultural statistical information is put, discusses the advantages and disadvantages of using farmers' estimates as yield data, and describes the resources and organization required for an extensive survey using farmers' estimates. The uses to which clients put agricultural information can be conveniently classified into three categories: warning systems at harvest, resource management, and improvement of the technical level of producers. Each purpose requires a different level of resolution for the data. Farmers' estimates may serve the purposes of warning systems and resource management, but may not be appropriate for technical improvement studies. The advantages of the farmers' estimates over crop cutting methods are that they require fewer visits, that a small, dispersed sample can be used, and that enumerators are not required to be there at the moment of harvest. Disadvantages are: difficulty in assessing the truth of farmers' responses, difficulties in converting local measures to standard weights, and the necessity to visit the field in order to obtain an accurate estimate. The paper presents a useful, general discussion of the issues concerning the use of farmers' estimates in crop yield assessment.

Murphy, Josette, and Leendert H. Sprey. 1982.
Monitoring and Evaluation of Agricultural Change. Wageningen, The Netherlands: International Institute for Land Reclamation and Improvement. Publication No. 32. 314pp. Also available in French.

This book is a general training guide for monitoring and evaluation staff in rural survey techniques. The section on estimating agricultural production covers both crop area and yield estimation. There is a description of a practical method for obtaining yield from crop cut plots in field surveys. Methods for estimating total household production described are granary evaluations and the basket method used by the authors in Burkina Faso. The authors discuss the advantages and drawbacks of each method from a very practical standpoint.

Provisional Government of Socialist Ethiopia. 1984.
General Survey of Agriculture. Preliminary report 1983/84 (1976 E.C.) Vol. 1. Addis Ababa, Ethiopia: Ministry of Agriculture. Planning and Programming Department. Oct., 1984. 127p.

Reports methods of adjusting area and crop yield estimates from sample data. The survey used farmers' estimates for yields and areas. These were adjusted by using correction coefficients calculated from crop cuts and measurements obtained from a smaller sample in each of the survey strata. The method is also described reports of previous agricultural

surveys in 1975, 1978, and 1979. An example of the use of (adjusted) farmers' estimates to derive statistics for planning.

Scott, Chris, Tim Marchant, and Vijay Verma. 1989.
Experiments on the Estimation of Agricultural Production in Africa. Paper presented to the 47th session of the International Statistical Institute (ISI), Paris, France, 29 August-6 September, 1989. 23pp.

This paper presents data from the study sponsored by the World Bank, the Food and Agriculture Organization (FAO), and the United Nations International Children's Emergency Fund (UNICEF) which evaluated methods of physical measurement and farmers' statements as yield estimation methods in five Sub-Saharan African countries. Methods employed by the study are described in detail. Sources of error and bias are discussed. Results show that in all five countries the crop cut method employed produced "serious bias of over-estimation, as well as from large variance at the level of the individual plot" (p.19). "By contrast, farmers' own statements, obtained shortly after the harvest, conformed in the average more closely to the measurement based on complete harvest and weighing of the product, and also had substantially smaller variances" (p.19). The implications of the study, including the validity and the general relevance of the findings, are discussed.

Thomas, Patrick A. 1988.
Migration, Household Production, and Consumption among the Pastoral Hal Pulaar of the Boundou in Eastern Senegal. Unpublished Ph.D. dissertation, Department of Anthropology, The American University, Washington, D.C., USA.
Thomas used two methods of yield estimation in his household labor survey of thirty households--self-reporting and crop cuts. Problems with self-reported estimates included considerable variation of sample estimates, and reluctance of household heads either to give estimates, or to permit estimation by others. Under these circumstances, Thomas concluded that his crop cut estimates were by far the more reliable measures.

Verma, Vijay, Tim Marchant, and Chris Scott. 1988.
Evaluation of Crop-cut Methods and Farmers' Reports for Estimating Crop Production. Results of a methodological study in five African countries. London, United Kingdom: Longacre Agricultural Development Centre, Ltd. June, 1988. 71pp.

Presents the results of five methodological studies carried out in five African countries-- Benin, Central African Republic, Kenya, Niger, and Zimbabwe. The purpose of the study was to test the hypothesis that the estimates of production obtained by interviewing farmers could be as accurate as estimates obtained from physical measurement, i.e., crop-cutting on subplots. The study found that measurement based on square cuts appeared to result in serious overestimates (about 30%) of the harvest. Farmers estimates are remarkably close to actual production figures (-8% to +7%) and have smaller variances than do the crop-cut estimates. Farmers' pre-harvest estimates are also good, but show higher variance. Farmers did not give good estimates of planted area, overestimating these considerably. The paper presents results of the study in tables, and discusses the implications of the findings. Very useful.

Warren, Fred B. 1986.
> Corn yield validation studies, 1953-83. Washington, DC, USA: United States Department of Agriculture (USDA), Statistical Research Service, Statistical Research Division, SRS Staff Report Number YRB-86-07. 24pp.

> Reviews the results of studies conducted by USDA over a thirty-year period to verify objective and subjective methods of yield estimation. The author summarizes each study and gives a general discussion and recommendations at the conclusion of the paper. The paper contains summaries of the methods used in many of the original studies. Studies of objective versus reported estimates conducted in the 1950's and 1960's reported that, with one exception (Southern farmers in 1964), farmers' estimates were lower than objective methods and total cutting. Studies conducted to examine relationships between objective survey estimates and actual yield of corn showed an unexplained difference of between 2.0 to 4.8 percent. However, differences between the objective survey estimates and the final estimated yields for a region of 10 major states generally have been between 6 and 12 percent. A useful review of validation efforts in the United States by USDA.

Zambia, Ministry of Agriculture and Water Development. Planning Division. 1984.
> Preliminary Crop Forecast, 1983-84 Crop Season. Lusaka: Ministry of Agriculture and Water Development. 1984. 5p.

> Reports results from preliminary crop estimate survey of 4,000 crop-growing households in the non-commercial sector in four provinces (Central, Eastern, Lusaka, and Southern) in Zambia during the 1983-84 cropping season. Data collected included estimates (presumably farmers') of area, expected production, and expected sales. No methods described, but one can assume that the methods used were those described in Chaudry (1986).

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