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FARM MANAGEMENT RESEARCH IN CENTRAL ZONE OF TANZANIA - VILLAGE PROFILE

(VOLUME III)

By

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FARM MANAGEMENT RESEARCH IN CENTRAL ZONE OF TANZANIA - ESTIMATION OF PRODUCTION FUNCTION

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I. INTRODUCTION

This is the third in the series of three reports on Farm Management Research in the Central Zone, Tanzania. The first in the series was entitled "Profile on Farmers in the Central Zone, Tanzania - Descriptive Analysis" and presented the characteristic features of the farmers (see Marhatta, et. al., 1981). The second report entitled "Farm Management Research in the Central Zone of Tanzania - Village Profile" outlined the socio-economic status of the village including the level of communal production and the evaluation of factors affecting the villages (see Marhatta, et. al., 1982). In contrast, this paper supplements the first report with additional analysis of farming activities together with the estimation of production function of the Central Zone farmers.

Objectives

The overall objective of the research project was to identify significant features of the farms and villages in the Central Zone of Tanzania to assist in formulating and implementing strategies for rural development.

The specific objectives of the project were to: (1) analyze the characteristic features of production activities, (2) identify constraints to increase production and income of small farmers by estimating production functions, (3) analyze the farming system and its evalution to determine its strength as well as weaknesses.

Research Procedure

A detailed explanation of the research procedure except for the production function methodology was presented in the first report of the series entitled "Profile of Farmers in the Central Zone, Tanzania - Descriptive Analysis" (Marhatta, et. al., 1981). Therefore, in this report, methodology for the production function has been included in addition to a brief explanation of the research procedure.

Two sets of questionnaires were developed for this research: (1) a farm questionnaire to collect information about farmers and their operations, and (2) a village questionnaire to collect data on the villages. Both questionnaires were administered in Swahili and data were collected in September and October of 1980 by 20 enumerators from the Economics Research Bureau of the University of Dar es Salaam. These enumerators were supervised by faculty members from North Carolina Agricultural and Technical State University and the Economics Research Bureau.

The samples were drawn from a population consisting of farmers in the Central Zone of Tanzania. Ten districts were identified and three of them were selected as representative districts. Next, using a multi-stage sampling technique, ten villages in each of the three representative districts were selected as a first stage. Then using a random systematic sampling method, 25 families were selected in the second stage as samples. Following this procedure 31 villages and 1,412 farmers were selected for the survey (see Volume I for the name of the villages and the distribution of the samples in each village).

This report presents the estimates of production function in order to obtain the relationship between the inputs and outputs. This procedure

allows for the identification of the major resources (inputs) and their relative contribution to output.

Furthermore, this section discusses the approach used in analyzing the data and in measuring the variables. Given the output and input information, the production function will be estimated using three forms: Cobb-Douglas, linear and quadratic. Although the Cobb-Douglas production function has been widely used in agricultural research, other forms were included to evaluate the best fit and to obtain the "best" possible fit.

First, a brief outline of all three models will be presented. Next, the model utilized for the analysis will be discussed. And, finally, the specification of variables will be elaborated.

In general, the relationship between the inputs and outputs takes the form as follows:

$$Y = F(X_1, X_2, \ldots, X_n)$$

where Y = output and X_i = ith input, i = 1, 2, . . ., n. Given this general form, a linear or Cobb-Douglas or quadratic functions could be specified and estimated.

The linear form is used when all variables are assumed to have a linear relationship to output. The production function in linear model has the following form:

$$Y = a+b_1X_1+b_2X_2+\ldots+b_nX_n$$

where Y is output, X_i are inputs and B_i are the coefficients that measure the marginal productivity of inputs (relative contribution of the inputs to output). This model may not be applicable to the whole range of possible outputs as most economists do not feel that the entire range is linear. Nevertheless, over a shorter range, this model may provide a good approximation.

The Cobb-Douglas or power function is of the form:

$$Y = AX_1^{b1}X_2^{b2}\ldots X_n^{bn}$$

where Y and X_i are outputs and inputs respectively; A, which is constant at a given time, refers to the state of the art of technology; and the exponents b_i are the elasticities of output with respect to the relevant inputs, i.e., marginal productivity of inputs. Furthermore, when sum of $b_i = 1$, then a given percentage increase in all inputs will result in equal percentage increase in output. On the other hand, if the sum of elasticities is more or less than one, increases in input will increase output by a greater or smaller percentage respectively. No output is possible with any factor at zero level. This equation is estimated in logarithmic form because this form transforms the power function to a linear form and also allows for the relationship to have a constant or increasing or decreasing marginal productivity.

Lastly, the quadratic function involves the second power of one or more of the independent variables. This model, which is used when the variables are not a linear function of output, has the form as:

$$Y = a+b_1X_1+b_2X_2+ \ldots +b_1X_1^2 + \ldots +b_nX_n+bnX_n^2$$

where Y is output, X_i are inputs and b_i are the coefficients. However, in this form, b is no longer the elasticity of output and the sum of b_i does not represent the returns to scale.

This section presents a brief summary of the models and the specification of the variables. The production function has been estimated using four inputs only as follows:

a) $Y = AX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}$

b) $Y = a+b_1X_1+b_2X_2+ \ldots +b_4X_4$

c) $Y = a+b_1X_1+b_2X_2+\ldots+b_4X_4+b_5X_1^2+\ldots+b_8X_4^2$

where Y = total value of output expressed in U.S. dollars.

X_1 = total amount of labor used in production

X_2 = total acreage of land under cultivation

X_3 = value of equipment and building (capital) used in production

X_4 = information index

Due to extreme low frequency of use, other inputs such as fertilizer (manure and chemical), improved seed, insecticides, and animal or mechanical power used in farming were not included in any of the production functions.

The following is a detailed discussion of the variables used in the equation:

Total value of output (Y): refers to the total dollar value of three major crops produced by the farmers in 1979-80. This final converted value has been obtained first by multiplying the quantity of output produced in 1979-80 by the prices received by farmers, then dividing the total value of all three crops by 8.1. This coversion was based on the exchange rate of U.S. $1 = shillings 8.1. Whenever the farmers did not respond to the prices, the producer prices announced by the Ministry of Agriculture has been used (see Appendix I in Volume II).

Because of the nature of the data, an estimate of production functions by major crops was not possible.

Total amount of labor (X_1): refers to the total days of labor used for production and has been calculated by summing the actual days worked by farmers, their children, very old hired laborers and middle aged hired laborers. The first two groups consist of family labor and the remaining two groups refer to hired labor.

Consistent with Spencer and Byerlee (1977), a weight of 1.00, 0.50, 0.50 and 1.00 has been assigned to farmers, children, very old hired laborers and middle aged hired laborers respectively to reflect relative wage rates received by each group (see Review of Literature section for detailed explanation of variables used by other writers). The middle aged hired labor and farmers are assumed to contribute equal amount of labor regardless of sex, while very old people and children work only half as much as the farmers. Therefore, the total labor can be defined as: TL = farmers + 0.50 (children) + 0.50 (very old hired laborers) + middle age hired laborers.

Total hectares of land under cultivation (X_2): refers to the total number of hectares devoted to the three major crops only. Fallow land as well as the rest of the land devoted for other crops are excluded from the total holding. No attempt has been made to distinguish the quality of the land.

Value of equipment and building (capital) used in production (X_3): represents the use of capital in agriculture. An attempt was made to estimate both working and fixed capital using equipment and buildings as fixed assets and the value of capital used by buying seeds, fertilizer and other variable inputs except labor as working capital. But the non-existence of fixed capital except for cattle poles, and the lack of reliable prices for few of the fixed capital necessitated the dropping of buildings as important variable.

