FACTORS INFLUENCING FARM INCOME IN MARGINAL AREAS OF THE LOWER COTTON ZONE IN EASTERN KENYA (MACHAKOS, KITUI AND MBERE DIVISION - EMBU)

BY

C. NYAWIRA MURIITHI

Thesis submitted in part fulfilment for the Degree of Master of Science in the University of Nairobi.

1979

I hereby declare that this thesis is my original work and has not been presented for a degree in any other University.

Nyawira

C. NYAWIRA MURIITHI

This thesis has been submitted for examination with our approval as university supervisors.

Mbatia

DOCTOR O.L.E. MBATIA

M.J. Dorling

PROFESSOR M.J. DORLING

TABLE OF CONTENTS

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF MAPS

ACKNOWLEDGEMENTS

I am very much indebted to the D.A.A.D. for providing me with the scholarship to under take this course.

I would like to thank my University Supervisors for the co-operation and encouragement they have individually shown me from the inception of this thesis to the end.

In addition there are those people who spared their time and showed alot of patience and understanding in discussing ideas concerning my thesis, reading the drafts and giving me constractive criticism. Above all they gave me the support I needed when nothing seemed to go my way. These people are too many to mention by name here but I am very grateful to them all.

Finally, my vote of thanks goes to the Central Bureau of Statistics for availing their survey data, staff and facilities to me. If it was not for their co-operation this thesis as it stands now could not be a reality. In this connection I would like to thank Mr. Scott Wallace for voluntarily taking the responsibility of guiding me in using the computor.

ABSTRACT

In view of the emphasis given to improving farm productivity in the marginal areas, the main objective of the study was to determine those factors that influence farm incomes in these areas. Other minor objectives were to determine the relative importance of these factors, and to establish whether their relationship with farm productivity depended on the method used to derive farm income.

The literature review indicated that various factors have been shown to influence farm income in the semi-arid areas as well as in other environments. Those that are considered in this study are the following; purchased farm inputs, crop area, labour, off farm income, sex of the farm operator, assets, family size and structure, the natural environment as defined by district, and the ease of transportation as specified in terms of the distance from nearest sizeable market to the holding.

The source of data was the Integrated Rural Survey 1 (IRS 1) of 1974/75 carried out by the Ministry of Finance and Planning. The analysis involved calculations of percentages, frequency distributions, correlation and regression coefficients and differences between the means of subsamples.

Three methods were used to calculate gross farm income and net farm income by taking into account that (a) livestock valuation change may be included or excluded in the calculation of farm income, and (b) as the data was collected during a drought period, an attempt can be made to offset the drought bias. Gross crop output was also considered as an independent variable.

It was found that although purchased farm input (fertilizer, seed, spray and machinery expenses) was the most important single factor influencing farm income and crop output, there was limited dependence on fertilizer, seed and sprays. Machinery expenses was the only specific purchased crop input significant in explaining the variation in crop output. The importance of this variable seems to stress the impact late planting and weeding have on crop output in marginal areas.

Crop area was shown to be positively related to farm income. However this was not indicated by the regression equation that had gross crop output as the dependent variable. Further analysis showed that different groups of farmers operating the same size of crop area had significantly different farm income. This was caused by significant differences in the amount of other factors used especially purchased crop inputs.

Both family and hired labour were significant in influencing farm income and crop output. Nevertheless, significant differences in gross crop output was detected between two groups of farmers who had comparable crop labour. Those that had a higher proportion of family labour achieved higher gross crop output than those who operated using a bigger amount of hired labour. Although further analysis in this connection was not possible in the study, the observation seems to imply that family labour contributes more to the success of small-scale farming than the same amount of hired labour.

With respect to off-farm income, the correlation and regression coefficients denoted that the relationship between this factor and farm income is small but negative. This finding supports observations made in the study area while it is contrary to other suggestions made on the basis of national sample of IRS 1. The farmers who have high off-farm income, hired significantly more labour but they did not purchase significantly more inputs. Off-farm income seems to offer an alternative to farming as the major source of livelihood in addition to competing for labour.

Farms operated by women were found to have significantly lower farm income and crop output than those managed by men. This is contrary to what was observed in high potential areas and confirms previous findings from the study area. The analysis implied that this is likely to be the result of the following factors; (a) women managers are associated with much higher off-farm income than men operators, (b) they use lower purchased farm inputs especially those that involve machinery expenses, and (c) they operate with lower family labour.

Assets were assumed to be the indicators of the "rich" farmers who could afford to purchase inputs and hire labour. The correlation and regression coefficients with respect to this factor and gross farm income indicated a positive association. Family size and structure, as measured in terms of consumer equivalents, was found to be positively related to farm income. Kitui District was shown to have lower gross crop output than Machakos District, which has higher and more reliable rainfall in general. The variable specifying the distance from the holding to the nearest sizeable market was not significant in any of the regression equations.

In general there was little variation in the relationship between the above factors and farm income, whether farm income was calculated including or excluding livestock valuation change, or compensating for the bias caused by the drought year. The gross farm income showed stronger relationship with these factors than net farm income.

CHAPTER 1

INTRODUCTION

1.1 Statement of the problem

In the past three development plans (1964-1978), Kenya Government has stressed the need to improve the standard of living and fulfil the basic needs of the population. The principal theme for the 1979-83 Development Plan is alleviation of poverty. In the agricultural sector, the plan focusses on small-scale farms, arid and semi-arid lands, with the intention of improving their participation in the monetary economy. Greater attention will be given to those small-scale farmers who have been lagging behind up to now. To realize these objectives the plan outlines some of the strategies as follows: First, resources will be devoted to identify inexpensive and easily repairable technologies which will promote small-scale farm productivity. Second, credit and extension will be directed more vigorously to small-scale farmers. Third, inorder to enhance the flow of farm inputs to these farmers and to expand the amount of farm produce that reaches the markets, rural access roads will be built. Finally, consumer goods, social services, water and power will be extensively extended in the rural areas (17, p. 14).

The plan pays special attention to arid and semi-arid areas because although they incorporate 80 percent of Kenya's land area, 50 percent of its livestock, and 20 percent of its population, they have received limited benefits from past development plans (17, p. 253). The 1979-83 Development Plan goes on to say that:

> They have major problems of increasing population pressure on a fragile ecology which has led to significant resource degradation, and low, risky income opportunities with a wide spread increase of poverty (17, p. 253).

Through the Ministry of Agriculture, the Government has launched a project called "Arid and Semi-Arid Lands Development Programme", to deal with the twin problem of alleviating poverty and rehabilitating land and water resources, in order to sustain development in these areas. It is hoped that this programme will minimize the need for famine relief, and integrate these areas into the national market economy, through increased productivity (17, p. 253).

This study focusses on the determinants of small scale farm incomes in semi-arid areas (marginal areas) of Eastern Kenya, that fall in the agro-ecological zone[1], Lower Cotton East of the Rift, as defined by the Integrated Rural Survey 1974-75 (IRS 1). The survey was conducted by the Ministry of Finance and

---

1 The definition of agro-ecological zone is given in Appendix 1.

Planning. Ambrose defines marginal areas as follows:

> Marginal areas (also called medium potential) refer to those areas where the production of annual field crops is limited severely by lack of available moisture, but where the use of out of the ordinary conservation methods and specially adapted crop varieties would make crop production sufficiently reliable for an increased population to be carried (2, p. 2).

