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Problems of Data Collection for Economic Research in Small Farmer Agriculture: Some Experience in Somalia

Aden Abdullahi Aw-Hassan
Utah State University

PROBLEMS OF DATA COLLECTION FOR ECONOMIC RESEARCH IN SMALL FARMER AGRICULTURE: SOME EXPERIENCE IN SOMALIA

by

Aden Abdullahi Aw-Hassan

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Aden Abdullahi Aw-Hassan

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ABSTRACT

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by

Aden Abdullahi Aw-Hassan, Master of Science

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Major Professor: Dr. Herbert H. Fullerton

Department: Economics

The purposes of this thesis are twofold. The first is to show problems encountered in collecting and analyzing data on small-holder agriculture. The second is to describe the role of data in supporting research and rationalization of alternatives for sustaining agricultural strategies in development.

Data collected from six villages of the Lower Shebelle Region of Somalia are taken as a case study to show the difficulties encountered in procurement and analysis of that data. The thesis discusses data collection methods that ensure gathering adequate data that can be used to undertake production economics and farm management research. The thesis also discusses critical sources of data biases that may preclude any meaningful conclusion from the research effort.

(111 pages)

CHAPTER I

INTRODUCTION

Agricultural Productivity and National Economic Growth

In the last two decades small-farm agriculture in developing countries has drawn great attention from the research community, as well as from national and international development agencies. One reason may be the continuing stagnation of agricultural production and productivity growth in some of the developing countries, while their populations are growing at high rates. This leads to an increasing food shortage which, if not supplemented by imports, results in chronic famine and its attending social and political problems. It is widely recognized in the economic development literature that agricultural growth is critical (if not a precondition) for industrialization and economic growth in other sectors of the national economy (Hayami and Ruttan). Agriculture's contributions to economic growth are generally summarized into five points:

1. The agricultural sector may expand food supplies in pace with the growth of demand resulting from population growth and possibly from increases in per capita income.

2. The agricultual sector in developing economies employs about 70 percent of the population; therefore, this sector may provide the labor force required for the expanding manufacturing and service sectors in a growing economy.

3. The increase of net income of agricultural families may stimulate the expansion of nonfarm sectors.

4. Exports of the agricultural commodities are major sources of foreign exchange in an economy dominated by agriculture.

5. In a developing nation agriculture accounts for 50 percent or more of the gross national product.

Thus, the agricultural sector should contribute a significant portion of the savings required to create capital for modern economic growth. A detailed discussion of these points is given by Johnston and Mellor and Gillis et al.

Agricultural Development Strategies

In an attempt to improve production of food commodities, the national and international agencies from the wealthiest countries have provided technical assistance to most developing nations since the 1950s. However, only modest success is noted, largely because of inadequate recognition of the location-specific character of agricultural technology. This apparent lack of response is at least partially explained by Schultz's hypothesis on traditional agriculture. Schultz hypothesized that small farmers make economically rational decisions and can reasonably be expected to behave as profit-maximizing firms. They are aware of factor substitution in production, and they allocate their resources efficiently. This hypothesis has not been rejected by results of numerous analyses of data of Indian peasant agriculture by W.D. Hopper, Venkareddy Chennareddy, and others. The idea of poor but efficient has, therefore, reshaped agricultural development strategies.

Agricultural development may not be achieved by reallocating the

existing resources of land, labor, and small traditional tools. Instead, sustainable agricultural development requires the introduction of new technology including improved seeds, fertilizers, new skills in crop management, education and extension. Hayami and Ruttan call this approach a "high-payoff" model for agricultural development. Large investments in human capital and the development of high-yielding crops and livestock adaptable to local conditions have resulted in substantial increases in agricultural production in some developing countries, namely India, Mexico, the Philippines, Korea and Taiwan.

Although interventions described by the "high-payoff" model seem to have dramatic results on agricultural production, there are some criticisms. One criticism is that modern technology is biased against labor; that is, it is labor-saving and land-using. Thus, it may reduce wage rates and increase land rents, increasing the income inequality in rural communities. Hayami and Ruttan citing empirical studies by Pranab K. Bardhan, Murray J. Leaf, Surjit S.Sidhu and others reject this criticism of the high-payoff model. Instead, they report "there is substantial evidence that in most areas where it [the modern technology] has been adopted, it has increased the demand for labor" (Hayami and Ruttan p. 344).

Another important aspect of the impact of modern technology on equity is the extent of expansion and diffusion of the technology. That is, do all farmers have the same access to modern technology in terms of costs and returns, risks, and adaptability into the more complex subsistence farming systems? The diffusion problem raises another concern about the success of modern biological and chemical

technology in enhancing agricultural growth in developing countries. Even if new technology is developed, its contribution to growth and equity will be small if it does not achieve rapid diffusion (Hayami and Ruttan). It is recognized that there exist institutional and political structures that serve large farmers more readily than small farmers; small farmers may lag behind large farmers in adopting modern technology because of institutional and political biases which do not favor their concerns.

From another perspective, it is argued that small farmers in some developing countries have not adopted technologies recommended by research programs, because these technologies are not always consistent with their circumstances (Byerlee, Harrington and Winkelman). Small farmers have more complex farming systems than large farmers, they lack major political influence on research decisions, and research centers do not give first priority to their problems. Attempts are being made to include the small farmers' production objectives, opportunities, and constraints into agricultural research and development. The necessity of considering the small farmer as a critical partner in agricultural research and extension is becoming better understood in the developing countries and within the scope of programs funded by international agencies. This is because of the evolution of understanding about small-farm agriculture by agricultural economics researchers and rural development planners. It is true that further research on farm-household production, consumption and expenditure decisions, and factors determining these decisions will be required to explain a wide

array of situations and to give greater assurance of predictable results in the formulation and application of development plans and policies.

Research and Data

Before any thorough research is done in any field of economics, it is essential to get relatively complete and reliable information on a set of predetermined variables from a statistically representative sample drawn from the population on which the study is being made. The data may be acquired from a previous survey or the researcher may conduct his own. Collection of data on small farmers, for various reasons discussed below, has never been easy. However, availability of adequate data on production, consumption and expenditure, as well as other exogeneous factors such as climate, cultural environment, market structure and institutional arrangements, is an essential part of any meaningful analysis. Throughout the developing countries, including Somalia, lack of data on agriculture is a major obstacle to any analysis. There is very little data available which varies across the different institutional and governmental agencies. The data inconsistencies, particularly in Somalia, have been demonstrated by John S. Holtzman.

Objectives

The primary objective of this thesis is to address a selection of problems encountered in acquiring and analyzing data on farm-household agriculture. Specifically, the analysis and discussion will be focused on small-holder agricultural data for farm management and production economics research with examples drawn from Somalia. A

survey of small farmers conducted in the Lower Shebelle Region of Somalia is analyzed to demonstrate the promise and problems inherent in exploring management questions in small-holder agriculture.

The specific objectives of the thesis are to:

1. Review a selection of the microeconomic research on small-holder agriculture for the purpose of identifying useful concepts, policy implications and the data required to conduct them.

2. Analyze the general characteristics as well as the production technology of small farmers, as reflected in the Lower Shebelle region (LSHR) survey data, to the extent that the data permits.

3. Identify data gaps discovered in conducting an analysis of the LSHR survey.

4. Review methods of data collection that will assure more reliable and complete data for conducting management and production economics research on small-farm agriculture.

CHAPTER II

A REVIEW OF MICROECONOMIC RESEARCH IN HOUSEHOLD AGRICULTURE, POLICY IMPLICATIONS AND DATA REQUIREMENT

Microeconomic research is most likely to be the key step towards modeling agricultural development in an economy. Eicher and Baker contend that because of the failure of western developmental models to deal with the key problems of employment, equity and food supply, it is necessary to go back to the basics and build an understanding of development in African rural economies based on meticulous microeconomic research. Microeconomic research is essential to provide the empirical results necessary for an acceptable specification of the agricultural sector. Such specification will, at least theoretically, be used to formulate agricultural development and policy programs.

Availability of accurate data on farm and farmer activities, as well as the surrounding environment, is essential to model testing and ex ante appraisal of economic phenomena which form the basis for understanding most agricultural problems in developing countries. In microeconomic research, relatively accurate data are required to examine the characteristics of existing systems and the consequential effects of any subsequent policy or technological changes. Because of the nature of the small farms, where the household acts as the unit firm maximizing its welfare, and the complexity of the environment under which production, consumption and saving pattern decisions are

made, the task of gathering accurate and complete data is not an easy one.

The importance of data in the field of economic research cannot be over-emphasized. Yotopoulos, Lau and Somel have described how the data produced by the Farm Management Studies of the Indian Ministry of Food and Agriculture have been a valuable source for the analysis of the Indian agriculture, as well as an empirical testing ground for economic theory. It is not always easy to get sufficient data to conduct research. Rather, frequently data problems which effectively preclude other than deductive approaches to policy formulation and management decisions in the agriculture of the developing countries are encountered. Eicher mentioned the scarcity of essential food policy analysis data, such as crop and livestock production data and human nutrition and food consumption data in African countries. The quantity of data required, as well as the type and accuracy needed, depend on the research to be carried out. A few examples of microeconomic studies of peasant agriculture, their policy implications and the data requirement are discussed subsequently. Some of these studies are:

1. Analysis of the economic efficiency of agricultural households.

2. Analysis of the agricultural household model.

3. Economic analysis of an alternative production technology from the farmer's perspective.

4. Sector economic efficiency analysis - the agricultural sector at regional and national levels.

Analysis of the Economic Efficiency of Agricultural Households

Measuring Economic Efficiency

There are numerous studies which focus on the microeconomic behavior of agricultural households. These studies provide a means for understanding the characteristics, such as family size; resource availability including land, family labor, and capital; and production and consumption behavior of farm families. The models used in these studies are descriptive econometric models which rely on estimation equations for production and consumption functions. Such models typically involve fitting one or several equations that are intended to describe the way the farm or household resources are allocated among alternative uses, or the way that different outputs are generated (Anderson, Dillon and Hardaker). The most common tool used to examine efficiency of resource allocation is production-function or profit-function analysis, usually of the Cobb-Douglas form. Both household- and crop/livestock-production functions are used. In the crop-production function, the dependent variable is the total physical output or yield. The independent or explanatory variables include the various inputs used in the production of that particular crop, such as seeds, planting labor, weeding labor, irrigation water, fertilizer, chemical pesitcides, animal or machine power, animal manure, and bird control labor. Other independent variables such as time of planting, replanting, and time of weeding are also included among the explanatory variables. As the number and variety of the variables increases it becomes difficult to measure and/or control many factors

affecting yield outside a controlled experiment. Under these conditions, statistically reliable relationships are not easily estimated. By contrast, the carefully controlled experiment station trials and estimation procedures do not always lead to coefficients that are realistic under farming conditions (Jaeger).

Crop-production function analysis depicts the technical relationship of inputs and output of a particular crop. Furthermore, the value of marginal product of the inputs can be compared with the unit factor cost to examine whether a farmer is allocating his resources efficiently. Economic theory posits that an efficient allocation of resources is achieved by equating the value of marginal product of the resources within and across various uses. This can be expressed as

$$p_j \, mp_i = w_i \qquad \text{for all } i = 1, 2, \ldots \text{ in inputs.}$$

where p_j = the price of output "j".

mp_i = marginal physical product of ith input.

w_i = unit factor cost.

The price of the output and the unit factor cost under competitive market conditions are essential information to complete this analysis. W. D. Hopper has tested the allocative efficiency of Indian traditional agriculture by using crop-production functions. From this analysis, he concluded that Indian small farmers are allocating resources efficiently.

The household-production function is also a common tool used for the analysis of the microeconomic behavior of the farm family. In this case, the dependent variable is the gross value of the total farm

output and it is given by

$$Q = \Sigma P_j X_j \qquad j = 1, 2, \ldots n.$$

where P_j is the price of commodity X_j, and X_j is the quantity of jth commodity. The independent or explanatory variables are usually smaller in number than for the crop production function. They are total land input, labor input, capital input, and other production expenses. Analyses of the household-production function may encounter an aggregation problem since both outputs and inputs are aggregated. However, it does provide a convenient way of examining how farmers use the major resources of land, labor, and capital to generate an income that will be partly consumed, partly transacted for other nonfarm goods, and partly saved for next season's investment. The use of household-production functions is extensively documented in the agricultural economics literature (Yotopoulos, Lau and Somel; Nevel; Norman, Simmons and Hays; Jaeger).

The household-production function has been used to examine other concepts and hypotheses. Among them is the concept of inter-group differences in production functions. Different groups may be classified on the basis of location; size of holdings; climatical conditions; resource endowments; sex of family head; access to supporting infrastructure such as market, credit, roads, irrigation facilities and other factors which influence relative prices and productivity. Farmers operating under the circumstances characterized by these factors may have different opportunities and limitations and, thus, may decide differently on commodity choice and intensity of resource use. The household-production function is used to investigate whether statistically significant differences exist

between groups in production technique. By using dummy variables and appropriate econometric tests, any difference in the production function between two groups of farmers can be quantified.

Early studies of Indian household agriculture suggested that significant differences exist in factor-use rates and in input-output ratios across size classes of farmers (Yotopoulos, Lau and Somel). These differences were assumed to be related to differences in the economic efficiency between the large and small farmers.

The question of relative efficiency in peasant agriculture has been studied by several authors. Among them are Lau and Yotopoulos; Yotopoulous and Lau; and Yotopoulos, Lau and Somel. The conclusion of their studies was in favor of small farmers (fewer than ten acres). That is, both large and small farms are price-efficient, but there is superior technical efficiency on the small farms. Similar studies were carried out by Sidhu on Indian farmers and by Barnum and Squire on Malaysian agriculture. In those studies, the authors reached a different conclusion; that is, that small and large farmers are equally (both technically and allocatively) efficient.

Policy Implications

The above review is suggestive of the importance of studies on small farmers' economic efficiency (both absolute and relative) and of the implications that can be drawn and may be adopted for agricultural development policies. The concept of economic efficiency for resources under the control of small farmers, as mentioned in Chapter I, has played an important role in agricultural development plans in the last two decades. It is a general consensus that agricultural

development may not be achieved unless technological change takes place through high investment in education, research and extension. This concept is almost universally accepted in developing countries.

On the other hand, the possibility of greater economic efficiency among small farmers relative to large farmers has important land-tenure policy implications. In most land-reform activities, in addition to other social and political factors, lower efficiency of large farms is strong economic justification for land-ownership reform, which typically calls for shifting ownership from few to many. However, some of the authors concluded that small and large farmers are equally efficient. The implication of this conclusion is that the land-reform policies intended to redistribute land-ownership from few to many may be based on social and political considerations, and not on economic grounds.

Data Issue

The production function and/or profit function used for the above-mentioned analysis usually require a relatively detailed cross-sectional data base. The most widely used approach is a survey that gathers detailed information on outputs, inputs, and prices for all production activities completed within a full calendar year. Most of the farm operations are time-specific; that is, they take place within a limited portion of the crop cycle. Also, many crops are grown and harvested at different times. So, in order to avoid missing data, the data collection must cover at least one full year. The main data required in those studies are:

1. A list of all farm enterprises such as annual crops (including

grain, legume, oil and vegetable crops), perennial crops, tree crops, fruit crops, livestock (all kinds), and nonfarm income-earning activities such as craftmanship.