In contrast to Shapiro and Muller (1977), who decided to drop the capital as a variable, the present study uses the value of selected items of equipment. As such, the equipment value, which acts as a proxy variable for capital, has been estimated by obtaining the total dollar value of seven items of equipment - shovel, fork, sickle, axe, ox plow, hoe and rake. Even though some other small equipment were reported in use, only these seven items were

selected because prices were not available for others. Given the nature of these items, no attempt was made to depreciate their value.

Information index (X_4): referred to the composite score obtained from five sources of management information available for farmers. This index, which is somewhat similar to the management index used by Moock (1981) represented the use of improved technology and also the effectiveness of government in improving farming practices through extension services.

The index is calculated as the weighted value of five extension activities - (a) talked with Bwana Shamba, i.e., extension agent, (b) attended farming demonstrations, (c) listened to Mkulima, i.e., livestock agent, (d) visited demonstration plots and (e) attended meetings called by Bwana Shamba. Each of the activities were rated and assigned a score of "0" if the response was never, "1" if it was rarely and a score of "4" if farmers responded with "often". The sum total of all five was then divided by 20 to get the weighted index. The range of such index will be between "0" and "1" where "0" indicates that farmer has not used any of the information sources and "1" indicated that he uses all sources fully. The larger score also implies the better use of available technology and the effectiveness of government action in using extension as an effective tool to improve agriculture and vice versa.

The estimated equations were tested for statistical significance using ten percent significance level.

Brief Review of Literature

The literature on production functions is voluminous. The work covers many aspects of production, from individual crops and farms, to regional and national production functions including many countries across the world. A

literature search shows that many types of production functions, simple linear, Cobb-Douglas, and other mathematical forms of the function, have been used. However, in agricultural research the use of a Cobb-Douglas production function is more common than any other functions. Recent works have attempted to improve the production function estimation power and even propose complex functions in addition to the variation in estimation approaches. Instead of one predetermined function, many researchers are now estimating several functional forms and selecting the one with the "best" fit.

The purpose of this section is not to review all literature, rather, to report on a few studies of particular importance especially those relating to less developed countries (LDCs). Review of the farm management research in LDCs focuses on the limitations and problems encountered in studies of such nature and provides a guideline for proper specification of variables.

The measurement and specification of the variables are crucial as they determine the usefulness of the model. Therefore, the review of literature looks more closely at these procedures. So far as the specification is concerned, land tends to be straightforward, measured as acres, hectares, or other area units within the various regions. Labor is the major factor of production in traditional farming systems. The differences in types of labor inputs (such as male, female and child) pose a problem in computing total labor inputs. Thus, a useful measure for total labor inputs for each farming system has to be determined.

Capital also poses a problem. First, the use of capital as a substitute for labor is very limited. Second, capital consists of two parts - fixed capital lasting more than one year and working capital that is used up in one production period. Therefore, to be consistent, fixed capital must be depreciated over a period of its useful life. Third, in many LDCs, fixed

capital, which consists primarily of draft animals, farm houses and basic hand tools, creates problems for depreciation. Working capital or operating capital, consisting of the value of fertilizer, seed, and machinery for hire used in the production process, is generally very small and hard to identify.

Management is one of the most difficult variables to specify. It is extremely difficult to quantify what is or is not good management. Therefore, most studies tend to use proxy variables to measure management. One variable that is used quite often is schooling; other times, the amount of research, some other times, things such as the use of improved seeds and fertilizer are used to indicate good management practices. Normally, economist treat management as residual.

In discussing the problem relating to estimation of production function, Heady and Dillon (1961) have summarized various approaches used by many of the writers in defining the variables. Therefore, readers are suggested to refer to this text for detailed information. Here we add specifically how some of the writers have treated variables in their research in LDCs.

Dovring, Jindia and Misra (1970) studied soybean production in Northern India. They selected one district randomly to represent each of the four-agro-climatic zones in India. For this they used a milti-stage stratified random sample and selected district in the first stage, followed by village in the second and farm within the village the third stage.

They used linear, Cobb-Douglas and quadratic functions to fit the data and found that the Cobb-Douglas function gave a better fit. In their estimation of production function, they measured land in acres of landholding without regard to land quality.

Labor was divided into two variables, human labor and bullock labor. (a) Human labor included family and hired labor actually used in the

production process and was defined in terms of days of man labor used per acre of the crop cultivated. (b) Bullock labor was expressed in terms of bullock-pair days used per acre. Both inputs were converted into value terms by multiplying the hours by the prevailing wage and rental rates respectively.

Capital was a total of both: (a) fixed capital measured in acres of land actually operated. This referred to the size of an operator's entire holding and not just the land under the crop for which the production function was fitted, and (c) working capital measured as cash input for seed, fertilizer, irrigation and insecticides.

Chen (1972-73) estimated agricultural productivity index in the newly settled region of Manchuria by using an aggregate production function. His results supported T.W. Schultz's hypothesis that agricultural productivity tends to become stagnant over time in traditional societies (Schultz, 1964). In this estimation of production function, he defined land as total cultivated area for the northeastern population series. Next, fixed capital was estimated as the total value of animal and mechanical energy available shown in horsepower equivalent for each year, and an approximation of working capital was made using the total nitrogen content of human and animal manure and of chemical fertilizers available for agriculture for each year.

One study that looked particularly at agricultural production functions in Tanzania was done by FAO and World Bank (1976). The purpose of the study was to provide farm management type information on small farmers and to use the information for improving their income. The survey was conducted throughout various administrative areas in the country focusing on specific crops as well. Morogoro, also included in our study, was one of the study areas. A Cobb-Douglas production function was used to estimate coefficients. The

study found in the case of maize in Morogoro was that land and seed rate had high positive elasticities of 0.49 and 0.25 respectively. The power input had an elasticity of 0.03, labor in land preparation 0.15, and in weed control -0.14. The sum of the elasticities totaled 0.78 and adjusted R^2 was 0.5. The results did not vary substantially from other regions of the countries although in some instances, returns appeared to be greater than one indicating increasing returns to scales.

In the FAO and World Bank study, (a) land was specified as the hectares of land used for production; (b) labor was obtained by adding permanent hired labor to farm family (number of people). Next, the labor availability (man equivalent) was calculated as: labor availability = 0.58 X total people on farm. However, it is not clear from the discussion of methodology if this or the number of hours of labor was used in the production function and (c) capital was not clearly defined in the methodology discussion.

Shapiro and Muller (1977) addressed the issue of improved specification by analyzing the role of information and modernization in the production process on cotton farms in Tanzania. Specification of a modified Cobb-Douglas production function was used to show how modernization of information has a direct effect on physical inputs. They found out that "...management is primarily labor augmenting in this part of Tanzania. Land is still relatively abundant and labor is far more likely to be the binding constraint, especially since the labor calendar shows sharp peaks at times of land preparation, weeding and harvesting... A farmer's performance in all these aspects of labor may be determined by his knowledge about them... (or) his willingness to be fully technically efficient - a willingness that is associated with modernization."

In their study land was specified as acres of cotton actually planted without any adjustment for differences in fertility, drainage, and so forth. Next, labor was specified as the actual number of hours worked in the fields. These were raw hours unadjusted for timeliness or age or sex, implying that an hour worked by any one person yields the same effective labor as an hour worked by any other person. Children under eight years of age were excluded completely.