The lack of adequate moisture and the unreliability of rainfall in marginal areas of Eastern Kenya has resulted in recurrent famines. Between 1860 and 1967, Mbithi (23, p. 6) points out that 12 severe famines and twice as many less significant crop failures were experienced in Machakos District. In the same area, famine is estimated to occur once in three years. Famine not only drains the economy but also interferes with the pace of development. Mbithi and Wisner (24, p. 5) emphasizing drought as a national problem observed that the cost of drought can be divided into direct costs and social costs. The former includes the cost the Government incurs mainly through famine relief. In addition, there are production losses because crops and animals in which farmers have invested money and labour are reduced in value. Social costs include nutritional problem and the diseases associated with this condition, family and community disruption as well as loss of human dignity. Finally, drought has been noted to have overall effects on the pace of technological change, which although most difficult to quantify, has significant negative and positive roles. The same authors point out further that the 1970 drought cost the Kenya Government KShs. 20 million in famine relief. They estimated that the total cost of drought was 10 times higher than the direct cost of famine relief (24, pp. 5,6).

The famine problem will be aggrevated unless small-scale farming technology exployed in marginal areas improves to accomodate the rapid population increase. Mbithi and Wisner stress that the annual population growth rates in certain of these marginal areas exceed 10 times the national average, and is up to 33 percent per annum in some parts of Machakos (24, p. 10). These extremely high population growth rates result from the influx of landless people from densely populated high potential areas, in search for land.

In summary, the marginal areas of Eastern Kenya experience famine regularly owing to hostile environment, especially inadequate rainfall. The condition is worsened by high population density and a farming technology not adapted to produce enough food for the population in the prevailing conditions. To amend this situation it is important to know what are the factors that determine small-scale farm income.

1.2 Objectives of the study

In order to contribute to solving the problem stated above, this study has the following objectives:

(a) To determine the factors which influence the level and variation of small-scale farm income in the study area, this is, Machakos and Kitui districts as well as Mbere Division of Embu district, as examples of the semi-arid region of Eastern Kenya.

(b) To determine the relative importance of these factors in determining small-scale farm income.

(c) To determine the influence different methods of calculating farm income have on its relationship with determinant factors.

1.3 Thesis organisation

The organisation of the thesis is as follows: Chapter 1 considers the problems of the study area and the resulting objectives of the study, Chapter 2 aims at familiarizing the reader with the special circumstances under which small-scale farmers in these areas operate. In Chapter 3 the literature is reviewed to summarize the present knowledge of the problem, with special emphasis on the factors that are likely to influence farm income. Theoretical determination of small-scale farm income is analysed in Chapter 4, while the methodology is covered in Chapter 5. The results of the analysis with respect to the objectives of the study is the subject matter of Chapter 6. Finally, Chapter 7 gives the conclusion and recomendations derived from the study.

CHAPTER 2

BACK-GROUND INFORMATION

2.1 Importance of Small-scale Farm Income

Inadequate income is the most obvious characteristic of poor small scale farmers. The 1979-83 Development Plan points out that:

> The Integrated Rural Survey of 1977 discloses that 41 percent of families engaged in smallholder agriculture - a group that represents about 80 percent of Kenya's total population - had incomes, including subsistence production, of less than Sh. 2,000 per family in the year 1974/75. Another 14 percent of those families had incomes in the range of Sh. 2,000 to Sh. 3,000 per family (17, p. 11).

The plan points out further that even incomes of that range are not sufficient to provide more than the basic necessities of life.

Although farming is the predominant occupation of small-scale farmers in the study area, net-farm income contributes only about 33 percent of the total household income per adult equivalent (Tables 2.1). Moreover the contribution net-farm income makes to total household income, depends on the agricultural potential of the area. Generally, the contribution made is highest in high potential areas where tea or coffee is the main cash crop. The contribution made is lowest in Lower Cotton Zone and the Coast Composite.[1]

---

[1] See Appendix 1

TABLE 2.1: AVERAGE HOUSEHOLD INCOME PER ADULT EQUIVALENT ACCORDING TO AGRO-ECOLOGICAL ZONES USED IN IRS 1 1974-75

	AVERAGE KShs PER ADULT EQUIVALENT			
AGRO-ECOLOGICAL ZONE[1]	NET-FARM[2] INCOME	OFF-FARM INCOME	TOTAL HOUSEHOLD INCOME	$\frac{\text{NET-FARM INCOME}}{\text{TOTAL HOUSEHOLD INCOME}}$ X100
Tea West of Rift	511	322	833	61.34
Coffee West of Rift	543	187	730	74.38
Upper Cotton West of Rift	330	258	588	56.12
Tea East of Rift	526	309	835	62.99
Coffee East of Rift	467	408	875	53.37
Lower Cotton East of Rift	196	406	602	32.56
Coast Composite	191	406	597	31.99
KENYA	437	310	747	58.50

SOURCE: Smith, L.D. (30, pp. 39, 41)

1 See Appendix 1 for IRS 1 definition of agro-ecological zone.

2 Definitions are given in Appendix 1.

Of the zones covered by IRS 1 these have some of the lowest farming potential.

2.2 The Study Area

The agro-ecological Zone, Lower Cotton East of the Rift, as defined in IRS 1 is shown in Map 1.1.

Luning (20, p. 4-5) estimated that the population living in marginal areas of Eastern Province is about 1.5 million, as assessed by the 1969 census. The distribution is shown below.

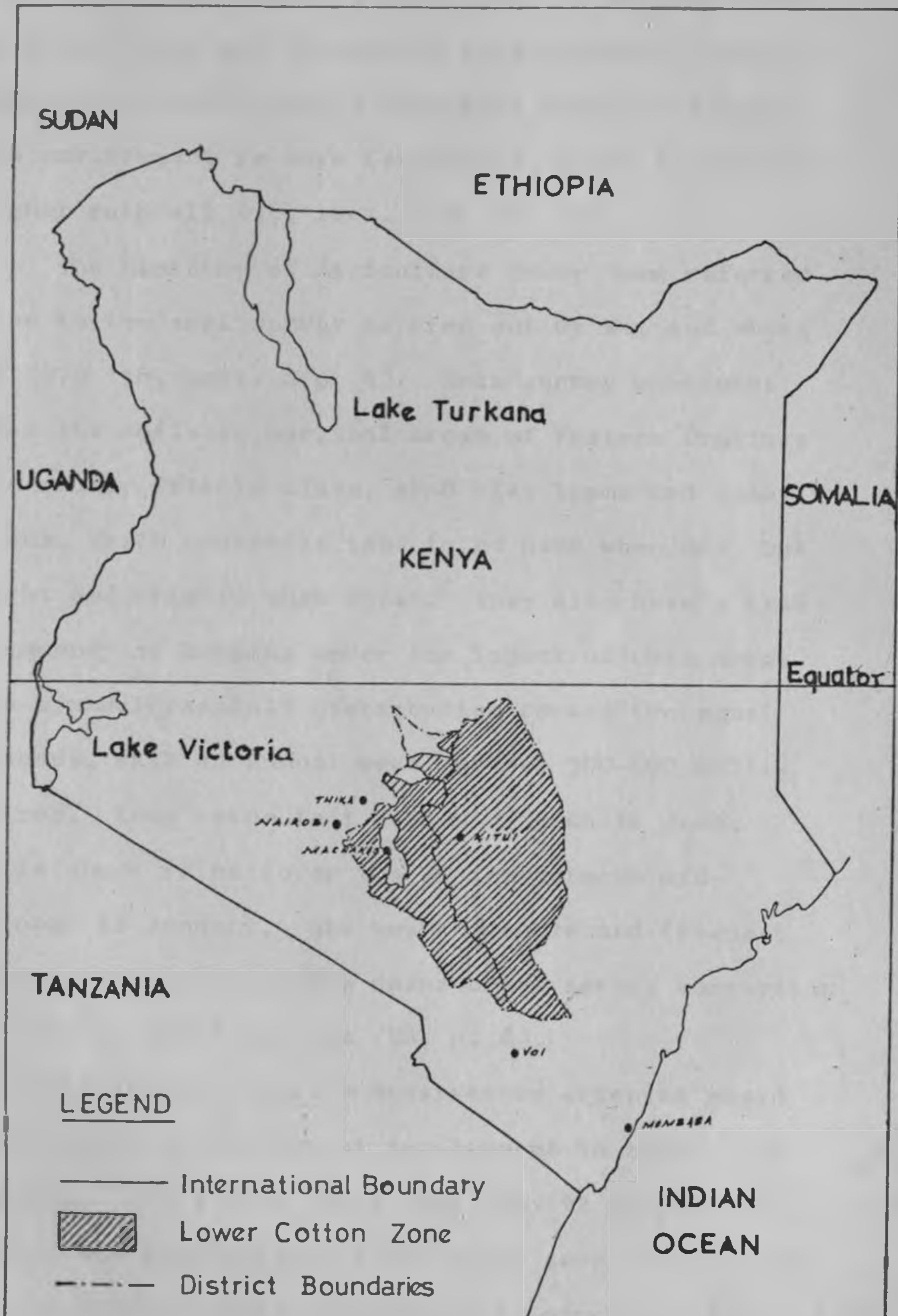
Machakos District	707,000[1]
Kitui District	343,000
Mbeere Division (Embu District)	65,000
Total (1969)	1,115,000