2. The physical output by crop season of all crops and livestock per farm.

3. Acres of land input for each productivity class used for each crop grown. Land is classified into soil types and acidity or fertility conditions.

4. Labor input per farm used for each crop production measured in man-days. Family labor (male, female and children labor) and hired labor are recorded.

5. Capital input used in production in physical units such as drought animals, tractors, etc., and/or rates per hour per season.

6. Other variable inputs per farm and per acre by productivity class and per season used for each crop include various fertilizers and pesticides in physical units.

7. Prices of all outputs and inputs, wage rates and land rents must also be recorded for each farm class for each season of use and disposal of output.

A more extensive discussion of data-collection techniques is given in Chapter IV.

Analysis of the Agricultural Household

Model Analysis

Another area of microeconomic research is the analysis of the agricultural household. Empirical studies on household agriculture did not reveal any evidence to reject the hypothesis that households decision making on production is based on an economic rationale of maximizing profits (Yotopoulos, Lau and Somel; Barnum and Squire). That is, with known factor prices and wage rates all inputs including labor will be used up to the point at which the costs of additional inputs are equal to the value of additional output. From the utility maximization point of view, it is argued that since income contributes positively to total household utility or satisfaction, the household will attempt to achieve the largest possible return from its fixed quantity of land (Singh, Squire and Strauss). Therefore, the household production depends on profit-maximization behavior, given prices of outputs, prices of inputs and wage rates. The production decision does not depend on consumption and labor-supply decisions. However, the consumption decision of the household is dependent on the income generated by the family production activities. Thus, in the agricultural household there is a one-sided relationship that is from production decision to consumption and labor supply decision. Singh, Squire and Strauss called the effect of that relationship on the farm household behavior as the "profit effect."

Agricultural household models have been developed by several authors including Singh and Subramanian in Korea and Nigeria, Pitt and Rosenzweig in Indonesia, and Strauss in Sierra Leone (Singh, Squire

and Strauss). John Strauss has done a number of studies in joint determination of food consumption and production in Sierra Leone by using estimates of agricultural household models (Singh, Squire and Strauss; Strauss 1982, 1984a, 1984b). As a result of those studies, estimates have been made on own-price consumption and cross-price consumption elasticities and marketable surplus elasticities of major farm crops for different household income levels. Such results of household models have important policy implications. The potential effect of government policies on the well-being (in terms of consumption or calorie availability) of farm households through prices or income can be explored. The difference between the analysis using the profit effect and without using it has been demonstrated by Barnum and Squire. As shown by the authors, the response elasticities of consumption of a major agricultural commodity, consumption of market purchased goods, labor supply, and marketable surplus with respect to own-price, wage rates, and technical change has changed significantly in magnitude and sometimes in direction when the "profit effect" is taken into account. The implication is that policy conclusions based on a household model that fail to account for both production and consumption decisions will, in general, be inaccurate in predicting either the direction of the induced change or its magnitude (Barnum and Squire).

An agricultural household model and a number of empirical applications in several countries has been presented by Singh, Squire and Strauss. The model is based on the assumption that farm households are maximizing their utility subject to (1) cash income,

(2) time constraint, and (3) production constraint. Utility is the degree of satisfaction of household members obtained from the consumption of their own farm production, market-purchased goods and leisure. The model is presented as follows:

$$\text{Maximize} \quad U = U(X_a, X_m, X_L)$$

$$\text{Subject to:} \quad P_m X_m = P_a(Q-X_a) - W(L-F)$$

$$X_L + F = T$$

$$Q = Q(L, A)$$

where X_a is the agricultural staple commodity, X_m is the market purchased goods, X_L is leisure, P_m, P_a are prices of X_m and X_a respectively, and W is the wage rate. L is the hired labor and F is the family labor. Q is the output of the staple commodity and A is the fixed amount of land. $Q-X_a$ is the marketed surplus. There are two omissions in this model. Variable inputs are omitted and all commodities other than the staple commodity are ignored. It is also assumed that hired labor and family labor are perfect substitutes, that all prices and wages are determined in the market, and that no risk is involved in the production.

The above-mentioned utility function is said to be recursive; that is, consumption decision and production decision are non-separable. The sufficient condition for recursiveness, as explained by Strauss (Singh, Squire and Strauss), is that all markets exist for commodities that are produced and consumed, with the household being a price-taker in each one, and that the household sells part of its output in the market. The household also has to participate in the labor market by either selling or hiring labor.

From the indirect utility function, a system of expenditure

equations with proper specifications can be derived. The specifications and kinds of restrictions imposed varies among the authors. For example, Lau, Lin and Yotopoulos use the linear logarithm expenditure system, while Barnum and Squire use a linear expenditure system. The output-supply functions, variable input-demand functions, and commodity-demand functions including leisure can be derived and then coefficients can be estimated. The response elasticities of various dependent variables with respect to the independent variables can be estimated.

Policy Implications

In a country like Somalia, which is dominated by a rural economy, it is important to understand and account for the behavior of farm households when analyzing government agricultural policies. Government policies are generally implemented through price programs and investment projects. Programs which are designed to generate revenue, subsidize urban consumers, secure self-sufficiency, earn foreign exchange, or improve rural incomes may also affect production, consumption, marketing and trade. Programs such as pricing policies, public investment on transport, irrigation facilities, research and extension may have a strong impact on production and incomes of agricultural families. Answers concerning whether the direction and magnitude of these policies affect the rural community, both farming and nonfarming, require a thorough understanding of agricultural households.

The preceding review of household-model analyses draws a baseline for a discussion of important policy questions. Policy makers are

concerned about the effects of policy interventions on the welfare and real income of farming households, on the supply of agricultural outputs, and on the income distribution of the rural community. The effect of the output and input markets on the real income of agricultural families is shown by analysis of the household model. As discussed by Singh, Squire and Strauss, the results of household-model analyses made in several countries show that higher output prices increase the real income of the agricultural household substantially, while lower input prices, due to subsidy, result in only minor increases in real income. The policy implication, therefore, is that incentives in output markets may be much more effective than incentives through input subsidies in increasing the real income (welfare) of the agricultural household.

Policy makers may also be interested in the impact of a boost in agricultural production, due to either price incentives or technological changes, on landless households and other nonfarm rural families. This question can be answered by looking at the effect of increased agricultural household income on labor demand, family labor supply and consumption of market-purchased goods and services.

An increase in the price of a major agricultural commodity increases demand for farm labor and consumption of leisure by the agricultural household, thus reducing the labor supply (Singh, Squire and Strauss). As a result, the wage rates rise as a benefit for the landless households. Higher incomes of agricultural households also induces higher consumption of market-purchased goods and services supplied by the nonfarm rural sector.

Policy makers may be concerned about investment in agricultural research and technical development and the ultimate effects of the technological improvement on the rural community. It is widely agreed that modern biological and chemical technology in agriculture is labor-using, thus increasing the farm labor demand. This point is confirmed by Hayami and Ruttan. Technological improvements increase the income of agricultural households, and as a result, these higher incomes affect indirectly both landless families and others in the nonfarm rural sector. The benefits of technological improvement are, therefore, dispersed throughout the rural community.

Data Issue

In those countries where it has been possible to build and estimate an agricultural-household model, availability of data was a crucial issue. To estimate a complete agricultural-household model, the analyst must have an extensive set of data on consumption expenditures (market purchases and subsistence), labor supply (possibly broken down by sex), farm and nonfarm outputs, purchased and household supplied variable inputs, fixed farm assets, and basic demographic characteristics and prices for both consumption and production inputs including wages (Singh, Squire and Strauss). Collection of such massive data can be expensive and requires taking data from identical farms over time.

When the objective is to estimate a separable model in which consumption-expenditure decisions are independent of production, less comprehensive data are required. Separated data collected by farm management surveys and household budget surveys can be used. Data on

family characteristics, production operations, inputs, farm labor demand, family labor supply are required. Traditional production, cost and profit functions can be estimated. But when the objective is to estimate a recursive model in which consumption and production decisions are nonseparable, both consumption and production data must be collected from the same sample. This can be done by coordinating household budget surveys and farm management surveys in a way that household coverage will overlap. In acquiring cross-sectional data, an adequate number of geographic regions is necessary to ensure the price and wage variations required to estimate the model. Longitudinal data, acquisition and analysis in contrast, will require less geographical dispersion because prices and other explanatory variables will vary over time. Thus, the quantity and variety of data required depend on the type of model to be estimated. Availability of data is a prerequisite for studies to be undertaken in agricultural-household behavior. Without such studies, policy makers will not know how major policy interventions will affect important developmental objectives including agricultural-household welfare, food self-sufficiency, income distribution in the rural community and others.

Economic Analysis of an Alternative Production Technology from the Farmer's Perspective

There are numerous government projects aimed at the development of small-farm agriculture through different avenues. Research, extension and irrigation projects are examples. The achievement of a project's objective, which is to increase farm productivity, depends on the reaction of the farmers on that project. The products offered

by those projects (i.e., improved technologies, new crop management techniques, irrigation water or new crop mix) are used as inputs in small-farm production. Farmers will adopt those products only if they are economically feasible from their perspective. In other words, farmers are very likely to adopt new products if they can generate higher incomes than the existing production system and, at the same time, are compatible with the farmer's constraints.

In African countries, where most agricultural production occurs on small farms, the adoption of modern crop technology by small farmers is a very important issue. The modern crop technology developed in international and national research centers did not change the production on most small African farms. Contrasted often with impressive on-station yields, new technologies usually fail to perform as expected under farm conditions and demand a higher level of management unknown to most small farmers (Matlon and Spencer). Matlon and Spencer pointed out that these failures stem to a large extent from an inadequate understanding of small-farm goals and resources in formulating research objectives. Christensen and Witucki have the same explanation and mention three reasons for the failure of widespread diffusion of the crop technologies to small farmers. First, production is predominantly rainfed, and varieties developed for irrigated conditions generally cannot be transferred without modification to rainfed areas. Second, location-specific factors (including disease) have limited transfer of improved varieties from other rainfed regions, as well. Third, production is typically very labor-intensive, and labor is frequently the limiting factor of production.

Matlon and Spencer recommended three major points to consider in conducting research on small-farm problems. These are greater understanding of farmers' objectives and resources, greater on-farm testing of new technology components, and greater balance between technology development and technology evaluation. Technology must be evaluated from the farmer's perspective, including the production system, resource constraints, institutional and policy environments. Microeconomic research is needed to compare yields, risk, and profitability of the improved technology introduced in the existing farming system. There are both simple and more sophisticated models used to validate new technology and/or to choose between alternative technologies.

Partial-Budget Analysis

The partial-budget analysis used by CIMMYT economists is an economic analysis in terms of costs and benefits associated with a potential technological component from a farmer's point of view (Anderson, Sweeney and Williams; Byerlee and Collinson). The partial-budget analysis is a technique used to compare two or more alternative methods before they can be taken as general recommendations to farmers. The procedure is outlined by Edward Reeves (Jones and Wallace) as follows:

1. Gross benefit for each treatment is estimated. This is found by multiplying adjusted average yield by the field price of the crop. Average yield is adjusted for harvest and storage losses. Field price is estimated by deducting costs of harvesting, shelling/threshing, and transportation from the market price.

2. Variable costs for each treatment are estimated. This is found by multiplying quantity of inputs by the input field price.

3. Net benefit is then computed by subtracting variable costs from the gross benefits.

4. The marginal rate of returns in capital is calculated for all treatments. The treatment which gives the highest net benefit and a marginal rate of return to capital of at least 40 percent is selected.

5. The selected treatment is then tested for yield and price variability. This is to test the sensitivity of the technology to changes in input and output markets.

The partial-budget analysis has certain deficiencies. It does not consider all effects of the new technology on the multi-enterprise household economy. The farmer has to adjust his whole farm plan according to new opportunities and to bottlenecks created by new technology. For example, crop technologies which increase peak labor requirements must have very high returns to attract labor from the rest of the farm activity. The new optimal farm plan is obtained only after all adjustments, including risk aversion, are considered. On the other hand, Edward Reeves (Jones and Wallace) pointed out that the analyst assumes that farmers think in terms of "net benefit" as they make decisions, and that both benefits and costs can be measured with considerable accuracy.

In order to complete those deficiencies in the partial-budget analysis the mathematical programming model, and particularly the linear programming model (LP), became a very useful tool in analyzing the farm plan. The LP will maximize or minimize the objective

function subject to farmers' physical and financial constraints, and thus it represents a more realistic model than the partial-budget analysis. The LP model and its use to the whole farm plan analysis is discussed in the next section.

Farm Plan Analysis

In addition to technology assessment programming models in general and LP in particular have wider practical application for agricultural sector analysis in numerous situations from the farm to the national level. Linear programming is a computational technique for solving constrained optimization problems of a linear-objective function subject to a system of equations that represent the inequality and equality constraints. The general form is

$$\text{Max.} \quad \sum_{j=1}^{n} C_j X_j \qquad j = 1, 2, \ldots n$$

$$\text{subject to} \quad A_{ij} X_j \leq B_j \qquad X_j \geq 0.$$

In its simplest form, the LP model solves a farm plan in a single period without considering growth or changes in the plan over time, assuming that the farmer is certain of future events. In a farm plan, some activities normally have long gestation periods where both returns and costs are planned. Fixed-capital investment has to be spread over a number of years. Likewise, tree fruits and timber have future returns that are included in the farm plan. Farmers also are never certain of their environment. There is a degree of risk due to crop failure as a result of drought, lack of irrigation water, influx of insects and/or diseases, and dramatic price changes. More serious disasters like hurricanes and floods may threaten farmers. Another

characteristic of agricultural production is the seasonality of crop activity. That is, crop-activity patterns vary during the growing season. There are peaks and troughs for each activity such as months of high irrigation demand, months of peak labor demand, and months of high tractor demand.

However, it is easy to incorporate numerous farmer circumstances in the LP model. Some of these are risk aversion, multi-period planning, seasonality, quality of different resources (soil types and fertility, differential labor productivity and costs), crop rotation, intercropping, intermediate crops, credit (institutional and other), and storage activities.

Because agricultural production is typically a risky business, farmers may sacrifice a farm plan of higher income to an alternative plan of lower income, if the latter provides a more satisfactory level of security (Hazell and Norton). Introducing risk into a farm model is, therefore, essential; otherwise, the results of the model will not represent the real situation facing the farmer. Small-scale family farms, which have limited resources and whose first priority is to produce food for the household members, can reasonably be expected to have a higher degree of risk-aversion than the large commercial farms. One of the methods used by Hazell for incorporating risk-adverse behavior in farm planning models is the MOTAD model (Minimization Of the Total Absolute Deviation) (Hazell and Norton). The computation procedure will not be discussed here; however, the concept is basically a minimization of the activity gross margin deviations from their sample means. Time series data on activity gross margins of the farm are required to estimate these deviations for use in the model.

In addition, parametric programming can provide insights about adjustments and responses to changes of coefficients in the objective function, on technical coefficients in the constraint matrix, and of resource limits. Product-supply functions and factor-demand functions can be derived from a model of this type by using post-optimality analysis. The shadow price of the scarce resource is an important result that should be compared with the actual farm value/cost per unit of that resource.