Fixed capital was not included in the analysis because all cultivation was done by hand and there was very little capital used in the area except for the long-handle hoe and other basic hand tools. Working capital was excluded in the analysis because of those farmers who used fertilizer or insecticide, only a small percentage used them properly.

Shih, Hushak, and Rask (1977) attempted to measure the validity of the Cobb-Douglas specification in Tiawan's developing agriculture. Both cross sectional and time series techniques were employed in analyzing farm records between 1964 and 1970 of 53 Tiawaneese families. They used the Cobb-Douglas and translog function in generating their results. The translog function relaxed many restrictive properties of the Cobb-Douglas function. Both functions gave similar degrees of fit. But the translog model did have two significant variables that were not significant in the Cobb-Douglas relation and that led them to reject the Cobb-Douglas specification. Economically, the major differences were the allocation of output to land and capital. The Cobb-Douglas function gave a higher return to land and lower return to capital services. With respect to the scale changes, the Cobb-Douglas function showed increasing return to land and decreasing return to capital while the translog gave the opposite.

Spencer and Byerlee (1977) looked at the small farms in Sierra Leone, West Africa, and found that "most farming systems in Sierra Leone are land extensive employing a bush fallow system to cultivate upland crops, mainly rice ... The most important resource currently used in Sierra Leone agriculture is family labor . . . and farmers have adopted labor intensive farming systems." Further, they reported that small farms were "largely based on traditional techniques which have considerable potential for expanded output. Land is still not a critical constraint in most areas; labor is slack in certain seasons and even as the peak seasons where labor resources are fully utilized, labor productivity is quite low."

In their study, they defined labor inputs for each farming unit in person hours. The relative wage rates were used to convert female and child labor to male equivalents. To reflect relative wage rates they applied weights of 1.00, 0.75 and 0.50 to men, women and child labor respectively in the IADP area, weights of 1.0, 1.0 and 0.5 to men, women and child labor in the Boliland area respectively.

Fixed capital included costs of farm tools, animal equipment, processing equipment and cost of land. Operating capital was defined as the value of fertilizer, seed, machinery for hire, and hired labor used in the production process.

Pachico (1980) used a Cobb-Douglas production function to measure the degree of allocative efficiency observed in three farming systems in the hills of Nepal. He found that because of the "...low standards of living, poor quality of land, high man/land ratios, and modest levels of use of modern technology, the returns to land and labor, both family and hired, were shown to be lowest in the ridge villages. Returns to land were found to be generally high in the mid altitude valley where the soil is fertile,

intensively cultivated and more modern technology is used."

In his study, he defined land as the area cultivated and measured in Ropanis, a standard are measurement in the hills of Nepal equal to about 1/20th of a hectare. Land is entered unweighted for differences in quality. Next, the total of family labor and hired labor was entered in the production function. Family labor was measured as the fixed stock available for use, age 15 - 55 working full time in agriculture; most family labor had no alternative employment opportunities. Hired labor was entered as the total days of labor hired for all operations on all crops. Finally, capital was measured as the amount of chemical nitrogen in kilograms.

Jean M. Due (1980) studied cost, returns and repayment experience of Ujamaa villages in Tanzania focusing primarily on the costs of and returns from communal production in the Ujamaa villages. Her study of food crop producing villages, most of which produce maize, found the situation less favorable.

> Maize acreage was substantial, averaging 192 acres per village per year. Many of the villages had borrowed heavily for mechanized farm machinery in 1971 and 1972. Maize yields were low with input costs high resulting in average net returns per village which were negative from the standpoint of Tanzanian society but negative for only one year from the viewpoint of the villages. Average net returns per village to society over the four year period were Ts $5,561; this is a cost to Tanzanian tax payers of $5,561 per village per annum for the food crop villages. But net returns from the viewpoint of the villages had improved to an average of Ts 55,282 by 1976; this $7,739 is a substantial cash income to the village even though it is a small amount per labor day per member.
>
> The food crop village members were consuming more maize as a result of the communal production; the percentage of production sold improved from 40 percent in 1974 to 76 percent in 1976 even though the total value of production was much higher in 1974 than in 1976; prices for maize also had improved over the period.

> The food crop villages had improved their repayment of loans from TRDB over the period (as the government was no longer allowing borrowing through the Cooperative Union). However, total cumulative arrears per village averaged Ts 117,830 ($16,496) by 1976 and the overall arrears rate was 74 percent.

Land was measured as the actual acreages planted, labor as communal labor recorded as total labor days, by the village officials. A village member was credited with a day of work regardless of the amount of time spent in the field. Therefore, to make it a more realistic estimate of labor spent on communal crop production, she divided the total labor days in half.

Capital was defined as all cost of production for which estimates were received plus an estimated depreciation charge on farm machinery, milling equipment and ox-plows.

II. PRODUCTION ACTIVITIES

This section analyzes the current production activities and aims to identify the problems and constraints. After investigating the production activities, an estimate of production function will follow in the next chapter.

As pointed out in Volume I, Tanzanian agriculture has most of the characteristics of primitive agriculture. Farms are usually very small with an average size of about one to two hectares with the large majority of the farms smaller than three hectares. And the average income ranges from a low of Ts 45 to a high of Ts 2500.[1] However, the Central Zone is particularly the poorest one as the mean income is less than one-fifth of the income in the highest agri-ecological zone of Tanzania. In this chapter, the response from the farmers will be analyzed with respect to their use of land, labor, and other inputs in production, harvesting and marketing.

Use of Land: In general, land in Tanzania is not a constraint for agriculture. Perhaps the quality and the proximity to the village may have been less than desirable, but the availability of land itself is no problem. Prior to the villagization program, a fallow type of agriculture was practiced. Under this system, the farmers cultivated a piece of land until they felt the productivity had been depleted. Then they moved in search for other productive

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[1]The exchange rate is U.S. $1 = Ts (Tanzanian shillings) 8.1 at the time of this study.

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land. However, the villagization program brought permanency to settlement and farmers were given land for cultivation within the village. Through the village organization a farmer could get as much land as he would need at no charge.

The real constraining factor for the majority of small farmers seems to be their ability to operate a large sized farm with very little equipment or hired help. A typical farmer, with the assistance of his family, can farm only a small plot of land in a day.

The average farm size for three crops in this study is small. Nearly two fifths of the farmers have an average of 1.89 hectares of land devoted to the three major crops (Table 1). Even though there was some lack of knowledge on the part of the farmers of their actual hectares in reference to landholdings, the results seem consistent with other studies.

The results from Table 1 show farmers in Manyoni had the smallest average sized farm with 1.72 hectares while they tended 2.04 and 2.21 hectares for Dodoma and Kilosa respectively. Nearly 40 percent of the farmers in each district had farms ranging from 1.51 to 2.5 hectares.