The population occupying the marginal areas of Machakos District is estimated by the Ministry of Agriculture Study Team, as 636, 954 (16, sect. 2 p.4). According to this team the average population density in marginal areas of Eastern Province is 53 persons per square kilometre, as assessed by 1977 population estimates. The averages for Machakos and Kitui are 91 and 26 persons per square kilometre respectively.

---

1 In the 1969 Population Census (13, p. 1), this figure shows the number of people in the whole of Machakos District and not in the marginal areas of this district only.

MAP 1.1: AGRO-ECOLOGICAL ZONE LOWER COTTON EAST OF THE RIFT.



The spatial distribution of population in the area largely depends on the influence of physical factors, especially topography, availability of surface water, soil fertility and prevailing socio-economic factors. Machakos is more densely populated than Kitui since its environment is more favourable, owing to relatively higher rainfall (16, sect. 7 p. 10, 11).

The Ministry of Agriculture Study Team referred also to the soil survey carried out by Weg and Mbuvi in 1975 (16, sect. 2 p. 4). This survey concludes that the soils in marginal areas of Eastern Province are mainly friable clays, sand clay loams and loamy sands, which generally tend to be hard when dry, but light and friable when moist. They also have a high frequency of capping under the impact of rain drops. The bimodal rainfall distribution covers two equal seasons, with an annual mean between 500-800 millimetres. Long rains fall from mid-March to June, while short rains cover the period between mid-October to January. The unpredictable and frequent late arrival of planting rains cause severe congestion of work in short periods (20, p. 8).

The farmers operate subsistence oriented mixed farms, with a substantial involvement in buying and selling. IRS 1 data shows that only 42 percent of total food consumption in the study area is produced in the holding, while 58 percent is purchased (15, p.63).

The main subsistence crops include maize (a high proportion is Katumani maize), beans, pigeon peas, cowpeas, sorghum, millets and cassava. A substantial number of farmers grow cash crops like cotton, sunflower and some sisal. Smith (30, p. 11) emphasizing the subsistence nature of farming in the study area, points out that 95.8 percent of the value of agricultural output is contributed by food crop, 0.8 percent by export crop and 3.4 percent by livestock and milk.

Except for Government sponsored effort, dependence on modern purchased inputs is limited. This is particularly so with respect to fertilizer and sprays[1]. The average cost incurred per holding for these inputs is negligible. However there is a substantial dependence on purchased seed and machinery expenses[2]. For these inputs each household incurred KShs. 58.00 and KShs. 49.00 respectively on the average (15, p. 69).

In the study area, it is found that the dominant tillage practice is the conventional hand hoe (jembe), ox-plough, or to a lesser extent, tractor ploughing coupled with harrowing. Infact, over 90 percent of

---

1 In this study the term 'sprays' will be used to refer to all plant protection chemicals which can either be dust or sprays.

2 The term 'machinery expenses' will be used to refer to the cost incurred hiring oxen, ox ploughs and tractors for farm operations. For those farmers who owned these implements the cost was imputed.

the farmers in Machakos and about 55 percent of the farmers in Kitui make use of ox-ploughs, through ownership or hiring (16, sect. 2 p. 24).

Soil erosion is a severe problem both on cultivated and grazed land. Livestock is kept more as savings than a production asset. As illustrated in Table 2.2, off-farm income contributes 72 percent of the average household income. This shows that many families depend heavily on off-farm income owing to unreliability and insufficient crop and livestock production.

2.3 Source of Data

IRS 1 data was selected in preference to conducting a field survey owing to reasons discussed below.

(a) Farm income and most of the explanatory variables considered in the analysis involve physical measurement converted into value terms, using prevailing local market prices over a period of one year. Owing to limitations of time and money, field survey would consist of a single visit interview. The farmer would be asked to recall what he had been involved in over a period of one year, since no farm records are kept. IRS 1 data is more reliable because farmers were visited twice in 4 weeks making this the maximum

TABLE 2.2: PERCENTAGE DISTRIBUTION OF AVERAGE HOUSEHOLD INCOME IN THE LOWER COTTON ZONE ACCORDING TO THE SOURCE OF INCOME

SOURCE OF INCOME	PERCENTAGE
Farm Operating Surplus[1]	26.06
Non-Farm Operating Surplus	24.65
Regular Employment	15.49
Casual Employment	15.97
Remittances from Relatives	15.45
Other Gifts	2.38
Total Household Income	100.00
Total Value of Household Income	KShs. 2,479.00

SOURCE: Kenya. (15, p. 57)

---

1 The definitions are given in Appendix 1.

recall period for the information obtained. In addition, land area and crop plots covering the whole of the survey period were actually measured by the enumerator.

(b) IRS 1 covered the whole of the ecological zone. This would not be possible with a field survey and the area covered would be confined to a single location. Such data may not be adequate for inferences to the whole zone.

(c) One of the objectives stipulated by the National Integrated Sample Survey (NISSP), and IRS 1 was the first survey conducted under this programme, was to "... yield the economic statistics required to investigate the performance of small-holder agricultural sector ..." (15, p. 1). This means that when researchers interested in smallholder farming make use of this data, they are contributing to the realization of the survey's objectives.

(d) Although the data was collected about four years ago, most of the analyses, especially that done by the Bureau, only consists of cross-tabulations at national level. In fact, it is reported that regression analysis has not been tried on the data (21). Hence, although the data can be termed as secondary, there is still a lot of analyses that it has not been subjected to at national and zonal levels. An example is an analysis of farm income determining factors in the ecological zone, Lower Cotton East of the Rift.

CHAPTER 3

LITERATURE REVIEW

This chapter will review the literature related to research findings and the methodology used in the marginal areas and comparable circumstance. It was found convenient to deal with the literature review under subheadings of selected explanatory factors, in order to clarify what information is available for each factor, and to indicate the additional information that can be contributed by the study.