Policy Implications

The policy implication of the economic feasibility of new technology is a research-resources-allocation problem. Development of modern technology adaptable to the farmer's environment calls for division of research resources including personnel, money, time and other facilities between basic or on-station research and applied or on-farm research. The two are, of course, complementary in the sense that applied researchers use the potentially promising technologies developed in the basic research, and then incorporate them into farm management while giving great attention to farmers' reactions to the new technology. Basic researchers will benefit from further identification by the applied researchers of the problems and bottlenecks of the technology when they lead to a modification of basic research priorities.

A programming model provides an optimal farm plan and resource use for different production possibilities. Some of the information output of a programming model that has important policy implications are:

1. Differences in gross returns and resource use between optimal farm plans and the data reported by the farmers.

2. Returns to resources; i.e., labor and capital under different farm plans.

3. Periods of scarcity and slacks of input use in a year.

If the optimal farm plan under traditional technology is found to be more efficient in resource use than the average farm as reported in the data, it may be suggested that farmers be informed of potential improvements through extension so that a more efficient allocation of their existing resources can improve farm income. In interpreting and extending such a result, it should be kept in mind that farmers' consumption preferences and risk aversion strategies may cause their behavior and management to differ from the normative optimum.

On the other hand, where the optimal farm plan under the improved technology is found to give higher gross margins and higher returns to labor and capital than the traditional technology, greater effort should be spent on technology diffusion through extension and education.

Another policy implication which can be examined with a programming model is the use of idle resources, if any should exist, in the farm sector. Because of the seasonality of agriculture, it may appear that labor and capital are scarce in a few months while they are in surplus in most other months of the year. In that case, it may be suggested that small-scale rural industries be developed for the off-peak season. Such industries might employ the idle resources and better utilize them when agricultural activity is slack.

On the other hand, policy concerns may be an introduction of modified crop-production systems to reduce long-run fertility loss, or new crops that will enhance family nutrition or new irrigation facilities that will expand the irrigated area or number of crop seasons per year. Under the assumption of rational-decision making, farmers' adoption of these new systems depends on their profitability. The farm-plan model provides a methodology of farm-level economic analysis of alternative crop-production systems. In cases where market forces; i.e., given relative commodity prices and production costs, could not be relied upon to encourage the adoption of new production systems, the analysis suggests the potential for and possibly a need for some form of governmental intervention.

Data Acquistion

The data required for economic analysis of alternative production technologies using the partial-budget anaylsis is much less than that required of the programming model, because the partial-budget analysis has a narrow focus on the new technology element rather than the total farm plan. The data required for analyzing a technology must be taken in a continuous monitoring of selected farmers who use the technology under consideration, as well as a baseline group of farmers who use existing technology. The data-collection method most effectively used in these studies is the multiple-visit survey. In such a study, data on specific variables are recorded continuously from beginning to end of the growing season. Data are recorded on the inputs, land, family labor, variable capital costs, on-farm prices of inputs and outputs, time spent on different farm operations, effect of the new technology

on women's work and on children's school time, and reaction of the farmer to how the new technology affected household decision making. The farmer's subjective evaluation of the technology is also important and should be recorded, because it gives a rough idea of the farmer's willingness to adopt the technology.

Farm record-keeping may also be used to collect data necessary for the evaluation of production as a new technology is introduced. The obstacle to farm record-keeping is the illiteracy in many rural communities.

Availability of reliable and accurate data is the most essential part of estimating an LP model for a farm plan. There are various ways of getting data. These are not competing ways, rather they are complementary. The data collection methods are:

1. General farm survey.
2. Specific crop survey.
3. Other data acquisition methods.

These methods are used in studies in many countries such as Thailand (Nicol, Sriplung and Heady), Mexico, Egypt and Turkey (Hazell and Norton), Burkino Faso (Jaeger), and Tanzania (Manday).

The general survey is the primary source of information on agricultural production, resources, alternative technologies, etc. In Thailand, the general survey used was a continuous annual survey of crop years 1971-72, 1973-74, 1975-76, 1977-78 (Nicol, Sriplung and Heady). Information gathered by the general survey is listed below.

1. Farm Family Characteristics

   -Family size.
   -Family members identified by sex, age, education.
   -Occupation, cost of education, and if migrated from area.

-Labor supply, permanent or temporary of the effective wages paid.
-Land holdings by size, tenure, and type, method of rental payment of land if land is rented.

2. Crop Production

-Variety of crops grown.
-Area planted and harvested under each crop, production.
-Labor input for each crop and operation, land preparation, planting, cultivation, harvesting and product transportation, (Labor is classified into family labor, hired labor, and collective work. Family labor is further classified into adult male, adult female, and children.)
-Use of animal power and machines for the farm operations.

3. Livestock

-Types of livestock, beginning and ending inventories by age and sex. Births, deaths, purchases, sales, gifts, and losses.
-Feed of concentration input and labor input in livestock.

4. Product Sales

-Quantity of crop sales periodically (monthly), value sold.
-Minor crops can be reported only by total sales.
-Livestock sales of value sold.

5. Inputs

-Information on inputs like fertilizers, pesticides and type.
-Acres treated and amount used.
-Other inputs like water pumps, type, number, fuel use, and rental income received.

6. Credit

-Cash and kind received.
-Source of credit, institutions that offer credit, and other sources such as friends, relatives, or land lords.
-Interest charged by each source.
-Non-agricultural uses of the credit.
-Form of payment.

7. Storage

-Quantity of grain stored, and type of storage.
-Losses in storage, quantity and value.

8. Income

   -Gross income data from crops, livestock, and non-farm income.
   -Expenditures of the family on agricultural and non-agricultural goods.

9. Membership in farm organizations, benefits, and burdens associated with it, and major problems perceived by the farmer.

10. Time series data is required to include risk-aversion in the model.

Crop-specific surveys are also implemented to provide detailed information to supplement general survey data. If a significant area is devoted to specialty crops which have unique ways of production and marketing, or if its importance as a foreign exchange source is deemed critical, crop-specific surveys may be most appropriate because they will provide the more detailed data required for analysis.

Other data acquisition methods include collection of price data from the market, farm record-keeping maintained by a selected group of farmers, research-center publications and field-research findings. All these additional sources of data will complement/supplement the data necessary for estimation and analysis using a farm model.

Sector Model and Policy Analysis

Policy Problem

In the agricultural sector, policy makers are usually concerned with allocating limited public resources among alternative policy actions to achieve desired goals. Some of these policy goals are creating more employment, increasing export sales, making the country self-sufficient in food, increasing farm incomes and keeping food prices low to consumers. Some of these goals are mutually exclusive.

Hazell and Norton have described such a policy choice as a two-level decision problem: a macrolevel and a microlevel. At the macrolevel, a policy maker is trying to decide how best to allocate funds in the face of more than one objective and in the face of uncertainty about what the allocation consequences will be. At the microlevel, farmers are trying to decide how best to respond to the new policy environment. Thus, before the macroproblem is solved, it is necessary to have an idea of how producers adjust their production possibilities through reorganizing their resources. Without accounting for farmers' decisions in the new policy environment, expected results from policy actions will be miscalculated. Farmers in different regions with varying agroclimatic conditions and farmers of different categories based on land holdings, cropping activities and resource endowments will react differently on policy interventions. Policy makers may also be concerned with the relative impact of the policies on different farm categories.

A sector model is an analytical tool used to simulate producer behavior. The objective of an agricultural sector model is to provide an analytical framework adapted to the evaluation of the implications of current and future agricultural policy alternatives.

Sector Model

Linear programming is the most common technique used to build an agricultural sector model. Hazell and Norton have described four important steps taken in conducting a sector analysis. The steps are:

1. To identify the products in the sector (crops, livestock, and their products).

2. To define the regions and subregions of the country by their variations in agroclimatic features, in crops grown, in access to other regions and other characteristics.

3. To describe the representative farm units based on their resources, production, use of machinery, degree of access to irrigation, credit and purchased inputs.

4. To identify production technologies available to each producing unit. For example, small farmers who primarily produce for home consumption are very likely to have fewer production possibilities than the large farmers who purchase modern inputs. Small farmers, who use family labor, may use more labor-intensive techniques.

After regions, products, representative farm units and production technologies are described the structure of the model to be built must be specified. A detailed discussion of the sector-model structure has been given by Hazell and Norton. A sector-programming model is set up to include three major parts: the objective function, the production activities (columns) and the constraint and balance equations (rows).

The sector model objective function, is a two-level problem. The first problem is the maximization of the policy objective function subject to

1. The government constraints of public funds and

2. The unknown producer's reaction to the new policy.

The second problem is a maximization of the producer's objective function subject to

1. His resource constraint and

2. The new policy constraints.

The policy objective may be to maximize export earnings and domestic sales, while the producer's objective maybe to maximize gross margins.

Production activities are categorized by regions, class of farmers and production technologies. Such activities are producing (crops and livestock), processing, marketing, transportation, supplying inputs and trade (imports and exports). Risk-aversion activity is also included. These are general activities of a model, but specific activities depend on the country in which the model is being applied.

Constraints and balance equations form the rows of the model. The analyst will specify resource constraints such as land, capital, irrigation water and credit. Classification of these inputs into types such as nitrogen fertility versus phosphate fertilizer and irrigation by gravity versus irrigation by pumps is important in building a realistic model. For example, labor is differentiated into hired labor and family labor. Family labor may be further classified into adult males, adult females and children. This classification is usually important in traditional agriculture where specific tasks are performed only by certain sex-age groups. Types of land that are required to be differentiated in the model may include low-rainfall land, high-rainfall land, flood-irrigation land and controlled-irrigation land. This classification is important because of productivity difference, and each type of land may be associated with different input-output combinations. For example, irrigated and dryland crops will have different fertilizer and labor use and different yields. Another important point is to identify input

availability with time of use because agricultural operations are undertaken in very specific time periods throughout the calendar year. Quarterly, monthly, or weekly classifications may be necessary depending on the types of inputs, outputs and operations under consideration. The following model depicts the general form of the constraints in such a way that they reflect variations in regions, land types, seasons (or quarters, months and weeks) and production processes (Nicol, Sriplung and Heady; Hazell and Norton).

$$A_{krjts} X_{rjts} \leq B_{krs}$$

where $s = 1, 2, \ldots$ for the seasons,

$r = 1, 2, \ldots$ for the regions,

$t = 1, 2, \ldots$ for the land types,

$j = 1, 2, \ldots$ for the production processess,

$k = 1, 2, \ldots$ for the inputs (resources) other than land,

A_{krjts} = the per unit input k requirement (coefficient) for production process j in region r on land type t in season s,

X_{rjts} = the level of the production process j in region r on land type t in season s,

B_{krs} = the supply of input k available for crop production in region r in season s.

Policy instrumental variables are also built into the model's structure in the form of matrix coefficients, or right-hand side or objective-function coefficients. Some of the policy instruments common to the agricultural sector are change in price of an input such as water and fertilizer, change in exchange rates, introduction of new technology and increase availability of irrigation. Policy goals, per

se, are not included in the model.

After model construction is completed, a programming algorithm is used to solve it. Once a solution is obtained and analyzed, the policy problem can be addressed. Hazell and Norton suggested that to solve the policy problem is to alter the model in a way that reflects a new policy or new values of policy instrumental variables, and then to solve the model again. For example, an introduction of an irrigation water supply will expand the irrigated area. Such an expansion will be reflected in an increase in the right-hand side coefficients representing irrigated land. Similarly, a change in the pricing policy for irrigation water will be reflected in a change in the coefficients of the objective function c's corresponding to the irrigation water column (activity). In each solution, new values of policy-goal variables can be calculated by hand and then recorded. The model analyst will, therefore, be able to show the alternative effects of policy actions on different goals.

Data Requirement

Once the framework of a sector-programming model is constructed, one can immediately see the very substantial volume of data required to develop and apply the model. Hazell and Norton have pointed out several data-related problems in the developing countries. First, in most countries at least some data corresponding to the programming model's variables don't exist. Agricultural employment in man-days or man-months and total farm income are examples. Second, many of the data series lack reliability and sometimes the same data sets available in different agencies are inconsistent. Third, they are

based largely on cross-sectional data rather than time series. Time-series data on production and prices are seldom available. Time-series data are needed, however, for the risk matrix. The fourth problem is that data on production cost obtained in the farm management surveys typically don't record the timing of input use; thus, at least some important information for building a realistic sector model will typically be unavailable.

Hazell and Norton list the standard kinds of data needed for their sector model as follows.

1. Input/output coefficients for production by product, technology, region, and farm type.

2. Resource endowments.

3. Base-period quantities produced and marketed.

4. Quantities and prices, tariffs, taxes, and subsidies for imports and exports.

5. Input prices.

6. Processing and marketing margins, physical input/output coefficients for processing and marketing.

7. Demand elasticities (subsistence demand, domestic demand, and export demand).

8. A time series on price and quantity by product and region for the risk matrix.

9. The risk-aversion parameters.

The primary source of data is typically a nation-wide survey supplemented with primary data from other smaller surveys and farm-management studies. The secondary data from agencies and departments

may also be very useful. Sources of secondary data include national census, land and irrigation authorities, extension services and research institutions, among others. Methods of data collection are discussed in Chapter III.

CHAPTER III

ANALYSIS OF THE SURVEY DATA

Introduction

In this chapter survey data collected from six villages of the Lower Shebelle Region (LSHR) of Somalia are used. Data on farm-family characteristics and on management and production of the maize crop were collected in a one-shot survey from a sample of 115 farmers in the Gu season, 1985. Those data are analyzed in an attempt to discover their limitations in supporting certain quantitative analyses from production economics and farm management. Limitations of the survey data and methods of acquisition are then discussed.

Objectives of the Survey Analysis

The steps to be taken following analysis of the survey are

1. Describe the general characteristics of the farmer and the surrounding environment.

2. Identify and measure types and relative efficiency among production technologies utilized by the farmers in the survey area.

3. Analyze the absolute economic efficiency of farms in production.

4. Examine the relative economic efficiency between different groups of farmers based on village and land-ownership.

5. Estimate supply elasticities of output with respect to prices of output and inputs.

Baseline Data and Trends for
Somali Resources and Agriculture

Somalia lies on the northeastern corner of the African continent. On the northwest it borders Djibouti and Ethiopia, and on the southwest is Kenya. The Gulf of Aden lies on the northern side and the Indian Ocean lies along the total eastern side of the country.

The country's population is approximately 5.2 million people (World Bank 1984), within an area of about 638,000 square kilometers with an average rainfall of 450-500 millimeters in the agricultural areas. The country has 8.2 million hectares of arable land of which only one percent, or 700,000 hectares, is cultivated. There are only 50,000 hectares (7 percent) under controlled irrigation while 110,000 hectares (16 percent) are subject to flooding cultivation. The remaining 540,000 hectares (77 percent) are wholly rainfed.

The population is growing at an annual rate of 3 percent. Agricultural productivity is not growing enough to counterbalance the demand pressure caused by population growth. This unbalance between food production and population has resulted in a decline in food production per capita. For example, food production per capita in 1982-84 was 69 percent of that in 1974-76 (World Bank 1986). Thus, the country faces serious food shortages which are most often solved by food imports and food aid. In 1984, 330,000 metric tons of cereals were imported and another 177,000 metric tons of food aid cereals were utilized.