Labor Use: One of the major inputs is labor. Farmers and their families provide the major portion of farm labor and hired labor is used to supplement mostly during peak seasons. Analysis of labor use shows that the distribution of labor for all of the major activities is almost the same: seed bed preparation used 17 percent of labor; followed by 16 percent for planting, transplanting and broadcasting; about 16 percent for storing and godown construction; 15 percent each for harvesting and transportation; and cultural operations (Table 2). However, great variation is noted between districts. In Kilosa, 30 percent of labor use occurred for seed bed preparation and 23 percent for cultural operation. While in Dodoma, storing and godown construction

TABLE 1

AVERAGE FARM SIZE FOR THREE CROPS

Hectares	Kilosa Frequency	%	Dodoma Frequency	%	Manyoni Frequency	%	Total Frequency	%
0 < .75	39	12.00	89	9.33	17	12.78	145	10.27
.76 - 1.50	101	31.08	308	32.29	50	37.59	459	32.51
1.51 - 2.5	125	38.46	329	34.49	52	39.10	506	35.84
2.51 - 3.5	36	11.08	105	11.01	10	7.52	151	10.69
3.51 & above	24	7.38	123	12.89	4	3.01	151	10.69
TOTAL	325	100.00	954	100.00	133	100.00	1412	100.00
AVERAGE	2.21		2.04		1.72		1.89	1.99 (mean)

TABLE 2

TOTAL LABOR USE BY ACTIVITIES (Days)

	Kilosa		Dodoma		Manyoni		Total	
	Days	%	Days	%	Days	%	Days	%
Seed bed preparation	11,437.5	29.9	63,886.25	15.0	5,856.50	28.40	81,180.25	16.8
Planting, Transplanting & Broadcasting	6,989.5	18.5	68,824.40	16.0	2,732.75	1.3	78,146.25	16.1
Cultural Operations	8,756.0	22.9	56,473	13.2	4,327.75	21.0	69,556.50	14.4
Harvesting & Transportation	6,384.0	17.8	60,185	14.1	3,700.75	18.0	70,719.75	14.6
Storing	3,468.75	9.1	70,244.75	16.4	1,775	16.9	75,488,50	15.6
Irrigation	199.75	0.5	60,542	14.2	110.50	0.5	60,852.25	12.5
Other activities	564.75	1.5	47,397.75	11.1	391.00	1.9	48,353.50	10.0
TOTAL	**38,250.25**	**100.0**	**427,132.75**	**100.0**	**18,893.75**	**100.0**	**484,277.75**	**100.0**

absorbed over 16 percent of the labor. About the same proportion was devoted for planting, transplanting and broadcasting operations. Very significant in Dodoma was the use of 14 percent of labor for irrigation purposes. Perhaps the dry area of Dodoma has forced farmers to irrigate more than either in Kilosa or Manyoni. Nearly one third of the labor in Manyoni was for seed bed preparation and farmers spent 21 percent of their time on cultural practices.

So far as the sources of labor are concerned, only 57 percent was supplied by family including the farmer, his wife and children and the remaining 43 percent came from hired hands (see Table 3). The farmer and his wife supplied nearly three-fourths of the family labor and children provided 29 percent of labor need. The labor of children is a weighted value and every two hours of work by children has been taken to equal one hour of adult labor. Similar weight was also used for adjusting the labor supplied by very old laborers.

Middle aged laborers were supplying two-thirds of the hired help and the remaining one-third was provided by very old workers.

Both in Kilosa and Manyoni, less than 4 percent of the labor was supplied by the hired workers, while in Dodoma nearly half of the labor was provided by hired hands. Also, in contrast to Kilosa and Manyoni, where child labor was only three percent of the family labor, nearly 35 percent of family labor in Dodoma was provided by children. In other words, more children in Dodoma participate in farming than either in Kilosa or Manyoni.

Use of Farm Machinery: Only a few farmers used machinery in any of the farming activities. Fourteen of twenty-four farmers (twelve in Kilosa and two in Dodoma) used machinery for seedbed preparation and the remaining ten farmers (seven from Kilosa, one from Dodoma and two from Manyoni) used machinery for planting and transplanting activities. No machinery was used in weeding,

TABLE 3

SOURCES AND USES OF LABOR (ACTUAL DAYS)

	Kilosa		Dodoma		Manyoni		Total	
	Days	%	Days	%	Days	%	Days	%
Total Labor	3,8250.25		427,132.75		18,893.75		484,276.75	
Family	36,975.75	96.7	219,147.75	51.3	18,630.75	98.6	274,756.25	56.7
Farmer	34,784	94.1	143,386.5	65.4	18,125	97.3	196,295.5	71.4
Child	2,191.75	5.9	75,761.25	34.6	505.75	2.7	78,458.75	28.6
Hired	1,274.5	3.3	207,985	48.7	263	1.4	209,522.75	43.3
Very old	664.5	52.1	66,722.5	32.1	132.5	50.4	67,519.5	32.2
Middle	610	47.9	141,262.5	69.7	130.5	49.6	142,003	67.8
Seedbed preparation:								
Total Labor	11,437.50		63,886.25		5,856.5		81,180.25	
Family	11,188.25		28,144		5,830.25		45,162.5	
Farmer	10,522.50		19,229.5		5,743.5		35,495.5	
Child	665.75		8,914.5		86.75		9,667	
Hired	249.25		35,742.25		26.25		36,017.75	
Very old	158.25		10,726.75		26.25		10,911.25	
Middle	91		25,015.5		-		25,106.5	

TABLE 3 (CONTINUED)

PLANTING, TRANSPLANTING AND BROADCASTING

	Kilosa Days	Dodoma Days	Manyoni Days	Total Days
Total Labor	6,989.5	68,424.0	2,732.75	78,146.75
Family	6,356.5	37,239	2,544.75	46,140.75
Farmer	5,994	23,475	2,466	31,935
Child	362.5	13,764	78.75	14,205.25
Hired	633	31,185	188	32,006
Very Old	209	11,326	65	11,600
Middle	424	19,859	123	20,406
Cultural Operation (Weeding, Hoeing, Spraying, etc.):				
Total Labor	8,756	56,473	4,327.5	69,556.25
Family	8,677.25	30,802.75	4,316	43,796
Farmer	8,326	22,909	4,089	35,324
Child	351.25	7,893.75	227	8,472
Hired	78.75	25,670.25	11.25	25,760.25
Very old	63.75	8,556.75	11.25	8,631.75
Middle	15.0	17,113.5	-	17,128.5
Irrigation:				
Total Labor	199.75	60,522	110.5	60,832.25
Family	196	38,006	110.5	36,314.5
Farmer	181	21,928	110.5	22,219.5
Child	15	14,080	-	14,095
Hired	3.75	24,514	-	24,517.75
Very old	3.75	7,595.5	-	7,599.25
Middle	-	16,918.5	-	16,918.5

TABLE 3 (CONTINUED)

HARVESTING AND TRANSPORTATION

	Kilosa Days	Dodoma Days	Manyoni Days	Total Days
Total Labor	6,834.0	60,185	3,700.75	70,720.25
Family	6,558	21,617	3,689.5	31,865
Farmer	6,200	13,807.5	3,640	23,647.5
Child	358	7,809.5	49.5	8,217
Hired	276	38 568	11.25	38,855.25
Very old	203.5	11,833.5	11.25	12,048.25
Middle	12.5	26,734.5	-	26,807
Storing:				
Total Labor	3,468.75	70,244.75	1,775	77,204.5
Family	3,435	40,409.25	1,775	45,619.75
Farmer	3,092	26,219.5	1,715.5	31,027.25
Child	343	14,189.75	60.0	14,592.75
Hired	33.75	29,835.50	-	29,868.25
Very old	26.25	10,805.5	-	10,831.75
Middle	7.5	10,030	-	19,037.5
Other:				
Total Labor	564.75	47,397.75	391	48,353.5
Family	564.75	24,927.75	364.75	25,857.25
Farmer	468.5	15,818	361	16,647.5
Child	96.25	9,109.75	96.25	9,209.75
Hired	-	22,470	26.25	22,496.25
Very old	-	5,878.5	18.75	5,897.25
Middle	-	16,591.5	7.5	16,595

cultivation and harvesting.