3.1 Relationship between Farm Size and Farm Income

IRS 1 defined small-scale farms as those farms not exceeding 20 hectares (15, p. 10). In marginal areas, the land area per person varies from 0.97 hectares in the longer settled areas with less variability in rainfall to 2.93 hectares in the newly opened settlement areas of high rainfall variability. Even assuming maximum efficiency there are currently smallholders operating on farms in marginal areas that are too small to guarantee subsistence. Lynam (21, p. 167) argued that as the average cultivatable area decreases to about 2.0 hectares, it becomes increasingly difficult to guarantee even basic subsistence food. The cropping pattern diversifies so that farmers grow more drought resistant crops that yield less, like cowpeas and pigeon peas, to avoid the risk of famine. IRS 1 (15, p. 45) shows that 53 percent of small-scale farms in the study area are below 2.0 hectares. After deducting homestead and grazing areas, the cultivated area is decreased even further.

Farmers can meet their minimum income objectives by varying the cropping pattern or by increasing the cultivated area. Since the study area is an in-migration area, farm size and hence cultivated area will continue to decrease. This will cause a shift to a cropping pattern that reduces the farm incomes even further, owing to low yields. One of the factors influencing benefits arising from adoption of new technology is farm size. This is supported by the conclusion Lynam made about the effect of Katumani maize technology, on farmers who had adopted inter-row oxen weeding in marginal areas of Machakos. He concluded that; "... for farm sizes of 3 hectares incomes improved by 50 percent with the new technology where as on farms of 5 hectares incomes improved by 70 percent" (21, p. 174).

In 1974/75, Lagemann (19, p. 105) analysed the determinants of farm family income for villages of different population densities in Nigeria. He concluded that only farm size (cultivated area) showed significant positive effect on farm family income in the multiple linear regression function. Ruthenberg (29,

p. 329) also used multiple linear regression model, to show the determinants of gross farm income of different farming systems in Tanzania. He concluded that land coefficients were high and almost always significant. This was not the case with labour coefficients. These two analyses were carried out in situations where labour was in plenty but land was scarce as a result of high population densities. This is expected in the study area because of high rate of in-migration which is reducing farm sizes. In addition some of the land is unsuitable for cultivation owing to topography and soil erosion.

3.2 Relationship between Labour Input and Farm Income

The major inputs available to a subsistence farmer are land and labour. Land is more or less fixed so that the seasonally variable resource is labour. Labour will influence farm income from three points of view:

(a) the amount of labour applied;

(b) the timing of labour application; and

(c) the efficiency of labour (21, p. 116). The seasonal shortage of labour experienced in marginal areas is caused by serious out-migration especially of male adults. Moreover, farming is carried on jointly with off-farm activities. In 1971 Mbithi

(23, p. 13) found that only 34 percent of the males in his sample did not have off-farm jobs, and 65 percent of the adult males were outside the survey area on employment. With respect to females 70 percent did not have off-farm jobs and only 6 percent were outside the survey area on employment. Stressing the importance of the amount of labour available, the Study Team of the Ministry of Agriculture (16, sect. 2 p. 68) pointed out that where traditional technology is used, the full time services of one adult are required for every 0.5 hectares of cultivated land. When this ratio increases labour shortage becomes a fact. Heyer (5, p. 8), examining the alternative development for marginal areas of Machakos farms concluded that although returns to labour are extremely poor and labour can not be considered scarce at the present returns to scale, shortage of labour at particular times of the year does determine production patterns.

The timing of farm operations requiring labour (timing of labour application) is important in marginal areas, because high crop yields will only be obtained if as much as possible of the available moisture is utilized by the crop. Thus time of planting and weeding is important in determining crop yield. In this respect Nadar and Rodewald (27, p. 7) emphasized Marimi's findings at Katumani Research Station. They stated that during the long rains 1974, delay in planting for 8 days after the onset of the rains reduced Katumani maize yield from 2530 kg/ha to 410 kg/ha or by 80 percent. It was concluded that late planting is the single factor which accounts for the most severe reduction in yield. The importance of timing of labour application is also reflected by the importance of time of weeding. This is because crop and weeds compete not only for nutrients but also for moisture, which is scarce in marginal areas. Table 3.1 shows that the highest yields for maize and beans were obtained when the crops were dry planted. The yield decreased as planting date was delayed after the onset of the rains. It shows further that the lowest yield was obtained from a crop that was not weeded at all. Moreover competition from weeds is most damaging during a period of 3 weeks after crop emergence. In fact clean weeding that is started 3 weeks after crop emergence and continued to the end of crop season, or clean weeding throughout the crop season, does not cause any major increase in crop yield over and above that obtained by weeding 3 weeks after crop emergence only.

The third factor of interest with respect to labour application is efficiency. This refers to the quantity and the quality of work provided by a man-hour of labour. These are difficult parameters to

TABLE 3.1: EFFECT OF TIME OF PLANTING AND WEEDING ON MAIZE AND BEAN YIELDS AT KATUMANI RESEARCH STATION IN 1970

Quintals/Hectare

	WEED CONTROL				
TIME OF PLANTING	WO	W_1	W_2	W_3	Mean
Grain Yield of Maize					
To	9.4	45.4	43.9	50.8	37.4
T_1	0.8	35.1	13.7	40.9	22.6
T_2	17.4	38.7	42.0	45.8	36.0
T_3	8.2	34.8	28.7	27.7	24.9
Mean	8.9	38.5	32.1	41.3	30.2
Grain Yield of Beans					
To	17.5	31.4	30.1	36.1	28.8
T_1	13.5	26.3	27.5	26.7	23.5
T_2	6.8	13.3	14.4	13.9	11.9
T_3	10.3	17.9	16.7	17.5	15.6
Mean	12.0	22.2	22.2	23.4	19.9

Time of planting

To - Dry Planting (pre-rain planting)

T_1 - Planting 7 days after the onset of rains

T_2 - Planting 14 days after the onset of rains

T_3 - Planting 21 days after the onset of rains

Weed Control

W_o - No weeding

W_1 - Clean weeding the first 3 weeks from crop emergence

W_2 - Clean weeding starting 3 weeks after crop emergence and continues to end of season

W_3 - Clean weeding throughout crop season

SOURCE: Kenya. (14, p. 221)

measure and have been excluded from most analyses concerning labour. In this study it will be assumed that a man-hour of labour produces the same quality and quantity of work.

Lagemann (19, pp. 103, 105) found that in the single variable linear regression model, the higher the labour capacity on the farm in man equivalents (ME), the higher the total farm family income. However labour capacity in ME and the cost of hiring labour, were not significant determinants of farm family income in the multiple linear regression analysis. Ruthenberg (29, p. 329) also concluded that labour in man-hours was not significant in explaining changes in gross farm income of smallholder agriculture in Tanzania. The possible explantion is that the quality of labour was not included in the multiple linear regression analysis. It is also likely that, for the technology used in these areas, land but not labour is limiting on most holdings. Owing to labour shortage during planting and weeding and in some cases during harvesting, labour is expected to be a significant determinant of farm income in the study area. Shortage of labour for harvesting occurs particularly where ox-ploughing has expanded the cultivated area.