Agricultural productivity is a crucial issue which deserves attention if food shortage and growth in agricultural production is to

be addressed. The agricultural sector is of great national significance as it employs 78 percent of the population and it accounts for 70 percent of the gross national product.

The Survey and the Region

The Survey

The survey of maize production and costs was conducted in six villages in the LSHR of Somalia. This region is one of sixteen similarly defined regions of the country. The LSHR survey was part of the applied-research activities of the Agricultural Extension, Farm Management and Training Project (AFMET). The survey was designed, tested and supervised by M. Y. Boateng, A.A. Ibrahim David and Sheik Yusuf Mire. The questionnaires were administered by the Field Extension Agents (FEAs) of the six villages. Local supervision was supplied by the regional extension officers and staff. The enumerators (FEAs) were given training on how to administer the questionnaire. The questionnaire was pretested and then translated into Somali (Boateng, David and Mire). Six FEAs were selected to conduct the survey. A systematic random-sampling procedure was established in which each farmer was selected from a master list of farmers in each village. The number of farmers to be included in the survey for each village was proportional to the population size of the village. A total of 115 farmers were interviewed in the six villages. The distribution of the interviewed farmers across the six villages is shown in Table 1.

Table 1. Distribution of Farmers Among Villages Surveyed in LSHR, 1985

Village	Approximate Farm Families	Weight	Farmers Sampled	Questionnaires Returned
Semi-semi	500	.10	12	15
Majabto	425	.08	11	11
Gebei	570	.11	15	17
Bulosheikh	650	.12	16	16
Moshani	1015	.20	24	27
Farhane	2038	.39	47	29
Total	5198	1.00	125	115

Source: Boateng, David and Mire, p. 14.

Physical Features of the Region

The LSHR occupies approximately 3.3 million hectares. The Shebelle River, which originates from the highlands of Ethiopia, passes through the region and provides limited irrigation water. The region contains one of the country's most intensively irrigated areas, which includes both large scale commercial farmers and small subsistance farmers.

There are four distinct seasons, two of them are dry and the other two are wet. The Gu from April through June is the wettest season. The Der is less wet and falls in October, usually lasting through December. The average annual rainfall is about 550 millimeters.

The soil of the survey area is a heavy clay. It becomes very hard when dry and, hence, effective land preparation by hand is difficult and somewhat ineffective.

Crops Grown

The major food crops grown by small farmers in the survey area are maize (corn), sesame, cowpeas and some vegetables including tomatoes and green peppers. Outside the survey area but within the region there is considerable rainfed agriculture where sorghum is the dominant crop, and drought-tolerant local maize is also grown. On the commercial plantations the crops grown are bananas, citrus (grapefruits and lemons), coconuts, watermelons, as well as maize and sesame.

Descriptive Analysis: Cross Tabulation

Land Holdings

The average farm size in the sample area is 5.4 hectares per family as shown in Table 2. Thirty-nine percent of the surveyed families own 1 hectare or less, 24 percent own 1.1 to two hectares, 18 percent own 2.1 to 4.9 hectares, and 19 percent own five hectares or more. The villages of Farhane and Semi-semi have the largest average holdings of 7.9 hectares and 6.8 hectares respectively; Majabto and Moshani have a little less acreage, 5.7 hectares and 6 hectares, respectively. The villages of Bulosheikh and Gebei have the smallest farm sizes of 2.2 hectares and 1.3 hectares, respectively. These holdings are often split into several sites, with an average of two sites per farmer reported in the sample area. The data show that all the farm families interviewed on average have more than one farm plot. These numbers of sites range from three hectares in Semi-semi to 1.3 hectares in Moshani, and the rest lie in between.

Another important characteristic of farm families is the land-man ratio. As shown on Table 2, there is an average land-man ratio of .66 hectares per person. The villages of Gebei and Bulosheikh have the smallest land-man ratios of .22 and .25, respectively. The villages of Farhane and Majabto have the largest quantity of land per person at .99 hectares and .81 hectares, respectively.

Table 2. Number of Farms, Average Farm Size and Land Per Person for Villages in the LSHR, 1985

Village	Average Farm Size (Ha)	Average No. of Farms	Land-Man* Ratio (Ha/Person)
Semi-semi	6.8	3.0	.68
Majabto	5.7	1.5	.81
Gebei	1.3	1.4	.22
Moshani	6.0	1.3	.67
Bulosheikh	2.2	1.6	.29
Farhane	7.9	2.2	.99
Average Total	5.4	1.8	.66

*Land-man ratio equals the ratio of total land holdings and the total family member.

Household Demography

The size of the family is an important determinant of many of the activities in the rural economy. In order to produce, the family has to meet the labor-work required to perform the various home-farm activities. The family also needs to generate nonfarm income by selling part of their labor sometimes to the detriment of farm activities. The large family size, on the other hand, accompanied by low land productivity virtually assures a subsistence level income. The family with limited resources of land and capital and with limited understanding of modern technology is less likely to produce a surplus

over family consumptions. So the family would hardly have the chance of investing in more new factors of production.

The average family size of the sample is eight persons. Across the villages there is a variation in family size but not as large as in land holdings. Table 3 shows the average household size of each village. The family consists of husband, wife/s, children and relatives living with them.

Table 3. Characteristics of Household Demography Within Villages of the LSHR Survey, 1985

Village	Average Family Size (Persons)	Age of Household Head (Years)	Female Household Head (Percent)	Total Children Attending School (Percent)
Semi-semi	10	54	7	Less than 1 (.8)
Majabto	7	43	9	3
Gebei	6	46	12	14
Moshani	9	53	4	26
Bulosheikh	8	49	25	25
Farhane	8	50	17	15
Sample Average	8	49	12	14

The average age of heads of the household is 49 years. This age does not vary much across villages as shown in Table 3. Only 12 percent of the interviewed families are headed by females. Education is an important factor in every society, but in rural societies it is usually overshadowed by the day-to-day struggle for existence, hence very little attention is paid to it. The data show that not more than one-quarter of the children go to school in any of the six villages, and an average 14 percent of the total children in the

surveyed families go to school. Families in Moshani send 26 percent of their children to school, while in Semi-semi only 0.8 percent of the children attend school.

Production Activities

Crop Tillage: The area in the survey has a heavy clay soil (vertisoils) which in the dry season forms very hard clods and deep cracks. So practically it is quite impossible to achieve satisfactory land preparation by hand. Thus, use of the tractor has become the sole mode for land preparation. Ninety-five percent of the farmers interviewed use tractors for land preparation, while only 5 percent depend on human power using the local hoe (yambo). Only 3 percent of those who prepare the land by tractor use their own tractors, while the remaining 97 percent hire it. An average of three tractor-hours are required to complete the plowing of 1 hectare. The human labor required for this job is about 16 man-days. One man-day in the traditional sense of LSHR does not mean man-work for number of hours in a day as it may sound. The term corresponds to man-work that is sufficient to cultivate or plow one "jibal," which is a generally accepted standard area of about .0625 hectares. So to avoid confusion in the contracts between hired workers and farmers, the jibal is used as a measurement unit. If a man or woman can cultivate two or more jibals in a day, he/she will be paid according to the number of man-days (jibals) he/she worked. It is more difficult and expensive to prepare the land by hand, but a few farmers in Majabto, Gebei and Farhane are still practicing it.

Another important operation in land preparation is harrowing.

This operation breaks down the hard clods dug out by the plow and produces a soft seed bed that is essential for seed germination and good root growth in the early stages of seedling growth. The study shows only 35 percent of the farmers perform this operation. None of the farmers in the villages of Majabto, Gebei, and Bulosheikh harrow their fields.

As shown in Table 4, an average 3.13 tractor hours (plowing and harrowing combined) has been used for villages in the sample. But this average varies across the villages. Villages such as Majabto, Gebei, Bulosheikh and Farhane using only one tractor operation, plowing, use fewer tractor-hours per hectare. Table 4 shows these amounts to be 2.33, 2.30, 2.49 and 2.91 hours, respectively.

Moshani uses 4.54 tractor hours per hectare and Semi-semi 4.23 tractor hours. Farmers interviewed in both of these villages practice a more complete land preparation by doing both plowing and harrowing.

Table 4. Tractor and Implement Usage for Land Preparation Among Villages in the LSHR Survey, 1985

Village	Farmers Plowing by Tractor (Percent)	Farmers Harrowing (Percent)	Plowing and Harrowing (Hours/Ha)
Semi-semi	100	87	4.23
Majabto	82	-	2.33
Gebei	94	-	2.30
Moshani	100	96	4.54
Bulosheikh	100	-	2.47
Farhane	90	3	2.91
Sample	95	35	3.13

Planting: Most of the farmers plant in the first week of April in the Gu season and early November in the Der season. These planting times vary from season to season and are adjusted to the rainfall pattern.

Sixty-five percent of the farmers in the survey use local seed retained from their previous season's crop. Thirty-five percent use improved seed. The seed rate for maize generally adopted in the study area is 16 kilograms per hectare.

Although it is reported that 89 percent of the farmers plant in rows, it is less accurate to say that farmers in general adopt row planting as an improved method of planting. Seed drillers are not known in the area and hand planting is constrained by the farmer's financial capacity to hire labor. Thus, farmers have come to rely on a less costly mode of planting. That is, dropping the seed behind the plow farrow which will be covered by the plow in the second trip, while opening a new farrow at the same time. The economic rationale of this mode of planting is obvious. Farmers save the cost of the 14 man-days per hectare that would have been used for planting by an alternative. Only 2 man-days plus the normal plowing operation using the tractor will do both plowing and planting at the same time.

Weeding is the most crucial and expensive production activity. In the absence of effective and timely weeding, valuable fertility and soil moisture are lost to the weeds. It is estimated from other studies of the area that it takes about 30 percent of the total production cost. Although there is pre-emergence weed control such as deep plowing and occasional burning of crop residues, the most prominent weed control method is mechanical using the local hoe

(yambo) and hand labor. It takes an average of 16 man-days of labor to weed one hectare. Timeliness of weeding is more important than number of weedings, but it depends upon availability of labor and cash. Unfortunately, this survey made no provision to measure timeliness of weeding. About 60 percent of the farmers weed three times, while 35 percent weed twice and only 4 percent weed four times. Table 5 shows the weeding patterns of the survey area.

Table 5. Weeding Pattern for 1985 Gu and Der Seasons Among Villages in the LSHR Survey

	Number of Weedings						
	Gu			Der			
	2	3	4	2	3	4	Average
Village	Percent of Farmers			Percent of Farmers			Man-Days/Hectare
Semi-semi	93	7	-	80	20	-	16
Majabto	73	18	9	35	64	-	16
Gebei	41	59	-	65	35	-	16
Bulosheikh	31	69	-	50	37	13	16
Moshani	-	100	-	-	100	-	16
Farhane	31	65	41	41	55	4	16
Average Total	45	53	2	45	52	3	16

The data reveal no measureable difference in weeding patterns between Gu and Der seasons. In each season about 45 percent of the farmers are weeding their fields twice, 53 percent weed three times, and only 2 percent of the farmers weed four times, while across the villages the data show some difference. Specifically, the bulk of farmers interviewed in Semi-semi and Majabto, 93 percent and 73 percent, respectively, weed their fields twice in the Gu season, while farmers in Bulosheikh, Moshani and Farhane weed three times.

This variation among villages of number of weedings may reflect local factors such as availability of labor and cash and incidence of weeds.

Irrigation: As shown in Table 6, all of the surveyed farmers get some irrigation to their crops. Irrigation is beyond the control of farmers. It mostly depends on the level of water in the river and the condition of primary and secondary canal systems maintained and regulated by the Ministry of Agriculture.

Table 6. Presence of Irrigation and Irrigation Frequency Among Villages in the LSHR Survey, 1985

Village	Farmers With Irrigated Farms (Percent)	Average Number of Irrigations Gu Season	Der Season
Semi-semi	100	2	2
Majabto	100	2	2
Gebei	100	2	2
Moshani	100	2	2
Bulosheikh	100	2	2
Farhane	100	2	2
Average Total	100	2	2

The survey shows that all of the farmers irrigate an average of two times during the growing season with an average labor input of about two man-days per hectare for each irrigation.

Use of Non-Farm Inputs: Normally there are three major purchased inputs used in crop production, seed, fertilizer and pesticides.

Use of Improved Seed: Table 7 shows that 35 percent of the farmers surveyed use improved maize seed, while 65 percent use local seed. Improved maize seed is a synthetic composite variety developed in the Afgoi Research Institute. The variety is open-pollinated and

farmers reproduce their own seeds once the initial planting is harvested, so the distinction between improved and local varieties may be obscure. Farmers indicate that it is not easy to get improved seed in the survey area. A government-owned seed-multiplication center is supposed to produce and sell the seeds.

An average seed rate of 16 kilograms per hectare for maize crop is reported in the data. This seed rate varies slightly from village to village as shown in Table 7.

Table 7. Utilization and Application Rates for Improved Seed and Fertilizer for Villages in the LSHR Survey, 1985

Village	Farmers Using Improved Seed	Seed Rate kg/Ha	Farmers Applying Fertilizer	Rate of Nitrogen Fertilizer kg/Ha
	(Percent)		(Percent)	
Semi-semi	67	16.0	20	46.0
Majabto	18	20.0	9	13.8
Gebei	18	11.2	6	46.0
Moshani	44	12.0	-	-
Bulosheikh	31	14.4	6	46.0
Farhane	31	20.8	3	46.0
Average Total	35	15.7	6	41.4

Fertilizer Use: Fertilizer is still new in the area. Only 6 percent of the respondents use the chemical, and 87 percent of them express difficulty in obtaining it. Lack of adequate market facilities for fertilizer explains low fertilizer use. In spite of the fact that the country has a urea plant that has a potential output of 40,000 tons per year, farmers do not have easy access to the product. As shown in Table 7, 20 percent of the farmers in Semi-semi use fertilizer. Nine percent in Majabto and 6 percent in both Gebei

and Bulosheikh, only 3 percent of the respondents in Farhane use fertilizer, and none in Moshani use it. Urea is the fertilizer that is being used and it is used only for the maize crop. None of the other crops are given fertilizer. The average rate of fertilization on the maize crop is 41.4 kilograms of nitrogen per hectare. Only Majabto, which uses 13.8 kilograms of nitrogen per hectare, is applying at a low rate. The other four villages who use fertilizer apply 46 kilograms of nitrogen per hectare.

Use of Pesticides: The sole popular pesticide used in the study area is a granular insecticide (Basudin-10G or Dursiban 10G) used to kill the corn-stalk borer. The stalk borer is the larva of kilo partelus that attacks the growing part of the corn shoot in the early stage, and then if not treated, attacks the stalk, the cob and the roots causing great loss in crop production. Sixty-eight percent of the farmers interviewed use the chemical. Table 8 shows that all of the farmers interviewed in Semi-semi use the chemical, while 96 percent of the farmers in Farhane use the chemical. Eighty-two percent of the farmers in Majabto and Gebei treat their crops with the chemical. None of the farmers in Moshani use this insecticide and only half of the farmers in Bulosheikh use it. The average use-rate of insecticides in the study area is 2.36 kilograms per hectare. This is much less than the rate recommended by the Agricultural Research Institute, which is five kilograms per hectare in two splits.