Use of Other Inputs: Farmers in the Central Zone relied on their own sources for seed, bought almost no fertilizer and insecticides and used very little manure. Only about 28 percent of the farmers reported buying seeds for planting. However, when the farmers were asked to estimate the cost of seed, less than eight percent reported paying for the seeds. Of those who paid the maximum amount was Ts 12 or $1.49 for the seed. Most of the farmers who used their own seeding retained it from previous harvest, and very little outside source is used. Farmers obtaining seed from friends and neighbors may not have to pay, and, hence, the low number of paid purchases.

Only three farmers, one in Dodoma and two from Kilosa, reported using any purchased chemical fertilizer. Likewise, very few farmers reported applying purchased manure. Only four farmers in Dodoma and none from either Kilosa or Manyoni used purchased manure in their fields. As a result, it is apparent that almost all of the farmers used only manure from their own animals; the dropping often occurring while the animals graze over cropland after harvest.

Finally, the use of insecticides is very minimal as only ten farmers - six in Kilosa, two each in Dodoma and Manyoni - reported using any insecticides. Farmers, therefore, depend largely upon the mercy of nature for the protection of crops from insects. This leads to a serious problem since 25 to 50 percent of crops are damaged by insects, birds and animals.

Crops Grown: Farmers were asked to rank the three major crops grown in order of their importance. Maize was the most important crop with over 33 percent selecting it as the first crop (see Table 4). The remaining farmers selected millet (by 29 percent), sorghum (by 28 percent), rice (by 4 percent), and peanuts (by 3 percent) as their first crops.

TABLE 4

MAJOR CROPS GROWN IN THE CENTRAL ZONE

Crop	First Choice			Total	Second Choice				Third Choice				Grant Total
	Kilosa	Dodoma	Manyoni	No.	Kilosa	Dodoma	Manyoni	Total	Kilosa	Dodoma	Manyoni	Total	No.
Maize	223	171	57	451	65	160	18	243	–	35	4	39	733
Millet	–	366	28	394	–	88	17	105	–	20	–	30	529
Sorghum	28	309	35	372	33	143	29	205	16	42	9	67	644
Peanut	–	40	3	43	–	199	18	217	–	191	20	211	471
Rice	33	26	–	59	76	134	–	210	–	–	–	–	169
Beans	12	–	–	12	67	–	–	67	28	–	–	28	107
Cotton	6	–	4	10	12	–	–	12	7	–	–	7	29
Sweet Potatoes	–	–	–	–	–	–	9	9	–	–	–	6	15
Bambara Nuts	–	–	–	–	–	–	–	–	–	61	–	61	61
Cassava	–	–	–	–	–	–	–	–	28	–	5	33	33
Bananas	–	–	–	–	–	–	–	–	14	–	–	14	14
Others	4	4	2	10	23	56	16	95	31	37	6	74	179
Total	306	916	129	1351	276	680	107	1063	124	396	50	570	2984

Maize was still important in the selection of second crop, followed by peanuts, sorghum, rice and millet. However, peanuts were selected by 37 percent of the reporting farmers as the third important crop. Rice was not selected at all as a third crop. Sorghum, bambara nuts, maize, cassava and millet were the remaining important crops.

However, the ranking of crops by district shows millet was very important in Dodoma and sorghum was a very close second. The arid area of Dodoma is the major reason for growing millet and sorghum. Maize ranked only third. In Kilosa, with better soils and climate, 73 percent of the farmers grew corn as their first crop. No millet and peanuts were grown and very few grew rice and sorghum. Manyoni farmers selected maize as their first crop followed by sorghum and millet.

In general, the farmers in arid areas with poor quality soil preferred sorghum and millet while those in less arid areas and better soils selected maize.

Planting and Harvesting Seasons: In the Central Zone of Tanzania, November through January seemed to be the primary season for planting (see Table 5). Nearly 90 percent of the farmers reporting planted their crops during these three months with two-thirds of the planting activities occurring in November and December alone. Although the same season was common for all districts, some individual variation was noticed. In Kilosa, planting extended to the month of March as 9 percent of the farmers reported planting some crops such as rice, beans, maize and sorghum as late as March. However, December and January were pointed out by 53 percent of the farmers as the two busiest months in Kilosa.

Planting season started a little bit earlier in Dodoma. About 6 percent

TABLE 5

PLANTING AND HARVESTING MONTHS FOR THREE MAJOR CROPS

District	PLANTING PERIOD						HARVESTING PERIOD					
	Nov.	Dec.	Jan.	Feb.	Remaining Months	Total	April	May	June	July	Remaining Months	Total
Kilosa	78	193	174	113	127	685	59	47	208	226	145	685
Percent	11	28	25	17	19	100	9	7	30	33	21	100
Dodoma	781	655	317	65	153	1971	244	772	773	141	41	1971
Percent	40	33	16	3	8	100	13	39	39	7	2	100
Manyoni	157	50	16	2	65	290	31	124	82	38	15	290
Percent	54	17	6	1	22	100	11	43	28	13	5	100
Total	1016	898	507	180	345	2946	334	943	1063	405	201	2946
Percent	34	31	17	6	12	100	11	32	36	14	7	100

of the farmers started planting in October. But November and December were the two most important months for planting activities for 73 percent of the farmers. Likewise, the primary planting season in Manyoni was also the same months of November and December. Over one-half of the farmers planted in November and another 17 percent in December.

So far as the harvesting season is concerned, April through July accounted for the 93 percent of the activities (Table 5). May and June were the two busiest harvesting months as 68 percent of the farmers harvested in those two months. But the individual variation among the districts shows that June and July were primarily harvesting months for Kilosa farmers, while May and June were the important months for both Dodoma and Manyoni.

In all three districts the time gap between the planting and harvesting appears to be six months as most farmers in Manyoni and Dodoma started planting in November and harvested in May. In Kilosa, planting started in December and harvesting was in June.

III. PRODUCTION FUNCTION ESTIMATES

As outlined in Chapter I., three forms of estimates - Linear, Cobb-Douglas, and Quadratic forms - were used to obtain the relationship between the inputs and outputs. The purpose of estimating all three forms was to find and select the "best" fit. In addition, estimates were made with four equations for each form, with following variables as inputs:

1. Labor, Land, Capital and Information Index
2. Labor, Land and Capital
3. Labor and Information Index
4. Labor and Land

Overall the results are less encouraging as none of the estimated equations have large R^2's implying that only a low percent of the variations in the production functions have been explained by the equation (Tables 6, 7, 8). In addition, some equations have coefficients with signs that we not expected. Therefore, caution should be observed in interpreting the results.