3.3 Relationship between the Level of Technology and Farm Income

Heyer et al (6, p. 216) pointed out that drought and famine, as well as general low income in the marginal areas of Eastern Province, can be seen as the result of population increase, which is faster than advances in technology of production cater for. The result is that the carrying capacity of land is reached and surpassed. The International Labour Office (ILO) (9, p. 152) points out that many of the working poor in the rural areas lack some of the requirements for intensive farming. These are relevant technology, training, credit, access to necessary inputs (including water), appropriate pricing policy for purchased inputs as well as agricultural commodities, and assured access to markets. It is argued further that if these requirements are fulfilled, there is a wide variety of farming systems by which 1.0 hectare or less would provide a family with sufficient food and the cash income for purchasing at least the necessities of life. In marginal areas emphasis is laid on improving crop production by advancing the use of technological inputs especially the following: improved seed, fertilizer, sprays and machinery for timely planting and weeding.

(a) Fertilizer and improved seed

New technology in form of new seed varieties especially Katumani maize adapted to drought conditions, and fertilizer to augment soil fertility, are of major importance in the study area. Table 3.2 illustrates the effect of fertilizer and improved seed on some of these crops. The survey consisted of 40 farmers in Mbiuni area of Machakos District during 1977 long rains. Low yields were obtained for all crops in this season. The table shows that the yield obtained from local seed increased when fertilizer was used. Sorghum was an exception. Improved seed without fertilizer shows very little increase in yield over and above that obtained using local seed and no fertilizer. In some cases for example that of beans, the yield actually decreased. The highest yield for maize and beans in pure stands was obtained using improved seed and fertilizer. However net income may not be increased by higher yields resulting from use of fertilizer and improved seed if the cost of these inputs is considered. Moreover rainfall may not be enough to make the fertilizer available to the crop. The risk of crop failure may be major reason for farmers not to invest the limited cash income in these inputs.

TABLE 3.2: AVERAGE YIELD PER HECTARE OF SELECTED CROPS GROWN UNDER DIFFERENT LEVELS OF TECHNOLOGY

CROP		Technology level kg/ha			
		1	2	3	4
Maize		240.00	324.00	261.00	739.00
Beans		338.00	525.00	283.00	551.00
Millet		247.00	617.00	-	-
Sorghum		889.20	370.00	-	-
Maize and Pigeon Pea,	Maize	441.51	-	232.97	323.15
	Pigeon Pea	194.34	-	204.96	127.28
Maize and Cowpea,	Maize	227.24	487.50	316.16	-
	Cowpea	88.92	129.95	37.05	-

Technology 1 = Local seed, no fertilizer used.
" 2 = Local seed, fertilizer used.
" 3 = Improved seed, no fertilizer.
" 4 = Improved seed, fertilizer used.

SOURCE: Nadar, H.M. and Rodewald, G.E. (27, p. 4)

(b) Plant protection chemicals

Crops vary in their susceptibility to pest and disease damage. Wilde (33, p. 109) cited cotton as one of the most promising and rapidly developing cash crop grown in marginal areas of Machakos District. Insecticides rank high as one of the necessary inputs to obtain high yields in cotton. Acland (1, p. 107) pointed out that in Kenya there can be a tenfold increase in cotton yield owing to a complete spraying programme. Failure to spray can result in complete crop failure. However, a crop that is not planted in time for the rains, properly weeded and thinned, will not produce high yield even if it receives a complete spraying programme.

Acland pointed out further that for cowpeas, a major drought evading crop in marginal areas, a 340-450 kg/ha yield can be obtained with good husbandry without using insecticides. The Study Team of the Ministry of Agriculture (16, sect. 2 p.17) stated that 25 to 30 percent of the yield of crops in marginal areas is lost due to insect damage. It is expected that farmers who minimise these losses realise higher yields. However net farm income may not be increased because there may be inadequate water to mix the sprays as recommended and there may be labour shortage during busy period.

(c) Machinery expenses

Late planting has been stressed as the major limiting factor in increasing crop productivity in marginal areas. Two reasons are given for late planting. First, the previous crop, usually maize, is late for harvesting. Second, although the previous crop is harvested, the ground is too hard to dig using hand tools and the farmers wait for the rains to soften the ground. The second problem can be solved by hiring a tractor or ox-ploughing immediately after harvesting the previous crop, before the ground hardens.

It was mentioned previously that 90 percent of farmers in Machakos and 55 percent in Kitui Districts own or hire ox-ploughs. The Kitui District Annual Report, 1975 (18, p. 25) shows that there were 30 tractors available for hire in Kitui that year. The charges for tractor ploughing that were common were KShs. 120 to KShs. 150 per hectare for new land and KShs. 50 to KSh. 100 per hectare for old land. The same annual report states further that in the same year, the Catholic Relief Service produced 200 ox-ploughs on loan, payable at KShs. 50 per season, although there were 4,277 ox-ploughs already in the district. It is likely that these were inadequate.

The use of ox-ploughs for land preparation and inter-row weeding not only expands the area under crop but also enables planting and weeding to be done on time, with respect to the rains. The result is increased crop output and hence higher farm incomes. Thus there is reason to associate higher machinery expenses with higher farm incomes.

3.4 Relationship between Off-farm Income and Farm Income

Smith analysed IRS 1 data on national basis and concluded that off-farm income:

> ... is the key element in determining the productivity and output of the farming enterprise and the overall level of household income. For instance, the relatively high level of income from regular employment by those household with a per adult equivalent income of over Shs. 1000 per annum, provides a constant source of cash, bringing in its turn flexibility, and security, a source of collateral for borrowing funds, as well as a higher standard of living (30, p. 36).

He states further that off-farm income, especially from a regular source, enables farmers to purchase farm inputs and hire labour. This might mean that more land is planted, weeded and harvested in time, leading to increased farm output. Although some potential farm labour is lost in off-farm employment, compensation can be made in terms of more hired labour and purchased inputs from off-farm income. However, there are differences in the importance of off-farm income among the ecological zones of IRS 1. Table 2.1 shows that off-farm income in the Lower Cotton

Zone accounts for 67 percent of the household income, while it contributes only 26 percent of household income in the Coffee Zone West of the Rift. Off-farm income seems to be of less importance in areas of high agricultural potential. Mbithi (23, p. 13) analysed the relationship between off-farm occupation and farm innovation in margianal, medium and high potential areas. He concluded that the agricultural potential of an area determines the magnitude of off-farm occupation. The region with the lowest potential had the highest off-farm occupation score. Those farmers who had the lowest score for adoption of recommended farming practices had the higher off-farm occupation score.

The literature seems to provide contradicting information on the effect that off-farm income has on farm income. Smith points out that a positive relationship exists while Mbithi argues that the relationship is negative. The analysis will attempt to find supporting evidence for these points of view.

3.5 Relationship between Assets and Farm Income

The term 'assets' will be used in the thesis to indicate the values of land, buildings, cattle and other livestock.

At national level, IRS 1 data analysed by Smith (30, p. 38) showed a strong positive relationship between household income and the level of assets per adult equivalent. Cattle and other livestock were the most important assets, and these contribute to over grazing leading to severe soil erosion. Infact, the Study Team of the Ministry of Agriculture states:

> Livestock in large numbers are still considered to be an insurance against drought and much overstocking is done for this reason. Attributes of wealth and prestige are additional reasons for the present very severe imbalance between livestock and forage (16, sect. 6 p. 13).

Smith observed that on the average the richest small holders seem to have higher levels of assets[1]. This gives them security against risk of crop failure and collateral for borrowing loans. In marginal areas the risk of crop output falling below subsistence level owing to drought is an important determinant of the economic behaviour of the farmer. Livestock as part of farm assets can be sold or slaughtered during a famine crisis. The importance of this security is emphasized by the frequency of crop failure previously mentioned and illustrated in Table 3.3. Out of the 5 years shown, 3 years had crop failure. In one of these years crops failed in both seasons while only one season failed in the other two years.