Table 8. Pesticide Usage and Application Rates for Villages in the LSHR, 1985

Village	Farmers Using Insecticide (Percent)	Average Application Rate (kg/Ha)
Semi-semi	100	2.13
Majabto	82	2.22
Gebei	82	2.27
Moshani	Nil	Nil
Bulosheikh	50	3.88
Farhane	96	3.64
Average Total	68	2.36

Fifty-four percent of the farmers who use the chemical feel that it is not easily available. Farmers get it from one of three sources: Ministry of Agriculture Department of Agricultural Inputs (ONAT), small-farmer credit recently initiated by the Somali Commercial and Savings Bank with United Nation's Capital Development Fund (UNCDF) and the open market. The latter is insignificant because the private sector does not deal with agricultural inputs as it is controlled by the government.

Labor Requirements: It is quite normal in peasant agriculture that family labor constitutes the most significant source of labor for agricultural production. Another characteristic of traditional agriculture is that all of the farming activities are labor-intensive and seasonal in nature. Due to these facts, seasonal labor demand fluctuations are the rule, reaching a peak in certain periods of the season when major activities (planting, weeding and harvesting) are being carried out. Thus, seasonal labor shortages are common and can be considered as another characteristic of small-farm agriculture.

When labor requirements reach their peak, casual labor has to be hired to supplement family labor. As shown in Table 9, 65 percent of the respondents considered May as the month with the highest labor demand, 45 percent said it was in July, 44 percent felt it was April and 32 percent felt June is the month that labor is needed the most, while 26 percent said they needed labor in August.

Table 9. Months of Highest Labor Demand by Percentage of Repondents from Villages in the LSHR Survey

Village	April	May	June	July	August
Semi-semi	33	66	-	-	-
Majabto	9	55	36	36	-
Gebei	-	71	41	6	-
Bulosheikh	13	88	45	6	31
Moshani	96	7	4	85	30
Farhane	100	100	-	90	17
Average Total	44	65	32	45	26

All farmers in the survey said they need hired labor for their farm operations. Land preparation is an exception since 95 percent of the farmers prepare their land by tractor. Table 10 shows activities in which labor is needed the most based on the farmers' responses. Weeding is the most labor demanding operation. Ninety-nine percent of the farmers interviewed need hired labor for this operation. Labor is also needed in planting and harvesting; 78 percent and 82 percent of the farmers responded that they need additional labor for these operations, respectively.

Table 10. Activities With Highest Labor Requirement by Percent of Farmers from Villages in LSHR, 1985

Village	Planting	Weeding	Irrigation	Harvesting	Husking
Semi-semi	93	100	-	100	-
Majabto	64	91	36	91	18
Gebei	41	100	41	18	6
Bulosheikh	75	100	44	88	-
Moshani	100	100	100	100	-
Farhane	93	100	21	93	90
Average Total	78	99	40	82	19

The average amount of additional labor (in man-days) that a farmer requires in a season, as reported in different villages, is given in Table 11. It is shown that an average of five man-days are needed for planting, eleven man-days for weeding, one man-day for irrigation, and five man-days for harvesting. These labor requirements are similar across the villages.

Table 11. Man-Days of Hired Labor Required for Farm Operations in the Gu Season, 1985

Village	Planting	Weedings	Irrigation	Harvesting
Semi-semi	7	12	-	5
Majabto	5	12	1	8
Gebei	2	12	-	1
Bulosheikh	4	10	1	5
Moshani	9	9	2	9
Farhane	5	10	1	4
Average Total	5	11	1	5

Credit

Rural credit markets in traditional agriculture are marked by imperfections and lack of competition. There are different markets across which the terms of credit vary substantially. In the survey area there are branches of the Somali Commercial and Savings Bank in the Merca and Koriale districts. All the surveyed villages come under the administration of these two districts. The bank gives credit to farmers, but only after a lengthy procedure and assurance of ownership of sufficient quantity of liquid assets to be used as collateral against loan default. The bank also may demand a guarantor. Small farmers with limited resources, who lack assets and/or an understanding of the system which would allow them to go through the lengthy loan application procedure, will become effectively ineligible for such credit.

The only institutional credit facilities that serve small farmers are the Food and Agriculture Organization of the United Nations (FAO) Fertilizer Program and the Small Farmers Credit Program recently initiated by the Somali Commercial and Savings Bank with UNCDF to extend seasonal credit for seeds, pesticides and fertilizers to small farmers.

Most of the farmers (89 percent) in the villages surveyed do not use credit. Only 11 percent of the farmers receive some kind of credit, only 8 percent use institutional credit facilities, while 3 percent obtain credit from non-institutional sources such as friends and relatives. Table 12 shows the percentage of farmers in each village receiving credit and the source of those credits. The production operations that farmers require credit for are land

preparation and weeding. As mentioned before, land preparation requires cash to hire the tractors for plowing and harrowing, and weeding demands hired labor.

Table 12. Percent of Farmers Receiving Credit and Sources of Credit from Villages in the LSHR Survey, 1985

Village	Farmers Receiving Credit (Percent)	Institutional Sources (Percent)	Non-Institutional Sources (Percent)
Semi-semi	-	-	-
Majabto	-	-	-
Gebei	41	41	-
Bulosheikh	6	0	6
Moshani	4	4	-
Farhane	14	4	10
Average Total	11	8	3

Livestock

Livestock is an important component of small-farm activities. It is most probable that all of the farmers interviewed have some livestock. The most common animal raised is the chicken, which 86 percent of the farmers raise. Fifty percent of the farmers raise cattle. Twenty-three percent have sheep and 13 percent own goats. Camels and donkeys are scarce in the study area. Only 2 percent of the farmers own camels, while 6 percent have donkeys. As shown in Table 13, each family in the study area has an average of five cattle, two sheep, two goats and thirteen chickens.

Table 13. Average Number of Animals per Farmer for Villages in the LSHR, 1985

Village	Cattle	Sheep	Goats	Chickens
Semi-semi	13	7	13	29
Majabto	4	2	0	4
Gebei	1	1	1	7
Moshani	1	0	0	14
Bulosheikh	5	0	0	8
Farhane	8	1	1	14
Average Total	5	2	2	13

Formal Analysis of the Survey Data

Production Function Analysis

Model Selection: The production function describes the relationship between the output and the observed inputs used in the production process. A Cobb-Douglas production function is chosen to depict this relationship. This is because of its simplicity for interpretation, comparability with other empirical studies and widespread usage in empirical work in agricultural economics (among many others see Barnum and Squire; Chennareddy; Hopper; Hossain; Nevel; Yotopoulos, Lau and Somel; Norman, Simmons and Hays). The Cobb-Douglas production function also has certain desirable characteristics from a theoretical point of view as well. For example, the estimated parameters provide valuable insights concerning returns to scale and marginal productivity of the inputs. Another reason for the selection of the Cobb-Douglas function is that available estimates from a wide array of applications do not, in general, lead to rejection of the unit elasticity of substitution hypothesis of the Cobb-Douglas function. Further, in most cases, other functional forms of the

production relationship do not produce superior estimates to those with Cobb-Douglas specification (Hossain). Usually, estimation of Cobb-Douglas function is manageable in a data and statistical sense because it has a relatively smaller number of parameters than most other functional forms.

Variables: Because output or production data are available only on the maize crop, the production function for maize is estimated. The estimated production function in Logarithm form is as follows.

$$\ln Q = \ln A + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + u$$

where Q = output of maize in quintals (100 kilograms) per hectare,

X_1 = land in hectares,

X_2 = labor used for weeding in man-days per hectare,

X_3 = labor used for irrigation in man-days per hectare,

X_4 = use of tractor for land preparation in tractor hours per hectare.

u = an error term which is assumed to be normally and independently distributed with zero mean and constant variance (σ^2).

All the variables are obtained from the farmer responses collected in the survey. It is assumed that quantities of these four variables will allow us to predict the production of maize in small-holder agriculture of the LSHR of Somalia. Output of maize is measured in physical units of weight harvested. Land is measured in terms of total land owned.

Weeding, which is labor intensive, is a critically important operation in maize production of the LSHR. Labor is scarce during peak weeding times of the growing seasons, so weeding labor is

considered to be a strong explanatory variable and have a positive effect on maize output. The weeding-labor variable is estimated by multiplying the number of weedings reported in each observation by a constant weeding-labor input per hectare, 16 man-days per hectare. This assumes that all farmers use 16 man-days per hectare in all weedings. It is obvious that the rate of weeding labor input (16 man-days per hectare) that was recorded in the survey cannot be the same in all weeding operations and across the sample. But, possibly due to problems in the survey design that are discussed in the following sections, actual labor input for each interviewer was not recorded.

Irrigation water is free in the survey area and the only irrigation cost incurred is the cost of labor involved in placing it on the crop via furrows and flooding methods. However, numbers of irrigations are recorded and the product of numbers of irrigations and labor involved is taken as proxy for irrigation. Given the low cost of irrigation water, if it is also plentiful we would expect the marginal value product to approach zero. However, if it is scarce then additional irrigation should have a positive effect on measured output.

Almost all farmers use tractors but with different intensities. Some farmers use them only for plowing, while others use them for plowing and harrowing. So, use of the tractor for land preparation in tractor hours per hectare (plowing plus harrowing) is also taken as an explanatory variable. Given the great difficulty and generally poor result associated with land preparation by hand, one would expect higher use-rates for tractor usage to be reflected in higher

production.

Farmers' fixed-capital inputs are not recorded in the survey. Other non-labor variable costs are also not included because they constitute a very minor portion of the total farm inputs.

Analyses Conducted: The production-function analysis is made in the following steps:

1. First, a whole sample production function of the maize crop is estimated using pooled data from the field survey. The cross-sectional estimates of the technical coefficients of production provide the necessary information for analyzing resource allocation behavior of the farm household in maize production.

2. Secondly, separate maize crop production functions are estimated for each village. This determines if different production technologies are present within the villages surveyed.

3. Thirdly, separate production functions are estimated for large farmers and small farmers in an attempt to discover whether the level of efficiency in production does or does not change between large and small farmers.

Regression Analysis: A linear regression model is fit to the pooled data by using the ordinary least square (OLS) technique. In the econometric literature, it is well-documented that the OLS method is inappropriate for the estimation of an equation in a system of simultaneous equations (Kmenta, Gujarati). So, it can be argued that the production-function estimate may be subject to simultaneous equation bias. However, several authors, including Kmenta, Zellner and Dreze, demonstrated that, given the lag between input decisions and output decisions that occur in agriculture, the OLS method will

give unbiased estimates of the production function (Barnum and Squire).

The regression results of the pooled data are presented in Table 14. The results of this analysis suggest that interfarm variations in maize output are not explained by the variations in the inputs as measured in the survey data. The R-square (adj.) is very small (.011). The regression coefficients for land and weeding labor have the correct signs (positive), while the coefficients of irrigation labor and tractor hours have unexpected negative signs.

Table 14. Estimated Coefficients of the Maize Production Function for the LSHR, 1985

Coefficients	All Farms n = 115	Large Farms n = 22	Small Farms n = 93
Intercept	1.9473	1.4708	2.0418
	(.52227)	(1.3436)	(.55699)
Land,	.01427	-.2204	.07506
	(.02406)	(.08255)	(.04473)
Weeding labor	.24894	.58925	.20904
	(.14044)	(.37062)	(.14706)
Irrigation labor	-.09985	-.21294	-.08148
	(.06335)	(.14605)	(.069311)
Tractor hours	-.00482	-.03904	.01208
	(.01255)		(.01455)
R-square (adj.)	.011	.30	.035

Results of the separate village land-production functions are not presented here. However, the results of the separate production-function analyses did not differ in any substantial way from these pooled data. The regression coefficients of the inputs had mixed

signs, most of them negative. The explanatory power of the independent variables was very weak as shown by a very low value of R-square.

Farmer-survey data were divided into large and small-farm categories. Holdings of five hectares and more were considered as large farms. There were 22 farms in this category. The remaining 93 farms with fewer than five hectares of land comprise the small-farms category. Two separate production functions were estimated for the large and small farmers. The regression coefficients of inputs and their standard errors (parentheses) are presented in Table 14. As these results were not expected or easily interpreted, coefficients for the inputs have mixed and unexpected signs. For the large farms, only weeding labor is positive as expected, while the coefficients for land, irrigation labor and tractor hours have negative signs. The R-square is 30 percent. For small farms, only irrigation labor has an unexpected negative sign while other coefficients have expected positive signs. But the R-square is very low (.035), suggesting that explanatory variables explain only 3.5 percent of the variability of the dependent variable, while 96.5 percent is unexplained.

The results of the production-function analysis offer an inconclusive explanation of the production of maize in the area studied. One falls short of answers for the questions of:

1. How production of maize changes with various inputs.
2. How inputs are relatively important for maize production.
3. What the marginal value of products of different inputs is.
4. If farmers are allocating their resources efficiently in

production.

The problem of analyzing the data may stem from two possible sources. First, the analytical tool being used in the analysis may not be adequate. Secondly, the data might have measurement or recording errors so that it will not work with the tools most often used.

The tool used in the analysis is well-known, and has been used with good effect in numerous production-function-based analyses. It has been widely used in agricultural economics research, and the results reported are usually consistent with models derived from economic theory in combination with measures of the predominant features of the area in the study. Alternative functional forms such as a quadratic-production function or a fixed-proportion (Leontif-type) production function could also be used to estimate the maize production function. However, as the results of the analysis show, it is quite unlikely that further improvement over the estimated results can be obtained merely by selecting an alternative functional form.

When results go beyond the capacity of the known theory, one may formulate new hypotheses that explain apparently new phenomena. Such a move would entail validation or testing by empirical research with successive independent data sets. Otherwise one could re-examine data and ask if it embodies measurement errors or systematic bias which dictate unexpected results. It is not uncommon to encounter such data problems, especially where data sets are procurred for purposes other than estimation of production function. Even when data are specific and collected carefully for a specific study, many problems are observed in the analysis. So, based on the latter possibility of data

difficulty, the survey data has been re-examined and some problems identified. The next section will discuss a selection of these observed deficiencies.

Further Examination of the Data

For further examination of the data, the correlation analysis and scatter diagram of the explanatory variables against the dependent variable are presented in Table 15 and in Figures 1 through 4, respectively. Although these analyses cannot answer whether the data are accurate or not, they can give insights to the relationships and the presence or absence of strong trends between maize output and the other variables examined.