The primary reason for such poor estimates may be error involved in the estimates of land and labor based on recall data. As pointed out in Chapter II, the error in this variable might have been magnified because of the lack of knowledge on the parts of farmers of total land holdings, the possible overestimation and underestimation of land by farmers and the most importantly, their guesswork in recalling the land and labor devoted for each crop. Since land is one of the two significant variables, overestimation or underestimation of the land variable surely obscures the accuracy in the estimation of

TABLE 6

PRODUCTION FUNCTION ESTIMATES
(Linear Form)

District & Equation	Constant	Capital	Labor	Hectares	Information Index	Standard Error	R^2
Kilosa 11	627.4788	-0.2194	-0.4496	0.3146	-54.7577	936.45	.02
12	605.9215	-0.2578	-0.4358	0.3112	-	935.66	.02
13	656.835	-	-0.4833	-	-52.6619	936.30	.01
14	607.7372	-	-0.4718	0.3117	-	934.23	.02
Dodoma 21	1509.676	38.5292*	1.5991*	4.7415	226.312	1815.91	.12
22	1511.370	42.3165*	1.7006	4.7361*	-	1817.81	.12
23	2056.322	-	2.6844*	-	347.614*	1906.205	.03
24	1811.905	-	1.7150*	5.0074*	-	1832.60	.10
Manyoni 31	66.2115	0.3958	0.1836*	.1651*	36.7919*	102.90	.15
32	73.3034	0.5501	0.2117*	.1675*	-	104.93	.11
33	91.5162	-	0.2249*	-	38.1598*	105.51	.09
34	77.4677	-	0.2079	.1722*	-	104.60	.11
District Total							
T1	1819.798	0.5517	-0.9759*	2.4904*	-11.956	1805.337	.11
T2	1817.097	0.6459	-0.9745*	2.4887*	-	1804.705	.11
T3	2033.381	-	-1.0687	-	19.8007	1839.020	.07
T4	1821.566	-	-0.9700	2.4910*	-	1804.115	.11

*Significant at 1 percent

**Significant at 5 percent

TABLE 7

PRODUCTION FUNCTION ESTIMATES
(Log Forms)

		Constant	Capital	Labor	Hectares	Information Index	Standard Error	R^2
Kilosa	11	0.1777	-0.4887*	0.0178	0.7668*	-0.05659	0.50	.41
	12	0.1848	-0.1405*	0.0209	0.7629*	-	0.50	.41
	13	1.2788	-	0.0873	-	0.0949	0.65	.01
	14	0.7699	-	0.0044	0.7806*	-	0.50	.40
Dodoma	21	2.0598	0.1006	0.4913*	0.5554*	0.2064**	0.58	.23
	22	2.0627	0.1044	0.4762*	0.5696*	-	0.59	.22
	23	1.9836	-	0.6341*	-	0.2604*	0.61	.17
	24	2.1353	-	0.4762*	0.5942*	-	0.59	.22
Manyoni	31	0.1485	-0.2512	0.4687*	.5777*	.5971**	0.60	.21
	32	.1616	-0.2490	0.3907**	0.6348*	-	0.61	.17
	33	0.4555	-	0.7148	-	0.6679*	.61	.16
	34	0.5951	-	0.4360**	0.5256*	-	.61	.16
District Total								
	T1	0.7902	-0.0893	-0.1492	1.4096*	0.0399	0.64	.69
	T2	0.7883	-0.0882	-0.1496	1.4087*	-	0.64	.69
	T3	0.3871	-	-0.6115*	-	-0.1413	1.09	.11
	T4	0.7371	-	-0.1592*	1.4087*	-	0.64	.69

*Significant at 1 percent

**Significant at 5 percent

TABLE 8

PRODUCTION FUNCTION ESTIMATES

(Quadratic Form)

		Constant	Capital	Labor	Hectares	Infor. Index	Capital Square	Labor Square	Hectares Square	Infor. Index Square	Standard Error	R^2
Kilosa	11	516.044	-2.8193	-0.9898	11.205*	18.4650	0.00592	0.00055	1.0733	-46.3766	928.0974	.05
	12	499.100	-3.152	-0.9361	2.505*	-	0.00655	0.00053	-0.0006*	-	926.7232	.04
	13	654.600	-	-0.4585	-	40.2691	-	0.000028	-	-45.7250	938.953	.01
	14	478.537	-	-0.9094	2.5839	-	-	-0.000399	-0.0006	-	924.286	.04
Dodoma	21	739.7033	29.5569	2.0435	17.52	-296.886*	-0.2854	0.002622	-.0075*	211.1049*	1633.363	.29
	22	727.8186	30.8636	1.9248	17.6924*	-	-0.2574	-0.00240**	-.0076	-	1633.871	.29
	23	1832.771	-	6.1667*	-	-176.2700	-	-0.00554	-	-	1895.775	.04
	24	895.882	-	2.0895**	18.1369*	-	-	-0.00269	-0.0077*	-	1637.403	.29
Manyoni	31	-12.9586	-1.6341	0.5906**	1.9344*	0.9204	0.0119	-0.0012**	-0.0031	11.1328	93.725	.31
	32	-15.944	-1.4086	0.6410**	2.0069*	-	0.00628	-0.00135**	-0.0032	-	93.986	.30
	33	37.9167	-	0.1.0352	-	1.3010	-	-0.00195*	-	15.8834	102.768	.15
	34	-23.0481	-	0.6699	1.8886*	-	-	-0.001387*	-0.0030*	-	93.565	.29
District Total												
	T1	1137.307	12.7416*	-0.7994**	11.1917*	-547.957**	-0.03252*	0.000056	-0.00318	206.535	1684.680	.72
	T2	1096.003	11.4266	-0.7994**	11.0942*	-	-0.0296	0.000070	-0.00315*	-	1686.538	.22
	T3	2016.486	-	-0.6695	-	-348.743	-	-0.000218	-	186.496	1838.442	.07
	T4	1165.024	-	-0.7246**	11.1913*	-	-	0.000043	-0.00317*	-	1687.555	.22

*Significant at 1 percent

**Significant at 5 percent

the production function. Further, the output estimation may also contain error as farmers were asked to recall the output and many times appear to be low. Lower estimates might have been provided to us for fear of being reported to a government agency and also it might have been because farmers traditionally underestimate total production.

Despite these problems, we hope the estimates will give some idea of the relationship between the output and inputs.

Below, a summary of the individual districts is discussed.

1. Production Function for Kilosa District

Among the several estimates, the Cobb-Douglas production function with capital, labor and hectares of land seems to be the best in explaining input and output relationships for Kilosa farmers (Table 7). The estimated relationship has positive coefficients ranging from 0.76 to 0.78 and 0.0 to 0.09 for land and labor respectively. The coefficients associated with capital were all negative, while those of information index were both positive and negative. In all the equations tested, the R^2 values were similar except equation 13 (Table 7) that has labor and information index as independent variables and whose R^2 was .01. In all the equations tested, land accounted for the greatest explanatory variable followed by labor. The standard error values range from 0.501 to 0.647.

The other two equations, 11 and 14 in Table 7, also have about the same R^2 value, 0.41 and 0.40, and land accounted for the greatest explanatory variable followed by labor. But for both equations 11 and 12, capital and information index have negative value signifying that the greater the use of capital and information index, the lower the value of output that results from them. This may partly be due to the high cost associated with the acquisition of capital resulting in more cost than returns from the farming operation.

Also, low coefficients for both variables reduce their importance and the negative value make them less meaningful. Perhaps this result might be expected as there is very little extension service and the amount of capital is not only very small but that the effect of other variables in the regression equation could have overshadowed the role of capital and information index in explaining the contribution to total value of output.

An attempt was made to estimate marginal productivity. The results found that marginal value products (MVP) for land was about 0.64 and between 0.002 to 0.069 for labor (Table 9). This means that for every unit increase in land and labor, the value of output increases by 64 percent and between 0.2 percent and seven percent respectively.

2. Production Function for Dodoma District

The results of production function estimates for Dodoma are slightly lower than that of Kilosa. Based on highest R^2 value and the appropriate signs for all the variables, equation 21 in Table 7 is the "best" fit. The equation, Cobb-Douglas production function, indicates that the value of output is a function of land, labor, capital and information used in production. The estimates show that land (hectares), similar to Kilosa district, is the predominant factor of production followed by labor.

The equation explains only 22 percent of the variation and is statistically significant when tested at five and ten percent significance levels. Furthermore, the estimates show that the farmers in Dodoma are experiencing the increasing returns to scale.