---

1 It is obvious that the richest farmers own a lot of farm assets. However, this is not the case if such assets have been acquired by accumulating liabilities.

TABLE 3.3: REPRESENTATIVE MAIZE YIELDS OF THE SEMI-ARID AREAS OBTAINED FROM KATUMANI RESEARCH STATION

Quintals/ha

YEAR	Long Rains	Short Rains
1968	34	51
1969	13	12
1970	35	fail
1972	fail	51
1973	fail	fail

SOURCE: Fisher, N.M. quoted by Lynam (21, p.12)

Wilde (33, p. 113) pointed out that livestock is kept as savings for security reasons, rather than production assets. The Study Team of the Ministry of Agriculture (16, sect. 6 p. 13) observed that the quality of animals is low and sometimes up to 30 percent of the herd are bulls. Smith (30, p. 37) stated that assets can also be viewed as an indicator of past economic performance and success of the farmer. Successful farmers are expected to have higher crop output owing to use of more technological inputs. Moreover if assets give security against crop failure, farmers with high asset levels may grow crops that are high yielding, although more susceptible to drought. These attributes suggest that farm income may be influenced positively by the level of assets on the farm.

3.6 Relationship between Family Size and Structure and Farm Income

Hunt (8) tested whether Chayanow's model of peasant household resource allocation was relevant in Mbeere Division, Eastern Kenya. The model suggests that in a given environment, income per consumer would tend to be more the higher the producer-consumer ratio of the household. Where this ratio is low, the work force would be compelled to work harder and longer hours to achieve minimum output per consumer. Hunt (8, p. 24) analysed 23 households and found no correlation between the producer-consumer ratio and income per consumer (per capita income). She explained this lack of correlation by the education effect and perhaps the small sample.

It seems plausible to suggest that the consumer pressure in a household will influence the output of a farmer, whose main concern is to feed the family. The analysis will attempt to find out whether household requirements for food and other necessities have any influence on farm output and hence farm income.

3.7 The influence of Sex of the Farm Operator[1] on Farm Income

The Study Team of the Ministry of Agriculture (16, sect. 7 p. 28) stated that in marginal areas 30 percent of the males are away on employment and the number of children attending school has increased. The result is an increased burden on women. Food preparation alone may claim up to 3 hours of their time a day. In addition they have to fetch water over long distances (many homesteads are located over 10 kilometres from water source), search for fuel and take care of children as well as livestock. Women are also

---

1 See Appendix 1

involved in the marketing of small amounts of farm produce, which is an important source of their cash income. All these activities are undertaken in addition to farm work. This team observed further that the most inefficient farms are those where the male household head is away. However it is cautioned that this is no reflection on a woman's ability as a farm manager, but an indication of the increased demand and pressure on her time. Moreover the team states:

> ... where husband and wife or wives are all present and working on the farm, the more successful the operation is likely to be. Whether this is an indication of the labour input into the operation by the husband or whether it is due to better farm management is open to question (16, sect. 2 p. 69).

The team goes on to point out that where ox-ploughs are used for land preparation and for the first two weedings, men usually do the ploughing. It can then be assumed that the success of the season arises from the contribution men's labour make during land preparation (so that planting is timely) and weeding. But since women too handle the plough, the presence of men should make no difference to the efficiency of the farm.

On the other hand Moock's (25, p. 251) study on determinants of maize yield in Vihiga western Kenya concluded that generally women are more competent than men as farm managers. In other words women produce more output from a given package of maize inputs than men. This argument still holds even when women managers operate with lower levels of formal education and extension contact. Wives of absentee heads of household have to operate with less inputs because husbands are reluctant to invest in the farm during their absence.

The above account seems to suggest that there is actually a difference in farm income between farms operated by men and those operated by women. This will be tested in the following analysis.

3. 8 The contribution of Credit to Farm Income

Hunt (7, p. 25) studied the response of different income groups of small-scale farmers to agricultural innovations recommended by the extension staff in Mbere Division. She concluded that the inputs recommended to farmers required higher capital outlay than they could afford because they often had hardly any capital. Moreover, the extension staff tended to concentrate on those farmers who are likely to adopt advice, and those are the well to do farmers with cash income to spend on purchased inputs.

Credit facilities like the Smallholder Production Services and Credit Project (SPSCP) started in 1975/76, and the Integrated Agricultural Development Program (IADP), started later, have the objective of enabling smallholders to overcome their cash constraints and use more modern purchased inputs. Moock (25, p. 256) stated that one of the reasons explaining maize yield differences between credit recipients and non-credit recipients is that the former used more physical inputs, especially improved seed and fertilizer. If credit is used on purchased inputs according to recommendation, then a positive relationship is expected between the volume of credit and crop output and hence farm income.

3.9 The influence of Distance to sizeable Markets on Farm Income

Mosher (26, p. 11) classifies transportation as one of the factors required to facilitate agricultural development. The Study Team of the Ministry of Agriculture (16, sect. 3 p. 19) observed that in marginal areas this service, so important for the development of a modern market oriented agriculture, is only available in the dry season on a limited basis. Although smallholders may be subsistence oriented, they are involved in selling their produce and buying other necessary items for subsistence. Moreover if modern purchased inputs are to have any impact on these farmers, they must be easily accessible. However, there is no research work done in marginal areas concerning the relationship between farm income and access to markets. This study will attempt to establish whether ease of transportation in marginal areas has any impact on farm income.

3.10 Influence of Natural Factors on Farm Income

Differences in soils and especially rainfall are expected to be the major source of variation in crop output and hence farm incomes between Kitui and Machakos Districts. The former is more arid and the probability of crop failure is higher. For this reason drought resistant crops are relatively more important in Kitui than in Machakos. Infact the Study Team of the Ministry of Agriculture (16, sect. 2 p.11) states that maize is commonly grown in Machakos as the major staple food, while it is replaced by cowpeas (more drought resistant) in Kitui. Drought resistant crops are generally low yielding, and for this reason crop output and hence farm income are expected to be higher in Machakos than in Kitui.

3.11 Conclusion for the Empirical Analysis

The above discussion gives evidence that the following factors influence small-scale farm income:

(a) Farm size will have positive effect as long as labour is not limiting.

access to markets. This study will attempt to establish whether ease of transportation in marginal areas has any impact on farm income.

3.10 Influence of Natural Factors on Farm Income

Differences in soils and especially rainfall are expected to be the major source of variation in crop output and hence farm incomes between Kitui and Machakos Districts. The former is more arid and the probability of crop failure is higher. For this reason drought resistant crops are relatively more important in Kitui than in Machakos. Infact the Study Team of the Ministry of Agriculture (16, sect. 2 p.11) states that maize is commonly grown in Machakos as the major staple food, while it is replaced by cowpeas (more drought resistant) in Kitui. Drought resistant crops are generally low yielding, and for this reason crop output and hence farm income are expected to be higher in Machakos than in Kitui.

3.11 Conclusion for the Empirical Analysis

The above discussion gives evidence that the following factors influence small-scale farm income:

(a) Farm size will have positive effect as long as labour is not limiting.

(b) Labour capacity is shown to be unlimiting in areas of high population density. Since the study area is a zone of in-migration for the landless, and at the same time there is serious out-migration especially of men looking for off-farm employment, the study will attempt to establish whether labour shortage influences farm income.