Correlation Analysis: The correlation coefficient measures the degree of linear association between two variables. So, in order to see this linear association between variables, a correlation coefficient matrix has been calculated, a part of which is shown on Table 15. Although a value of the correlation coefficient close to

Table 15. Correlation Coefficients for Maize Output and Inputs

Inputs	Output
Land	- .101
Weeding Labor	+ .140
Irrigation Labor	- .054
Tractor Hours	- .079

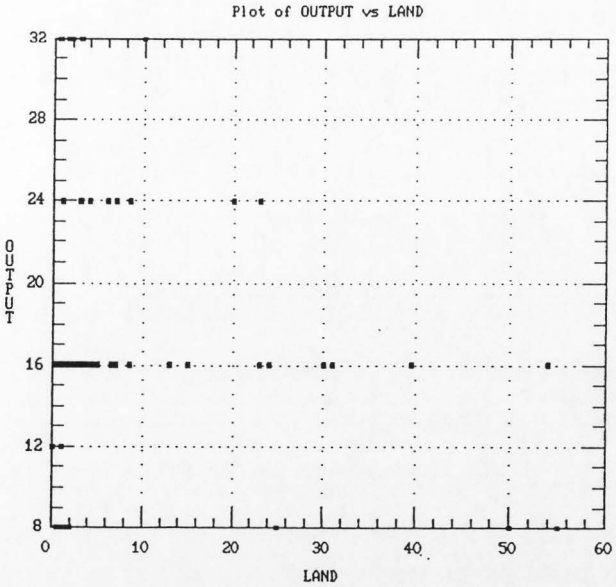

Figure 1. Scatter diagram of maize output (OUTPUT) per hectare and land holding (LAND) in hectares

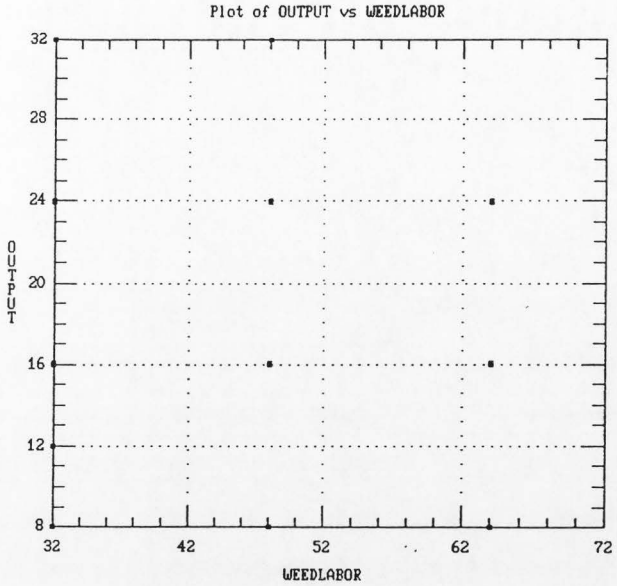

Figure 2. Scatter diagram of maize output OUTPUT) per hectare and weeding labor (WEEDLABOR) usage

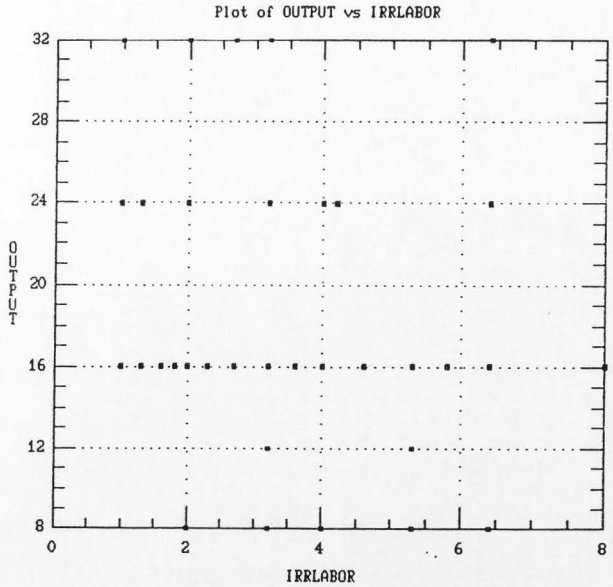

Figure 3. Scatter diagram of maize output (OUTPUT) per hectare and irrigation labor (IRRLABOR) usage

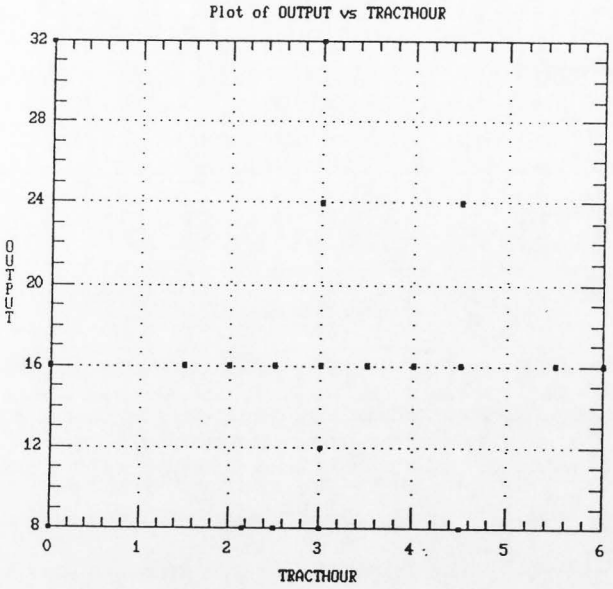

Figure 4. Scatter diagram of maize output (OUTPUT) per hectare and tractor (TRACTHOUR) usage

zero cannot be interpreted as implying that there is no relationship between the two variables. It does not, however, suggest that a significant linear association exists between the variables. In this case, all correlation coefficients estimated between output and inputs have very low values. In addition, the correlation coefficients of output-land, output-irrigation labor and output-tractor hours have unexpected negative signs.

Scatter Diagram: To obtain further insights about the linear relationship between the variables and to present possible outlyers among the observations, an attempt is made to graph each independent variable against the dependent variable. As shown in Figures 1 through 4, the plot of the output per hectare versus each one of the variables shows no obvious trends. In Figure 1, the scatter diagram shows that the average yield per hectare shifts vertically from lower levels of eight quintals per hectare to higher levels of 10, 12, 18, 24 and 32 quintals per hectare irrespective of the amount of land used. This could be explained if those higher levels of yield per hectare were associated with higher input usage (i.e., higher labor, tractor hours and irrigation inputs). However, this does not appear to be the case.

The other three figures show that irrespective of the level of input use, the output per hectare shifts upwards. For example, with lower levels of input use such as 32 man-days per hectare of weeding labor, zero tractor hours per hectare and 2 man-days of irrigation labor, the average yield increases from lower levels to higher levels. Similarly, at higher levels of inputs used the average yield of maize

increases independently. This means the input-use rates as measured in the survey do not explain the level of maize output. In other words, the outputs and inputs used in the production of maize appear to be completely unrelated. This has been confirmed by the extremely low R-square (adjusted) estimated in the regression analysis. This suggests inaccuracies in the data collected rather than an economic reality of the small farmers in the LSHR of Somalia.

Critique of the Data

After the data were analyzed, the accuracy of the data were questioned. Further examination revealed certain errors in measurement in the data. A few possible causes of the measurement bias in data recording will be presented here and a more detailed discussion of the data collection methods will be presented in Chapter IV.

Coverage: The data do not cover the whole farm's activities. While the data cover the Gu season, they do not cover the activities of the Der season. Also, farmers grow more than one crop. While the data record the production activities of maize crop, data on other crops are not recorded. Another problem is that all six villages were purposely (non-randomly) selected from the villages in the irrigated agricultural area of the region. In addition, all of the selected villages had field extension workers who were used as interviewers, and that may have introduced a systematic enumeration bias. So, this procedure may give results that are not generally applicable to the region. The coverage of the data in terms of data required, as well as the statistical representativeness of the population, are discussed

in Chapter IV.

Questionnaire Design: Questionnaire design has a very important role in eliciting objective information from the farmer. Important aspects to be considered in developing a questionnaire are wording, phrasing and terms of reference. In the LSHR survey several questionnaire-design problems may have led to data-recording errors.

First, questions were asked in terms of averages, such as average yield and average input use. Farmers do not use the concept of average, instead they know their outputs in terms of total product harvested from a plot and their inputs in terms of total amount used on a plot. In a pre-survey test, average data may be requested to get an idea of the farming systems of an area; but in a formal survey, averages are calculated from the raw data collected. The questionnaire should be designed for the farmers in such a way that it asks questions in terms and units that the farmer understands and can answer.

Secondly, questions were not focused on a specific period of time. This may create a great deal of ambiguity in interpretation and farmers may give wrong information to avoid silence and embarrassment.

Thirdly, units of weight used in the questionnaire were standard international units, kilograms. Farmers in the survey area use volume measurements such as sacks and drums. So it was not clear how enumerators converted local measures of weight and volume into standard units. Lack of uniform conversion ratios may have resulted in errors.

Measurement Errors: The measurement error comes either from a poor questionnaire design or from lack of recollection by farmers.

Information on labor use in this survey is not complete because of either of those reasons or both. The information given by the survey on weeding-labor use is 16 man-days per hectare, which is the same for all 115 observations. This happened because farmers hire labor on a contract basis and 16 man-days per hectare is the average figure used in the labor market. This may reflect the hired labor, but not the family labor input. To make this point clear, let us take an example. A farmer who has plowed and planted two hectares of land may have faced a shortage of family labor and cash during mid-season. Thus, he may have been able to cultivate only 1.5 hectares. This farmer may still respond that his weeding labor input is 16 man-days per hectare because he is referring to hired labor but not to his family labor. In this case, the actual labor input use is much less than reported.

Another example is that a farmer who has three hectares of land may have plowed two hectares by tractor and the remaining one hectare by hand. This farmer responds that he used three tractor hours per hectare, refering to the two hectares but not to the total land cultivated which, obviously, will reduce the intensity of tractor use in this case.

Another measurement problem lies in the nature of the data. Farmers may not recall continuous data, like labor. This problem will be further elaborated in Chapter IV.

Enumerator Bias: The interviewers (enumerators) may be a source of data bias for several reasons. First, interviewers who have worked in the area as extension workers may be biased towards the practices recommended by the Extension Service. Secondly,

interviewers may have expectations based on their knowledge of the area and, thus, may guide farmers to give information similar to what they expect. Thirdly, because of inexperience, interviewers may be unable to establish confidence with interviewees which then leads to lack of collaboration. Finally, personal character, i.e., responsibility and morale of the interviewer, may affect the reliability of the data.

CHAPTER IV

DATA COLLECTION METHODS

Data collection in small-holder agriculture is important for gaining an understanding of what the farmers do, how and why they do it. A wide variety of government projects are implemented in developing countries in order to enhance the productivity of farm households and/or to achieve other desired policy goals. Data on farm and farmer activities, as well as the surrounding environment, are essential to carry out microeconomic research. Such research provides the basis for understanding small-farm decision behavior and responses to government programs. With this understanding, it should be possible to make better decisions on micro- and macroproblems in agricultural development.

Macroproblems are the concerns of the policy makers at the national level, who want to allocate limited public resources to alternative government projects such as research, extension and irrigation in order to achieve specified goals. The microproblems are the concerns of agencies dealing with specific aspects of the farmers' problems such as local research centers and extension service. Research workers may be interested in developing an improved technology acceptable to a target group of homogenous farmers. Extension workers may need to know the characteristics of farmers of a certain area to plan an appropriate extension program. The distinction between macro- and microproblems facing the agencies involved in agricultural development is not the issue. Each agency faces both macro- and microproblems during the course of its work. As

discussed in Chapter I and II, data on farm-households' production, consumption, expenditure and other exogenous variables play a very important role in the choice of an effective and efficient agricultural-development plan and policy program. Development policy questions, including increase in welfare of farm families, increase of foreign and domestic sales, and food self-sufficiency can be addressed through microeconomic research using farm data. Reliability of data may be questioned for various reasons.

Questions that arise from the analysis of the survey data of the Lower Shebelle Region (LSHR) concern:

1. Coverage of the data,
2. Questionnaire design,
3. Measurement error, and
4. Enumerator bias.

Problems in the data may influence the results of the survey or may make them unusable for scientific analysis and without value for drawing conclusions about the population. These problems and ways for dealing with them are discussed in the following sections.

Coverge of Data

It has been pointed out that the survey of the Lower Shebelle Region had inadequate coverage in two aspects. First, all farm enterprises and their related input/output data were not fully recorded. Second, the seasonality of farming in that region was not reflected in the data.

In general terms, the extent of data coverage required is dictated by the types of studies to be carried out. Examples of the

common microeconomic research are discussed in Chapter II. These types of research, therefore, determine the types of data to be covered and the methods used for data collection, as well as the geographical boundaries of the population under study.

Types of Data and Methods used for Data Collection

Secondary Data: Secondary data provide the basic information of the farm environment which comprises physical, biological, social and economical settings.

Physical data include climate, water and land (slopes, soil fertility and type, dry land or irrigated). Biological factors that affect farm-production activities are types of crops and animals, insects, diseases, birds and weeds. For example, Kulea birds present an abiding threat to the rice and sorghum farmers in Somalia.

Physical and biological factors surrounding the farming interprise may partly explain the degree of risk involved in farming and the management problems faced in a risky business. Usually, records of long periods of time are preferred to analyze the risk problem.

Data on social factors typically describe norms and customs related to land ownership and use, division of labor within the society of the family, rights and obligations according to sex and age groups, descent and inheritance systems and other customs and norms.

The economic factors that influence farmers' decisions include access to market, availability and cost of credit, transportation and communication infra-structure and the pricing system as reflected in

both output and input markets. The farmer chooses an optimum combination of resources on the production surface under each combination of relative factor costs and output prices.

Secondary data are gathered from various sources including national censuses, national archives, reports of the village heads, credit offices, local extension services and irrigation and production offices. Other sources are research reports, university research studies, agricultural studies and publications from the private sector.

Primary Data: Primary data are the first-hand production (input/output relationship), consumption, income and expenditure data that are collected from farmers through informal and formal methods. The informal methods are casual interviews and/or unstructured surveys and direct observations.

The Informal Survey: The objectives of the informal survey (also called reconnaissance survey, exploratory survey, and sondeo [in Spanish]) are to develop a rapid understanding of farm circumstances through direct informal interaction between researchers and farmers (Franzel). This technique is a rapid and less costly way of acquiring information where time, money, and personnel are limiting factors. The informal survey is very important in the initial understanding of the area under study.

Informal surveys help the researcher to properly design a formal survey. As the researchers get acquainted with the farmer and his environment, they will learn his words, his production systems, his units of measurement and wordings that may be insensitive to local customs. Collinson (Kearl) states that the reconnaissance survey

allows us to determine the characteristics of attributes and to outline general aspects of each data category known to be important to the format of the survey questionnaire. Shaner, Philipp and Schmehl mentioned that informal surveys help to determine the type and size of the sample for formal surveys.

Informal surveys establish the characteristics of the farmers and aid the researcher in stratifying the population into more homogenous groups based on the differential agroclimatic zones, subregions, scale of production and limiting resources. The reconnaissance survey will explore any pattern of events that may be important in farmers' decisions.

Informal surveys are less demanding of time and other resources and, therefore, may cover a larger number of respondents. This approach is increasingly favored because of its low cost and advantage of completing a study within a few months (Upton).

When the objective of a survey is development of technology adaptable to the farming system of a target group, the informal survey will help the researchers to establish appropriate research objectives and methods.

In the informal survey, researchers arrange meetings with the key informants who are willing to participate in discussions. Typical key informants are village/community heads, progressive farmers, merchants, extension workers, bankers, landlords, government officials and suppliers of inputs. These discussions cover a wide range of topics such as crops, marketing, credit and other agricultural problems.