Equations 22 and 24 in Table 7 have the same R^2 value of .22. Unlike few of the negative coefficients in Kilosa, all the coefficients of the equations (Cobb-Douglas) for Dodoma are positive. However, as pointed out in the case

TABLE 9

MARGINAL VALUE PRODUCT (MVP) FOR THE CENTRAL ZONE

	LABOR	LAND
Kilosa	$\bar{L}$ = 1.8142 $\bar{Y}$ = 1.4250	$\bar{H}$ = 1.7166
	Equation 1. 0.002	0.637
	2. 0.014	0.633
	3. 0.069	
	4. 0.003	0.648
Dodoma	$\bar{L}$ = 1.8809 $\bar{Y}$ = 3.1510	$\bar{H}$ = 0.1963
	Equation 1. 0.823	8.915
	2. 0.798	9.143
	3. 1.062	
	4. 0.798	9.538
Manyoni	$\bar{L}$ = 2.0430 $\bar{Y}$ = 1.8655	
	1. 0.428	0.619
	2. 0.357	0.680
	3. 0.654	
	4. 0.398	0.563
Aggregate	L = 1.9888 Y = 2.6681	$\bar{H}$ = 0.1749
	1. -0.8363	2.2852
	2. -0.8311	2.2837
	3. -0.8204	
	4. -0.8691	2.196

of Kilosa district, the role of land and labor is dominant. In all the equations tested, land is followed by labor except in the case of equation 23 where labor and information index were used. The coefficients associated with capital and information index while having positive signs, have values ranging from 0.09 to 0.10 and 0.21 to 0.26 respectively.

The marginal value product (MVP) for the coefficients indicate much larger values than in Kilosa and they range from 8.9 to 9.5 and 0.79 to 1.06 for land and labor respectively.

3. Production Function for Manyoni Districts

All the production function estimates for Manyoni district are poor. The "best" fit, as determined by highest R^2 value with some of the coefficients having the right signs, seems to be equation 31 in Table 8. The equation in a quadratic form explains about 31 percent of the variation on output. Consistent with the last two districts, land is the most important variable followed by labor. The equation is statistically significant and the standard error of the estimate amounts to 93.725.

Even though R^2 is only 0.21, equation 31 in Table 7 is the better of the Cobb-Douglas functions. Equation 33 shows that the output depends upon land and labor and use of information sources and has a marginal value product of 0.563 to 0.680 and 0.357 to 0.654 for both land and labor respectively. The estimate also indicates that farmers are experiencing increasing returns to scale. Also, the benefits from extensive service and other information sources seem to have been realized in Manyoni. Both equations have the same standard error and are statistically significant at or below ten percent significant level.

Like the estimates for Kilosa district, equation 31 in both Tables 7 and 8

have greater explanatory powers but in both cases the capital has a negative coefficient. As explained in the case of Kilosa, perhaps the small amount of capital overshadowing by other variables might have led to a negative estimate for capital.

4. Production Functions for Central Zone

As was for the individual districts, three types of production functions - linear, logarithmic and quadratic - were used to obtain aggregate estimates. These results are also presented in Tables 6, 7 and 8. However, recognizing that some differences exist between the districts, a new model was estimated with the inclusion of dummy variables (D_1, D_2, D_3) used to obtain estimates of the parameters for the aggregate (Central Zone). Except in few cases, the coefficients maintain the appropriate signs and most of them are significant at five percent level or less (see Tables 10, 11, 12). The Cobb-Douglas function appears to be the better function. In this function, land and labor are also the dominant factors of production. We found that the R^2's for all the log forms (Table 11) range from 0.73 to 0.78, rather significantly higher values than when estimated separately. In almost all the production functions tested, the coefficients of information index were negative. However, the coefficients associated with capital, while some of them are negative, most of them were positive and modest in their values.

The marginal value products (MVP) for labor and land were computed, and the values range from -0.82 to -0.86 and between 2.23 and 2.29 for labor and land respectively (Table 9). The negative sign implies that for every unit of increment in labor, the value of output decreases by 82 to 86 percent.

TABLE 10

PRODUCTION FUNCTION ESTIMATES WITH DUMMY VARIABLES FOR AGGREGATE
(Linear Form)

	Constant	Capital	Labor	Hectares	Infor. Index	D_1	D_2	D_3	Standard Error	R_2
T1	-17.0337	0.1204	0.0131	4.2856	-0.0050	611.494	8.302*	-	453.94	.22
T2	-17.4945	0.1155	0.0128	5.2477	-	592.954*	8.213	-	454.09	.22
T3	-15.1757	-	0.0133	-	-49.5291	622.427	9.508	-	454.13	.22
T4	-15.5213	-	0.0129	5.2427	-	591.983	8.498	-	453.97	.22
T1	570.1523	-0.0727	-0.0044	5.9779	-39.5159	-	-560.925	-571.569	457.13	.21
T2	555.5871	-0.0718	-40.8999	5.9360	-	-	-546.767	-556.896	457.16	.21
T3	582.1721	-	0.0038	-	-38.6162	-	-572.535	583.494	457.42	.21
T4	554.7534	-	-36.0846	5.9474	-	-	-546.670	-556.072	457.01	.21
T1	-9.3497	.1178	0.0135	5.2865	-50.4081	603.811	-	-8.684	453.941	.22
T2	-9.9714	.1129	0.0132	5.2483	-	583.401	-	-0.080	454.09	.22
T3	-6.3076	-	0.0138	-	-0.0050	613.542	-	-0.001	454.13	.22
T4	-7.6565	-	0.0133	5.2424	-	584.069	-	-0.093	453.97	.22

* Significant at 1 percent

** Significant at 5 percent

TABLE 11

PRODUCTION FUNCTION ESTIMATES WITH DUMMY VARIABLES FOR AGGREGATE
(Log Form)

	Constant	Capital	Labor	Hectares	Infor. Index	D_1	D_2	D_3	Standard Error	R_2
T1	2.0001	-0.0236	.1699*	.2433*	0.0920	-	-2.4125*	-2.4642*	.5740	.73
T2	1.9962	-3.4115	.1658*	.2468*	-	-	-2.4125*	-2.4462*	.5741	.73
T3	2.0104	-	.1782*	-	0.1108	-	-2.4922*	-2.5409*	.5771	.73
T4	1.9757	-	.1627	.2467*	-	-	-2.4007*	-2.4484*	.5740	.73
T1	-0.7502	0.1011**	0.2305*	0.1602*	-0.0366	2.6339*	-	-0.0389	.5263	.78
T2	-0.7517	0.1018**	0.2310*	0.1592*	-	2.6386*	-	-0.0395	.5261	.78
T3	-0.6574	-	0.2423*	-	-0.0342	2.6587*	-	-0.0476	.5286	.77
T4	-0.6574	-	0.2349*	0.1620*	-	2.6120*	-	-0.0485	.5270	.77
T1	-0.7792	0.1027**	0.2283*	0.1604*	-0.0397	2.6655*	0.03444	-	.5263	.78
T2	-0.7805	0.1035**	0.2288*	0.1593*	-	2.6701*	0.0337	-	.5762	.78
T3	-0.7182	-	0.2399*	-	-0.0378	2.6929*	0.3707	-	.5287	.77
T4	-0.6880	-	0.2325*	0.1622*	-	2.6469*	0.0373	-	.5271	.77

* Significant at 1 percent

**Significant at 5 percent

TABLE 11

PRODUCTION FUNCTION ESTIMATES WITH DUMMY VARIABLES FOR AGGREGATE
(Quadratic Form)