(c) The studies done so far indicate that although fertilizer and improved seed do have positive effect on farm income, ox-plough and/or tractor hire, which enable the farmers to plant and weed early, are even more important in marginal areas because moisture is limiting. The analysis will give more evidence for supporting this point of view.

(d) The literature review gives contradicting suggestions on the influence of off-farm income on farm income. The results of this analysis will give grounds on which to support these proposals.

(e) It is stressed that high asset levels denote those farmers who have resources to improve farm productivity. This assertion will be confirmed if the analysis indicates that assets are positively associated with farm income.

(f) There is limited research findings available on the relationship between family size and structure on farm income. The analysis will attempt to indicate what kind of relationship is expected.

(g) Studies done in high potential areas show that women are more competent in managing small-scale farms than men. The contrary has been suggested in marginal areas.

(h) Farmers especially in marginal areas do not use recomended purchased inputs like fertilizer, seed and spray. It is implied that they are short of cash revenue to spend on them. Thus, the provision of credit is expected to increase the volume of the purchased inputs and hence farm productivity.

(i) It is anticipated that in areas which are adequately served by means of transportation there will be the incentive to produce for sale. Purchased inputs will also be easily accessible. The study will attempt to establish that the association between farm income and distance to the nearest sizeable market, as an indicator of ease of transportation, is positive.

(j) Natural factors especially rainfall and soils affect farm production. Kitui District is more arid than Machakos District, implying that other factors remaining equal, farm incomes are expected to be lower in the former area.

CHAPTER 4

THEORETICAL ANALYSIS

The literature review outlined the effects of some of the factors that are likely to influence farm income, as analysed in marginal areas and other environments. The purpose of this chapter is to relate Economic Theory to the observations and information available.

The factors of production[1] in agriculture are land, labour, capital, management, infrastructure and natural environment. If Y is the output, the production function becomes

$$Y = f\ (a, b, c, d, e, f)$$

where

Y = Farm income

a = Land

b = Labour

c = Capital

d = Management

e = Infrastructure

f = Natural environment

---

1 These factors of production are not meant to correspond with the classical concept of four main factors of production.

In the review of the literature, land was dealt with as farm size and labour was referred to directly. Technological inputs, credit, assets and off-farm income will be covered under the term capital. Differences in the sex of the farm managers is used to show variation in management capabilities between sexes. Transportation is the only aspect of infrastructure that will be considered, while geographical location, as defined by district, will be used to indicate the differences in natural environment between Kitui and Machakos Districts. Finally farm production decisions are made bearing in mind family's subsistence needs, hence, the pressure exerted by subsistence requirements will also be considered.

Local market prices were used to convert farm output into value terms. It was assumed that resources were equally productive regardless of the activity they were used for. This procedure can introduce some bias as resource productivity varies with its scarcity. For example, a man-day spent in planting the crop in time for the rains may contribute more to crop output and hence farm income than a man-day spent looking after livestock. However, the scope of this study does not allow the consideration of other alternative methods.

Land becomes an effective limitation in agricultural production where population density is high.

This is because under a given level of technology, the total yield will be increased by putting more land under cultivation. As denoted in the literature review, land has become a limiting factor in some parts of the marginal areas, especially where rainfall is relatively more reliable, owing to in-migration from high potential areas. If more intensive methods of production are used, farm productivity will be increased without expanding land under cultivation. However, if intensification is done without replacing the soil nutrients removed by the crop, the soil will deteriorate. This is what happened when the intensity of production was increased by eliminating the fallow period. Modern technology aims at improving farm productivity without impoverishing the soil.

Land as a variable affecting farm production can be considered either as total farm size, cultivated area or crop area. Crop production and livestock (grazed in the open field) are activities carried on side by side in the study area. The cultivated area is controlled by the subsistence needs of the family and grazing requirements. Since livestock is kept as savings rather than for production purposes, the major contribution to farm production is made by crops. As such, the crop area is expected to be positively related to farm income and particularly to crop output. Total farm size is not an adequate parameter for area under crop, because some parts of the farm are used as homestead and grazing areas, while others may not be suitable for cultivation. Crop area is considered a better index for land under crop, since it puts together the effects of cultivated area and the number of croppings in a year. In the study area the rainfall is bimodal and two crops in a year are recommended.

The effort human beings put into production, be it manual, mental, skilled or unskilled is termed as labour. The total amount available depends on the number of people available and the effort made by each of them. Upton (32, p. 3) states that productivity of labour is increased by the time and effort put to training and education. Labour input is measured in terms of man-hours and the variation in work output per hour is ignored. This study does not make any attempt to distinguish between male and female labour. Infact, Upton points out that "the different sorts of labour may be perfect substitutes for certain tasks in which case it would be appropriate to treat them all as one resource" (32, p. 233).

If family labour is the most limiting factor, intensity of cultivation can be improved by using hired labour. The literature review indicated that the study area experiences shortage of labour during some periods of the year. The study will attempt to find out whether labour is one of the factors that determine farm income in this area. Family and hired labour will be considered separately because their availability depend on different factors. The amount of family labour will depend on the number of family members available for farm work and the contribution each of them makes. Availability of cash income for wages will determine the amount of labour that is hired.

Capital represents resources which are the result of past human effort. These may be durable items like ox-ploughs, or stock used in a season for example fertilizer, seed and sprays. Upton (32, p. 204) states that capital is important for the improvement of farm production because all innovations are embodied in new forms of capital. Innovations or technological changes may include new products, for example, cotton and sunflower introduced in the study area. More commonly, they consist of new methods of production which reduce the average cost per unit of output. In other words, technological change means that the average productivity of at least one resource, land or labour, is increased. Fertilizers, improved seed and sprays, recommended new technology, increase yield per hectare and are therefore land saving. Ox-plough is labour saving because it reduces labour requirements per hectare during land preparation and weeding.

A superior technology represents an upward shift of the production function. This means that the same amounts of inputs result in higher output. This kind of relationship is illustrated in Table 3.2. Superior technology does not consist of new inputs only. It may involve a new method of carrying out the familiar farm operations, so that they are more effective and result in higher yield. For example, ox-ploughing and pre-rain planting in marginal areas result in higher yield because the crop utilizes all the moisture available. Infact, Lynam (21, p.170) emphasizes that in conjunction with Katumani maize and inter-row oxen weeding, pre-rain planting forms the most advanced type of technology currently used by smallholders in marginal areas of Machakos. The study will attempt to determine the influence of capital items like fertilizer, seed, spray and machinery on farm income.

Cash income is required to purchase the capital inputs mentioned above. The likely sources of cash income for smallholders are off-farm occupation and credit facilities. Farm assets can also be used to generate cash income. Positive relationship is expected between farm income and each of the following factors; off-farm income, volume of credit and level of farm assets.

The resources of production, that is land, labour and capital, are not productive by themselves. They have to be organized and co-ordinated by a person who makes decisions. In small-scale farms this is usually done by the farmer himself, or the wife when the husband is away from the holding. Upton (32, p. 322) points out that man-hours or any other estimate of labour is not an adequate indicator of management capability, because achievements of a manager depends upon his ability rather than the number of hours he works. Managerial ability varies from person to person and will also vary with the scale of operation. A farmer who is competent in managing a small farm where all labour requirements are met by the family, may show lower managerial ability for a larger farm with hired labour, because there is need to supervise and motivate others to work. The literature review suggests that there are differences between sexes in their ability to manage small-scale farms. If such differences exist, the analysis will show significant differences in farm output obtained by male and female managers, from the use of the same level of inputs.