Farmer interviews are also used in the informal survey. Farmers are asked questions without using any formal questionnaire. Robert E. Rhoades (Jones and Wallace) has identified four stages in interviewing farmers, the warm-up, the dialogue, the departure and recording of information. The warm-up refers to the establishment of a respectable relationship with the farmer. As an intruder, the researcher avoids manners that may create an unpleasant situation, thus affecting the farmer's collaboration. It is important to explain very clearly the purpose of the survey, the agency taking it and how the information gathered may have direct benefit for his family or village. If there are risks or unresolved questions from the perspective of either the interviewer or the respondent, they should be fully communicated.

The dialogue is the discussion of questions and answers between the researcher and the farmer. Questions must be asked in a natural and relaxed manner, so the farmer feels comfortable. Sensitive issues such as income and expenditures are usually avoided until the end of the discussion. The researcher tries to keep his inquiries simple and understandable while at the same time extracting as much useful information as possible without undue imposition on the farmer's time. After major topics are covered, the researcher should attempt to depart on a positive note with a reiteration of what and when to expect any additional communications, pictures or followup. The information is recorded either during the discussion or after the departure. If notes are taken during the discussion, the researcher needs to make sure that the farmer understands what is being recorded and has no reservations about it. If data are to be recorded after the departure, it must be done very quickly to avoid inadvertant

mixing of responses and erosion of significant details.

In the farming systems research literature, an approach called "sondeo" is commonly found. This approach relies on a multidisciplinary team effort for conducting informal surveys. In this approach, team effort is emphasized because the main objective is to identify researchable problems and to understand them from the farmers' perspective. The purpose of the sondeo is to provide the information required to orient the work of the technical research-generating team (Hildebrand 1986). The team members consist of an economist, an agronomist and an anthropologist. Other specialists such as plant protection specialists, engineers and sociologists may also be included depending on the subjects being examined. The task is to identify research objectives and methods that will ensure research products which are more applicable to the farmer's conditions.

Hildebrand noted three characteristics that are critical to an efficient and functioning multidisciplinary effort. First, the members must be well-trained in their own field. Second, they need a working understanding of one or more other fields. Third, all members of the team should view the final product as a joint effort in which all have participated and for which all are equally responsible. The final product should lead to improved technology which can be successfully adopted for the benefit of the target group. The sondeo procedure, as Hildebrand (1981) described, takes a short time (six to ten days), and the outcome of the survey is a report used to orient the research program.

The Formal Methods: The formal methods frequently used in data

collection are structure of surveys and farm-record keeping. The formal survey is the major method used to collect primary data in agricultural economics research. Formal surveys provide quantitative data that can be subjected to statistical analysis. Formal surveys can be either focused to a specific group of producing units or expanded to a larger population and wider area. The first type of survey, which forms on a specific group, are most often designed to study production and consumption systems, resource limitations and how farmers allocate resources to achieve production and consumption goals. Farm-management and farm-budget surveys are typical examples. The second type of formal survey is a baseline in sector level effort in which data are collected on a wider scale. The objective of a baseline survey is to provide benchmark data describing the farm structure in terms of resources and organization; to determine production, yield and income, and to obtain information on input/output and production/consumption relationships.

The information obtained from a baseline survey is essential to support more general types of economic analysis including systems of projects, regions and sectors. Policy analysis using household models or sector models, which require a massive set of data, usually require baseline surveys. Data collected in baseline surveys and those gathered in farm-management and farm-budget surveys are not mutually exclusive. Instead, this distinction points out the different levels of data coverage required.

Farm record-keeping is a data-collection technique that can be used in an area where farmers are able and willing to keep all their farm activities in a daily record. This method is discussed in a

section below.

Population Coverage of Data

The geographical coverage of the population under study may vary depending on the objectives of the research. The population under study may be a small group of farmers in a few settlements or villages in a region, the whole farm population in a region or the regional or national agricultural sector.

For example, the survey in the Lower Shebelle Region was confined to the irrigated areas. Dryland farms were excluded. Another exclusion was the villages where the extension service didn't have field workers. All of the six villages in the survey had field extension workers. A random selection process was sacrificed to avoid duplication of work by several agencies. Those agencies were, at the time, working in liason with the regional extension service and were the research institute conducting on-farm trails, the Somali Commercial and Savings Bank providing in-kind credit to small holders, the FAO Fertilizer Program conducting fertilizer and providing credit on fertilizer, and the National Extension Service which was responsible for the LSHR-survey and also conducted on-farm trials.

The fact that the villages selected were confined to those where the extension service operated may have introduced a bias towards the adoption of new technology. Reported yields and incomes may have been higher than in other villages because it is expected that higher adoption rates for improved varieties and technology occur in villages where extension workers are stationed.

The population under study has to be defined in the light of

research objectives and the extent of generality required in using the research results. In any case, it is impractical and costly to interview all individuals of the population. A sampling procedure is required to assure that a statistically representative sample is drawn which removes redundancy and maximizes the reliability of coverage.

Sampling: Before any survey is implemented, a reliable sampling procedure should be chosen. Sampling is a process of selecting a representative number of individuals from the population under study. Because of practical limitations regarding time, cost and staff, it is not possible to study the whole population. The data collected from a representative sample will enable the researcher to make scientific statements about the population in general. Sampling methods of household agriculture have been discussed by Shaner, Philipp and Schmehl; Upton; Kearl and others.

There are random and non-random sampling methods. In random sampling, each individual in the population has the same probability of being selected. There are four random sampling methods, which include simple random sampling, systematic ordered sampling, stratified random sampling and cluster sampling.

Simple Random Sampling: In a simple random sampling, the researcher uses population lists to establish a sampling frame. In rural areas there are various types of lists, such as village head lists, tax lists, land registration lists and cooperative lists. Sometimes these lists are incomplete and/or outdated. Collinson (Kearl) also reported cases where the lists were biased upwards. Thus, care should be exercised to prepare an adequate sampling frame

from those lists. In cases where lists don't exist, lists of households in each village under study are prepared with the help of the local community administration. This procedure was used by O. Guceliogl u (Kearl) in conducting a survey of Kenyan farmers. Starting with the population list, the units in the population are numbered from 1 to N. Random numbers are then used to select every unit of the sample from the population list. The procedure of using random numbers to select a simple random sample, as Anderson, Sweeney and Williams outlined, is found in most sampling and applied statistics textbooks.

Systematic Ordered Sampling: For a systematic ordered sample, researchers start with a random number on the list and then take every Kth unit on the list (Shaner, Philipp and Schmehl). In that case, if the researchers want to draw a sample of 30 farmers from a population of 600 farmers, the population size is divided by the desired sample size to get the sampling interval, K. In this case, $K = \frac{600}{30} = 20$, a number between one and twenty is then selected, say twelve. The farmer number of twelve is selected from the list and then every 20th farmer is selected until the sample size is complete. Systematic random sampling is usually preferred because it is quicker and easier than selection by simple random procedures. But if the units to be sampled are not randomly listed, this procedure will not give a representative sample. For example, a list ranking farmers according to farm size will produce a biased sample. Systematic ordered sampling was used in the Lower Shebelle Region (LSHR).

Stratified Random Sampling: Stratified random sampling is the process of dividing the population into groups, called strata,

containing relatively homogenous units and then taking separate random samples from each strata. The main objective of the stratification is to obtain homogenous farmers within each strata so that the variances are minimized, and so that relatively small random samples can be drawn from each strata with the required degree of accuracy. Tollens (Kearl) suggested several characteristics on the basis of which the population can be stratified. These include climate, soil type, crop production systems, farm size, sex, age and distance from the market.

Cluster Sampling: In cluster sampling the population is first divided into clusters or villages. A sample of villages is randomly selected from the total number of villages/clusters. A random sample of households is then taken from the list of all households in each chosen village. Cluster sampling will give good results if each cluster includes the full range of variability for the data being gathered. In the ideal case, each cluster is a representative small-scale version of the entire population (Anderson, Sweeney and Williams). Tollens (Kearl) points out that in household agriculture where the use of capital is modest and, thus, wide intervillage variations do not exist, representative villages can be chosen in a non-random way. Cluster sampling is usually cost-saving because the interviewer's travel time is reduced. Upton mentioned two cases where cluster sampling is particularly useful: (1) where there is no population list to serve as a sample frame, and (2) where there are large dispersed populations or where communications are difficult.

In a population where there is no sampling frame, multi-stage sampling is used. Multi-stage random sampling consists of a

consequent random sampling step starting from a large scale such as a nation or a district, and ending at the smaller units such as villages and farms. The population is first divided into groups from which a sample is randomly selected. Each selected group is then divided into subgroups from which a sample of subgroups is taken. This continues down the hierarchy until the sample of data collection units are selected.

Most of the field inquiries in the agricultural sector of developing countries have been based on multi-stage samples (Upton). J. Ascroft (Kearl) has used aerial photographs to make groupings for selection of a multi-stage sample in Kenyan agriculture.

Non-Random Sampling: In addition to random sampling methods discussed above, there are non-random selection methods. Non-random sampling, also called non-probability sampling, is a process of selecting a sample either by accidental (whomever encountered), or by purposeful choice of individuals on the basis of subjective judgment. This procedure will only by chance provide a representative sample. If non-random sampling is used, researchers have no way of knowing whether the individuals interviewed represent the population being studied (Shaner, Philipp and Schmehl). The disadvantage of this approach is that one cannot make conclusions about the population.

Questionnaire Design

Questionnaire design is an important factor that may affect the validity of data. When developing a questionnaire, important points include the following:

1. Pre-survey investigation.

2. Terms of reference used.

3. Language of the questionnaire.

4. Pretesting of the questionnaire.

A careful incorporation of these points will strengthen the data-collection instrument and should assure gathering more reliable information. In the LSHR survey, a fuller recognition of these points may have produced a more adequate questionnaire and the data collected may have had greater practical use for small-holder microeconomic research.

A general understanding of the farmer and his environment acquired during the informal survey should be utilized. This understanding will sharpen the focus and structure of the questionnaire. Collinson described the pre-survey requirements for attributes such as land, labor and capital, which are important to consider in the survey. These requirements include a decision on sample size, aspects of each variable that are important to record, and renumeration of the questions for each variable to remove possible confusion and gather more useful information. For example, in the LSHR farmers weed their fields two to three times in a season. Data on labor use in weeding can be obtained by asking the farmer how much labor he or she used in first, second, and third weedings. A general question on labor use in weeding is too vague, leaving the respondent confused and guessing, and introduces noise into the data set.

The terms of reference (i.e., reference period and unit of measurement) in the questionnaire must be very specific and those used and understood by the farmers. A reference period which is not clearly defined as being a year, a season or a month, will cause

errors. For example, in the LSHR survey, farmers were asked what their average input use data for maize was without referring to a specific season. Farmers' responses, therefore, can not be relied upon to reflect the actual inputs used. Input usage is determined by management decisions which are seasonal and based on the farmers' bio-physical, political and economic environment. Instead, farmers may be confused due to the ambiguity of the question or give stereotyped answers. For example, in the LSHR survey all respondents reported that their weeding labor use was 16 man-days per hectare. In order to obtain a reliable response, the farmer must be reminded that the data requested refers to one specific season, such as the Gu season 1985.

Likewise, the data must refer to a specific plot and crop. If the enumerator and respondent go to a plot for which data are to be recorded, the respondent refreshes his recall and his responses will be more accurate. In small-holder agriculture, farmers usually own two or more separate farm plots. If a question is not plot-specific, the farmer may refer only to a part of a plot or to one of several plots. So, the questionnaire must be designed to collect data from each separate plot. A failure to set up the particular field as point of reference will introduce different interpretations of the respondents' answers.

Another important term of reference is the units of measurement. Usually, the local units of measure and the standard units of measure that are used in the analysis are different. Questions must be posed in a form which allows the farmer to respond in units of measure which

he understands and uses. For example, farmers in the LSHR use bags, tins, drums and other containers of varying volumes to measure their produce while questions were asked in kilograms per hectare. Volume/weight conversion ratios should be prepared on a formal sampling basis to the required level of accuracy. These conversion ratios must be used in all questionnaires to estimate the standard units.

The local language must be used in the questionnaire. In case the questionnaire is initially prepared in a foreign language, careful translation of the questionnaire must be made to ensure that the content of the questions does not change. As T. B. Kabwegyere (Kearl) mentioned, literal translation may distort the meaning of the questionnaire and, therefore, it should be avoided. Back and forth translation by different people may be done until the translation is consistently equivalent to the original questionnaire. Finally, questions should be organized into sections in such as way that the questionnaire has a logical follow-up, starting with simple and more general questions, to the more specific and sensitive ones.

The questionnaire should be tested by interviewing farmers and checked to see if the required information can be obtained. Pre-testing is of special importance in formal surveys. The attitude of the farmer and the confusion of the interviewer and interviewee will make clear the points at which problems are occurring. Both the interviewer and the interviewee may provide suggestions on easier and more understandable ways of asking the questions without changing their meaning. The questionnaire, then, may be revised and modified to best suit the situation. The time taken by each interview, which

is important for planning purposes, may also be determined.

Measurement Error

The technique used in the LSHR survey was a one-shot survey where enumerators visited each respondent only one time and all the data were based on the farmer's recollection. Accuracy of the data collected depends on farmer's recollection. Farmers are not literate and most do not have records for reference. Farmers' recall depends on the nature of the data questioned. Any failure of the farmer to recall past events will result in data errors. In order to understand the nature of measurement error in a formal survey, first it is necessary to look at the techniques used in collecting the data. There are three techniques used in data collection in formal surveys, single-visit technique, frequent-visit technique and farm record-keeping. Measurement errors involved in each technique depend on the type of data collected. For example, the one-shot or single-visit survey has difficulties in recording the seasonality of labor and will likely have a high measurement error for continuous variables such as labor, while frequent visits by enumerators are able to capture the seasonality of labor use and to control measurement error on the flow (input/output) data (Eicher and Baker).

Secondly, it is important to identify the characteristics of the events whose data are to be recorded. Events are classified as "single point" and "continuous" (Upton). Single-point data are those that occur over a short period of time, like land tenure, while continuous data are those that have a longer duration. Each of those events is further divided into registered and non-registered.

Registered data are those which occur through transaction mechanisms so they have a distinct and vivid recollection (hired labor and purchased inputs fall in this category). While in the non-registered data, no transaction is involved so it is very easy to forget (family labor and consumption are examples).

Another data distinction made by Collinson is between frequent and regular occurrence, and data with frequent and irregular occurrence. The farmer establishes an experience with the frequent and regular events, like the number of weedings. But the frequent and irregular events, like number of laborers used in each weeding, may not be remembered.

Single-Visit Technique

The single-visit technique has been used in the survey data of the LSHR. In a single-visit survey the farmer is visited once and most of the information is based on recall. This technique is used to collect data that may not be affected by lack of recollection. Those include data on family characteristics like family size, sex, age, education, literacy, and other factors such as beliefs, knowledge about outside institutions, attitudes and motives that affect the farmers' goals. Other sets of data that can be collected by a single-visit technique are data that do not change frequently, like land tenure, farm size, stocks of animals, tree crops and machines. Single-visit interviews are also used to collect data that occur rarely like planting time and harvesting time. The advantage of the single-visit survey is that it is the least costly of the formal methods per unit of usable information, and it takes the least amount

of the farmer's time than any other formal data collection method (Shaner, Philipp and Schmehl). The single-visit technique, however, as demonstrated by the LSHR survey, cannot give good results on continuous data or data that occur frequently and, thus, require a more detailed recording. These are the data the farmer may not be able to recall, such as inputs used in each operation and each time for all crop activities.