	Constant	Capital	Labor	Hectares	Infor. Index	Capital Square	Labor Square	Hectares Square	Infor. Index Square	Standard Error	D_1	D_2	D_3	R_2
T1	133.1019	0.5121	-0.2026	56.3199*	-5.8550	-10.8466	0.00007**	-0.6311*	-28.4561	450.9330	388.9162*	9.9201	-	.23
T2	129.1053	0.4845	-0.1969	55.0142*	-	-0.0010	0.00006**	-0.6142*	-	451.1510	376.6445*	9.4577	-	.23
T3	127.5496	-	-0.1877	-	9.4280	-	0.00006**	-	-30.5217	453.7705	[illegible]3474*	13.2638	-	.23
T4	132.0069	-	-0.1936	54.8869*	-	-	0.00006**	-0.6124	-	450.9191	377.2759*	10.7130	-	.23
T1	140.0821	0.5227	-0.2009	56.4149*	-6.2749	-0.0011	0.00006**	-0.6313*	-28.2466	450.9425	381.6533	-	-1.3789	.23
T2	135.7504	0.4949	-0.1954	55.4149*	-	-0.0011	0.00006**	-0.6144	-	451.1596	369.6930*	-	-0.8967	.23
T3	137.1419	-	-0.1848	-	8.8045	-	0.00006	-	-30.2208	453.7841	487.4849*	-	-6.2547	.22
T4	139.7060	-	-0.1915	54.9063*	-	-	0.00006	-0.6126*	-	450.9293	369.2935	-	-3.2731	.23
T1	501.5651	0.5363	-0.2988*	63.111*	8.8011	-0.0014	0.00009*	-0.7078	-32.2849	452.6521		-276.8973*	-278.5673*	.23
T2	488.8125	0.5153	-0.2915*	61.7367*	-	-0.0017	0.00009*	-0.6909*	-	452.7815		-269.9974*	-271.2717*	.23
T3	613.6539	-	-0.3004*	-	26.7153	-	0.00009*	-	-34.1117	456.4123		-377.9188*	-383.5887*	.21
T4	492.4345	-	-0.2888*	61.6680*	-	-	0.00009*	-0.6898*	-	452.5199		-269.5722*	-272.3977*	.23

* Significant at 1 percent

**Significant at 5 percent

Analysis of the Results

As expected, the coefficients associated with the major (traditional) agricultural inputs, namely land and labor, were usually positive and significant, indicating the direct relationship between the crop produced and the inputs used. Even though some of the values of the coefficients are small, they confirm that agricultural activity and the farming practices that are traditional, output can expand as these two factors are increased. For the coefficients associated with information index, most have shown negative signs. However, the sign of the capital coefficients, for all the equations tested, seems to be equally divided.

Among all the production functions tested, the Cobb-Douglas equations do appear to be appropriate measures of production function in the Central Zone. Not only the values of the coefficients with the expected signs seem acceptable, but the coefficient of determination (R^2's) are much higher (in particular for the aggregate).

The production function estimates may have the limitations, such as underestimation. However, the results were useful for purposes of analyzing the utilization of farm resources in accordance with the objectives stated. It is not expected that data from the small farmers interviewed will be used to make specific recommendations such as those arising from biological production functions. In this profile study, the production functions used may be used to indicate the degree of utilization of the various input coefficients that may give broad indication of whether returns to the inputs used (land, labor, capital and information index) would vary between the three districts. The estimated production functions, while they are not an end in itself, simply provide the framework through which input-output relations may be evaluated in economic terms.

Judging all of the equations for three districts, it can be concluded that, except for equation 34 in Table 8, production function estimates are better when a Cobb-Douglas production function is used. None of the equations in linear form are good and few equations in quadratic form are better.

Finally, based on the discussion so far, land is the predominant factor in all districts individually and in Central Zone, followed by labor in the production of output. In almost all cases land has higher MPP than labor implying that farmers in the Central Zone should expand their landholdings and have extensive farming. Since there is very little difficulty in acquiring additional land except for obtaining the right quality, there seems to be no immediate production constraint to increased output. Lower MPP of labor indicates underemployment and the excess labor should either be used to farm additional land or divert to other sectors of the economy. Credit should be made available to them and the information and needed technology for adoption be provided on time by the extension service.

IV. SUMMARY AND CONCLUSION

This report is the final one of three reports prepared to summarize the production activities and to estimate production functions in connection with the Farm Management Research in Central Zone. Tanzania. The first part outlined the characteristic features of farmers and the second one presented the village profile. Therefore, the combined three reports summarized the complete results of the survey undertaken in September and October 1980, by North Carolina Agricultural and Technical State University with joint collaborative efforts by the Economic Research Bureau, University of Dar es Salaam, Tanzania. These findings would be useful in formulating and implementing strategies for rural development and especially for the development of agriculture.

The data were collected from a total sample of 1412 farmers in 31 villages consisting of 10 villages in Kilosa, 17 in Dodoma and four in Manyoni, all in the semi-arid area of Central Zone, Tanzania. The sample was stratified with village being the first stage and the farmer being selected in the second stage. The distribution shows that there were 954 samples (68 percent) from Dodoma, 325 (23 percent) from Kilosa and the remaining 133 (9 percent) from Manyoni.

The major purpose of the research was to identify singificant features of farms and villages in the Central Zone of Tanzania to assist in formulating and implementing strategies for rural development. As a result the research concentrated on collecting basic data on the villages and farms and in

providing working knowledge of the area.

The production function was estimated using the standard models - linear, Cobb-Douglas and quadratic. The output was defined as the market value (in dollars) of three major crops and the four inputs used defined as: (a) total amount of labor measured as the days of labor from both family and hired sources, (b) total hectares of land devoted to three major crops, (c) value of equipment measured as the total dollar value of seven equipment - shovel, fork, sickle, axe, ox plow, hoe and rake, (d) information index used for management and defined as a weighted value of extension activities.

The study found out that 75 percent of the farmers in the survey reported having an average of approximately two hectares of land. The results were somewhat high but refer to the total area used for three major crops. Farmers in Manyoni had the smallest average sized farm of 1.72 hectares while Dodoma and Kilosa had 2.04 and 2.21 hectares.

Farmers and their family members provided 57 percent of farm labor and children contributed 29 percent of the family labor. The distribution of labor shows that 17 percent of labor was used for seed bed preparation; 16 percent for planting, transplanting and broadcasting; some 16 percent for storing and godown; and 15 percent each for harvesting and transportation and cultural operations.

Except for a few, none of the farmers used any outside sources of seed, chemical fertilizer, insecticides and hardly any of them used farm machinery.

Maize was the first and most important crop for 33 percent of the farmers followed by millet (29 percent), sorghum (28 percent), rice (3 percent) and peanuts (3 percent). In an aggregate, 85 percent of all farmers grew maize; and November through December was the primary planting season while April through July, the primary harvesting season.

"Best" fits for this study were obtained using the Cobb-Douglas production function and the estimates showed that land had higher marginal physical product than either the labor or management practices.

Policy Implications

Based on the findings, the following are the major policy implications:

1) The government could encourage farmers in increasing land usage and expand the farm size.
2) The excess labor in the farming sector should either be used in expanding agricultural operations or be used in some off-farm activities.
3) The government should increase extension service to inform and educate farmers more in using improved inputs and proper farm management practices.
4) The farmers should be provided with liberal credit to procure and use improved inputs.
5) And the resulting effect of these policies will be to increase the production which, in turn, would require better marketing systems.

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