Frequent-Visit Survey

The problem of memory bias is a major concern in the validity of data. It is obvious that farmers may not recall events that occur frequently, and the validity of data on those events depends on the degree of dependence on farmers' recollection. Frequent visiting is necessary to reduce the dependence on memory. The frequency of visits depends on the topics, the degree of accuracy required and the funds available (Shaner, Philipp and Schmehl). Generally, one to three times weekly during applicable season or seasons of the year are necessary (Eicher and Baker). The kinds of data that require frequent visiting are discussed below.

Data on Crop Acreage: Farmers may have a precise idea of the area of land they farm, so it seems easy to get land data either by asking the farmer or by direct measurement. But as the characteristics of land become more complex due to increasing cropping intensity, mixed cropping, crop rotation, multiple-cropping and continuous cropping due to overlapping of seasons, a more careful inquiry is needed. Collinson points out that in areas where double-cropping is practiced without distinct plot boundaries, single-visit

surveys are ruled out because each phase of crop establishment must be covered while the plot pattern can be identified on the ground. The Lower Shebelle Region of Somalia is a typical example. There are two cropping seasons, the Gu and the Der. Farmers grow maize and sesame as major crops and several vegetables and legume crops as minor crops for home consumption. A minimum of two visits may be required to acquire data on crop-acreage measurement and possibly more if it is important to discover differences between planted and harvested areas.

Data on Labor: It has already been mentioned that data on labor of the family is divided into sex and age and can be obtained by a single-visit survey. Labor use is the most crucial information that requires a detailed recording. Labor is used in three areas, crop enterprise, outside commitment and non-agricultural activities. In each use the labor data must cover a specific activity (off-farm employment, school, crop activity, domestic care, fishing), amount of labor used (number of labor, number of days, length of day), and timing (what time of the year or what time of the cropping season). Labor used in each activity has to be classified into sex and age. Man-equivalent values as a base for comparing the labor capacity of different categories has to be recorded. In the case where one crop activity has a sequence of operations, like three weedings and two or more irrigations, the data sequence and amount of labor used at each time must be recorded. The wage rate and mode of payment for off-farm employment is also required. Use of hired labor is also recorded considering the type (permanent, seasonal and causual), activity, duration of employment, timing and wages.

Other Inputs: The detail of data required in all other inputs, irrigation, chemicals used, and seeds, is similar to that of labor. For each input, data on acreage of crop applied, the operational sequence for each crop, the timing of the sequence and the rate of application of the input must be noted.

Data on Income and Expenditure: Data on income and expenditure are usually sensitive in peasant agriculture because of tax avoidance or other traditional beliefs, so farmers may be unwilling to uncover this essential information until the enumerator establishes good rapport with them. Household budget studies usually cover most of the data on income and expenditure. Family income and sources are recorded for the whole year. Sales of produce (crops, livestock, crop and livestock residue), time of sales, prices and market destinations are needed. Family expenses on purchases of farm inputs, food, and other goods, prices and time of these purchases are also important.

Farm Record-Keeping

Farm record-keeping is also used to collect data that are easily forgotten. This technique is more difficult to implement in areas where high levels of illiteracy exist, which is the case for most rural areas. In Somalia, the illiteracy campaign and the adult-education program may have reduced the illiteracy rate in rural areas. Shaner, Philipp and Schmehl suggest that literate members of the family, like school children, can be used. This approach is very useful in recording good data on the events that occur frequently and are easily forgotten like consumption expenditure, input use, labor use, etc.

Measurement Accuracy -
Sample Size Trade Off

As described above, single-visit and frequent-visit techniques of data collection are polar approaches regarding the number of times to visit the respondent. On the one hand, the single-visit technique is inadequate to collect the information essential for a detailed quantitative analysis of the economic systems in peasant agriculture, but it is cheaper and faster. On the other hand, the frequent-visit technique increases the accuracy of data per farmer, but it is expensive, time consuming, and puts a heavy burden on the respondents. The criteria for choosing either technique depends on the following factors:

1. Complexity of the farming systems in the area under study.
2. Availability of financial resources.
3. Type and level of accuracy required.

Complexity of the farming system affects the survey technique. For example, in an area where there is only one cropping season, a single-visit survey may be used without great measurement error. But in an area where multiple cropping is practiced, or there is overlapping of seasons, a continuous recording of the data in a complete cycle is necessary.

Financial resources are an important factor in determining the survey technique chosen, because the techniques are not alike in their costs. In a frequent-visit survey, the sample size will be reduced and, hence, increase sampling error. In order to minimize the sampling error, one has to increase the sample size. Collinson (Kearl) showed that a standard error of 10 percent can be obtained

from a sample size of 100 farmers with a cost of 1:6 in using the single-visit versus frequent-visit technique. To reduce 25 percent of the standard error (down to 7.5) will require an increase of 45 percent and 62 percent of the costs of single-visit and frequent-visit techniques, respectively. In another study, Collinson states that costs per area covered of a program based on daily-visit data collection will be about four times that of a program based on single-visit collection.

The above discussion suggests the kind of trade-off to be weighed between survey costs and data accuracy. Collinson emphasizes that the number of visits can be limited to a few important times if the researcher makes an effective "pre-survey investigation" that enables him to understand the complexity of systems and all aspects of the attributes that need to be analyzed. The author believes that if a proper enumeration of the data is made, the limited-visit survey technique can be very useful in collecting the continuous data. The exact number of visits required depends on each specific area and study, but the researcher needs to choose the number of visits under a constrained budget and under the pressure of collecting data within an acceptable level of accuracy.

Finally, in the LSHR of Somalia, where there is double-cropping, continuous cropping of perennial crops (bananas, citrus, and coconuts) and sometimes an overlapping of activities, the single-visit survey technique has very little chance of collecting reliable data. At least two visits to collect data for the two seasons may be required at minimum.

Enumerator's Bias

Enumerators play the most important role in the implementation of the survey. In the Lower Shebelle Region (LSHR) survey, the Field Extension Agents (FEAs) were used as enumerators. Each FEA was assigned to the village where he worked as an extension agent. In this case, farmers may have been unwilling to give responses different from what the interviewer had recommended. Even if farmers do so, the FEA may be reluctant to record data that is not in accordance with Extension recommendations. Otherwise, the FEA feels that he is negatively reporting against his own work.

It was my experience, as a Regional Extension Officer in the area at the time of the survey, that it was difficult to get unbiased information on farm-management practices from the FEAs. If the FEAs report farm-management practices as different from the Extension recommendations, usually they feel that this may be translated as ineffectiveness of their extension/teaching efforts. So, the data collected by the FEAs from their own working circles were likely to be vertically biased. It must be noted that extension agents have great advantage in their knowledge of the area and subject matter, and their relationship with the potential respondents could be very important in the design and organization of the survey questionnaire.

Another source of enumerator bias may be due to an assumption of lack of variation after interviewing five or six farmers. The remainder of the questionnaire is then filled by the answers of those farmers. The enumerator may also inadvertantly encourage the farmer to give an answer close to what is given by other respondents. The

problem of low morale may also lead to irresponsibility and invalidity of the data.

Those problems can be reduced by hiring enumerators independent of the Regional Extension Service, by using realistic selection criteria in hiring them, by training the enumerators before the survey begins, by making close supervision and by checking a selection of completed questionnaires at an early point in the enumeration process.

There are various criteria that should be considered in hiring enumerators. Among these criteria are education, language, personality and behavior. Enumerators must at least know writing, reading and basic arithmetic. An eighth grade to senior high school education is suitable. The result of the survey is determined by how effectively the enumerators communicate with the farmers. Any language barrier creates a communication gap that will affect the survey and it must be avoided.

The enumerator's personality and behavior are important elements for establishing good relationships with farmers. It may not be easy for young people without experience in a rural environment and culture to perform very well in the sometimes harsh unfamiliar rural conditions. Some problems may be obviated if enumerators are hired from the local population. However, to do so may increase the effort devoted to training. In any case, enumerators have to be trained. The importance of training enumerators has been emphasized by many authors. Among them are Ogunfowora, Flinn, and the Beirut Seminar Working Group in Kearl. The training consists of classwork and field work. In the class, topics like calculations and objectives of the survey, are taught. In the field, using the measurement instruments,

taking field samples, filling in questionnaires and ways of approaching farmers are instructed.

Collinson suggested that permanent units of enumerators are better because temporary workers introduce a new dimension of error arising from inexperience. A permanent team also reduces supervision requirements. However, supervision is an essential part of the survey. Through supervision, the quality of the work can be controlled and the morale of the enumerators be maintained. Supervisors may visit regularly with the enumerators in order to evaluate local conditions, to encourage high morale among them and most importantly, to help the enumerators to solve new problems when they are encountered. It is suggested that a field manual be prepared for the enumerators so that they may refer to it for problem resolutions. Where supervisory resources are very limited, one or two unannounced supervisory visits in the early stages of the survey may provide backup and a somewhat stronger incentive for producing a reliable product.

CHAPTER V

SUMMARY AND CONCLUSION

Summary

The objective of this thesis is twofold: to identify problems of data collection in small-holder agriculture and to elaborate the role of data in supporting research and rationalization of alternative strategies in sustaining agricultural development.

Agricultural development substantially contributes to a nation's economic growth and it is critical for industrialization and sustained economic growth. Several agricultural development strategies have evolved over the last two decades. However, the "high-payoff" model appears to have created the most dramatic developmental result on agricultural production in Asian and Latin American countries such as India, the Philippines, Korea, Taiwan and Mexico.

However, there is no research evidence to support the success of such a model in the growth of agricultural production in Sub-Saharan Africa (Eicher and Baker). Applicability and adaptability of modern technology to resource-limited small-holder farmers have been questioned (Byerlee, Harrington and Winkelman). Great interest has been expressed in further research with the objective of better understanding small-farm agriculture. This understanding entails meticulous microeconomic studies of areas where few data are available and many questions remain unanswered.

Microeconomic research of agricultural households and their bio-physical, political and economic environments is essential to providing the empirical basis for an acceptable specification of the agricultural sector. Such specification will, at least theoretically, be used to formulate agricultural development plans and policy programs. The policy programs may include land-tenure policies, public investment in education, production and management research, expansion of extension services and physical infrastructures such as roads and irrigation facilities, and price policies such as subsidies on inputs or output floor prices for the producer and/or ceiling prices for the consumers. Those policy programs may or may not serve desired policy goals such as increases to the welfare of the farm families, ensuring self-sufficiency on food, increasing domestic and foreign exchange revenues, reducing long-term soil erosion, etc. The effects of those policy programs, both in direction and magnitude on the desired policy goals, depends on the economic behavior of the farm households depicted by the microeconomic research.

Availability of reliable data on farms and farmer activities as well as the surrounding environment is required in undertaking microeconomic research of small farmers. Because the small-farm households act as unit firms maximizing welfare and the complexity of the environment under which they decide production, consumption and saving patterns, the task of gathering accurate and complete data is not an easy one.

Somalia, one of the world's least developed countries, has a greatly under-developed agricultural sector. Agricultural productivity is low and it is not growing in any significant way.

Food production per capita in 1982-84 was 69 percent of that in 1974-76 (World Bank). Thus, the country continuously faces a serious food shortage which in times past has been resolved on a temporary basis by food imports and food aid.

Agricultural data in Somalia are extremely scarce and inconsistent in their coverage and reliability across various agencies. The accuracy of the data, even when available, is questioned. One important reason for this deficiency is the absence of a farm-management unit with long-term responsibility for collecting and maintaining the agricultural data base. In conducting farm-management and production surveys or baseline-data surveys, it is important to identify the types of data to be collected and then decide the most appropriate technique that can assure the collection of accurate data.

Survey data collected from samples in six villages of the LSHR of Somalia was analyzed. The survey was a part of the applied research component of the Agricultural Extension Farm Management and Training Project (AFMET) conducted in the Gu season of 1985.

The descriptive analysis, using cross-tabulation of the data, gives some useful insights into the farming systems in the area. For example, some of the averages of selected variables calculated in the sample are an average family size of eight people, average landholdings of 3.75 hectare, average weeding labor use of 43.13 man-days per hectare, average irrigation labor of 3.75 man-days per hectare, average of 3.37 tractor hours per hectare used for tillage operations and an average yield of 16.63 quintals per hectare.

Differences and similarities across the villages were analyzed and reported in Chapter III.

The survey data were also subjected to formal analysis using statistical regression to estimate a Cobb-Douglas production function for maize. Production-function analysis was attempted to estimate the functional relationship between output (maize) and inputs used, and to test certain hypotheses regarding resource use and allocation in small farms of the LSHR. The results of the regression anaysis would not allow us to make any useful inferences from the data. The survey data failed to depict in a significant way any relationship between the output of maize and the inputs used.

These unexpected results arising from the production-function analysis and a further examination of the data raised questions concerning the accuracy and completeness of the survey. It was discovered that the data have serious deficiencies and measurement errors. Those errors were mainly due to a questionnaire design, i.e., the ability to ask the correct questions to the farmer and to place questions in a form that were understandable to him. There is also the possibility that the technique used in conducting the survey may have diminished its accuracy. The survey technique used was "one-shot" sampling. This technique cannot be relied upon to gather accurate information on flow (input/output) data.

This thesis demonstrates that the choice of data-collection technique may importantly influence survey results. Survey-design issues which may influence survey results include:

1. Selection of the sampling frame.
2. Procedures used for gaining knowledge of local farming

practices in order to design the questionnaires (pre-survey investigation).

3. Approaches for securing support and cooperation of interviewees.

4. Degree of dependency on farmer's recall for collecting information on continuous data such as labor and farm inputs.

5. Use of conversion ratios to change data from traditional units to standard units.

6. Methods for gathering information about sensitive issues such as ownership of landholdings, livestock, buildings, and credit.

7. Methods for making field-data checks to reduce inconsistencies and to verify recorded responses.

Conclusion

Based on this investigation, it is concluded that the one-shot survey technique used in the LSHR survey fails to collect the data necessary for microeconomic research. In the Lower Shebelle Region of Somalia where there is douple-cropping, overlapping crop seasons, and where different types of crop-production systems exist and both irrigated and dryland farming are engaged in by small-scale and large-scale farmers, a more rigorous sampling technique would be more appropriately used. At a minimum, a multiple-visit survey is necessary to collect a complete and accurate set of agricultural production data.

Study results also suggest how important availability of accurate data and microeconomic research on farm families is in choosing and implementing effective agricultural development plans. Development

projects and policy programs may not have been alloted enough time to carry out essential surveys, so they may be implemented without having sufficient knowledge. A premature rush to projects and development programs may result either in total failure or a disappointing effect on the desired objectives.

Therefore, it can be concluded that in order to further encourage the achievement of national agricultural development goals, there is need for a clarification of responsibility in the collection and storage of the agricultural data within the Ministry of Agriculture. Data collected and maintained may not always have an immediate use. However, as the agricultural sector expands and the nation's research capacity increases, more and more questions will be asked about the performance of the agricultural sector and its effect on other sectors of the economy. A well-managed and reliable data base is necessary to analyze those questions in order to improve management and policy decisions in the future.

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