In all but purely subsistent societies, transportation network is required to take farm produce to market centres and to bring supplies to the farm. The difference between farm gate price and consumer price reflects, among other things, the transportation cost, which is related to the distance between market centres and areas of production. An efficient marketing system will permit the small-scale farmers to obtain revenue if it can pay reasonable prices for any surplus that they produce. This revenue may be used to buy goods and services required by the household, as well as technological inputs, like seed and fertilizer, to improve farm productivity. It might therefore be expected that farmers living near market centres have the incentive to produce and sell more than those further removed from demand centres. This is caused by lower transportation cost, enabling them to enjoy higher profits.

One of the factors that cause agricultural production to vary from place to place is the variation in natural environment. These differences originate from variations in climatic conditions, especially, rainfall and temperature, soil fertility and topography. The result is that some areas are more suited to certain types of crops and livestock than others. The climatic condition which is of major importance in marginal areas is rainfall variability, not only from place to place, but also from year to year. The Study Team of the Ministry of Agriculture (16, sect. 2 p. 4) points out that Kitui District is more arid than Machakos District. Thus, it is likely that there are differences in farm income and crop output between these two districts arising from differences in the natural environment especially rainfall.

Farming in the study area is a way of life whose major purpose is to provide subsistence needs of the family. These include not only food but also other necessities like clothing and school fees. The size and the composition of the family with respect to age of the members will determine the amount of pressure exerted by their basic needs. Therefore, it is expected that farmers who have larger families put more effort in their farm work in order to meet their basic requirements. The analysis will attempt to show that farm income is positively associated with household basic needs, as measured in terms of consumer equivalents.

CHAPTER 5

METHODOLOGY

5.1 Design of the Survey and Sampling Frame

As stated in Chapter 1 the imperical part of this study is based on data from IRS 1. The respondents of the IRS 1 were selected as a sub-sample of Small Farms Census Survey sample of 1971/72. This was a national survey of smallholders in the main small-scale farming areas of the country. As such the traditional pastoral areas, except those that had been turned into settlement schemes, were excluded. Since the agricultural population was the main focus of the study, all sub-locations (Primary Sampling Units - PSU), which are also the smallest administrative unit in the country, were initially classified into agro-ecological zones by the Ministry of Agriculture. IRS 1 Basic Report points out that "the probability of selection for a PSU was based on the product of the square root of the rural population and the cultivated area as estimated from 1969 population census and the 1969 Small Farms Census Survey (15, p.9). Since most of the data was required on provincial bases, each province had 23 PSU in the final sample. The only exception was Eastern Province because it had 24 PSU owing to sub-location boundary readjustment since the last census. There are 6 provinces in the part of Kenya which the survey focussed on, making 139 PSU altogether.

In registered areas, 12 smallholders were selected in each PSU, using registration list available at the District Land Offices. In non-registered areas, 2 Enumeration Areas, as assessed in 1969 population census, were selected in each sample sub-location, with equal probability. A complete list of households within these 2 Enumeration Areas was made, and 6 households randomly selected from each area. Each selected household was visited to determine whether it was unofficially sub-divided into independently managed holdings. If this was the case, one of the holdings was randomly selected to appear in the sample. Hence the national sample had 1,668 households, 18 of which were later discarded as non-respondents. Of the remaining households, 132 fell in the ecological zone, Lower Cotton East of the Rift.

5.2 Data Collection

Data pre-testing

A pilot survey was launched in three districts between March to May 1974. Considering the broad objectives of the survey proper, the pilot survey's planning and preparation was undertaken through a series of meetings between head staff and field staff. This enhanced the quality of the data obtained in the survey.

Enumeration procedure

Enumerators were selected according to minimum academic qualification of School Leaving Certificate. In addition they had to attend a training course organized for this survey. Apart from the course at the begining of the survey, refresher courses were held during the survey to review problems and inconsistencies encountered.

The survey took place from October 1974 to September 1975. Each enumerator was assigned a single PSU where he could use his mother tongue. The review period was divided into 13 four-lunar-week cycles of equal length. During each cycle, each household was visited twice with a maximum period of 4 days between these 2 visits. The supervisor visited the enumerator regularly to check the forms filled in during the week. At the end of each cycle the forms were submitted to provincial statistical offices for rechecking and forwarding to Nairobi.

5.3 Limitations of the Data

Since IRS 1 was the first survey of its kind to be launched by the Central Bureau of Statistics, the survey could not benefit from experience gained from it for subsequent IRS 2 and IRS 3. As the survey was scheduled to cater for many disciplines, the analysis of the performance of the smallholder agricultural sector was one of the many objectives. For this reason the survey lacks some details which could be available if the survey was designed to provide data on the performance of smallholder agriculture only. The major limitations are as follows:

(a) IRS 1 sample as mentioned earlier was a subsample of another survey carried on in 1971/72. IRS 1 started in October 1974 so that the changes in small-scale farms that occurred between these periods were ignored. Examples of some of these changes are holding sub-division and migration to areas where land is less scarce.

(b) IRS 1 (15, p. 45) shows that only 32 percent of the holdings have farm sizes below 1.0 hectares. Smith (30, p. 7) points out that according to IRS 2, these holdings make up 52 percent of the smallholdings in Kenya. He continues to argue that although some farm sub-division occurred after IRS 1 and before IRS 2, the former failed to cover as many holdings below 1.0 hectare as the latter, because its sample was not based on all smallholders. This means that IRS 1 does not give an accurate distribution of smallholder by farm size. This is not seen as a major problem in the study because land was considered in terms of crop area.

(c) The review period (1974/75) was a drought year. Marginal areas experienced increased deaths and depreciation of livestock as well as poor performance of crops. The question arises whether data from this year can be used to infer to a year with average rainfall (normal year). It might be thought that farm incomes of a normal year are significantly higher than those of a drought year. Wilde (33, p.113) points out that the number of cattle slaughtered or sold alive in marginal areas of Machakos is correlated to rainfall and pasture condition. When grazing is short, more animals tend to be slaughtered or sold. During good pasture conditions herds are increased and kept off the market. He concludes that the variation in the disposal of cattle seems to have the effect of stabilizing total farm income, and this illustrates the importance of cattle as a means of savings. Given this point of view farm income in a drought year ought not to be significantly different from that of a normal year (as long as drought does not extend over several years). An attempt will be made to confirm or refute this suggestion.

The specific limitations of the data relating to the variables referred to in the previous two chapters are discussed below:

(1) Crop output is the most important component of farm income as pointed out earlier. This means that the productivity of the most important crop, maize, plays a major role in determining farm income. Local market prices may have varied over the study area such that considering crop output in value terms masks the actual farm productivity. Although IRS 1 gives the weight in kilograms of individual crop output, it is difficult to calculate the productivity per hectare because crops were grown in pure as well as in mixed stands.

(2) The amount of labour available during land preparation, planting and weeding is likely to be more closely related to crop output than the amount of labour available during other periods. IRS 1 data cannot be used to test for this relationship because it gives the total amount of man-hours that were available during the review period, without partitioning them to specific labout peak periods.

(3) The expenses for fertilizer, as given by IRS 1, does not take into account the crop area over which the fertilizer was used. If the differences in soil fertility, residual effects of fertilizer applied in previous years as well as the different fertilizer rates recommended for different crops are taken into account, the variable fertilizer expense per hectare would be a better indicator of the relationship between crop output and fertilizer expenses. Moreover IRS 1 considered only chemical fertilizers.

(4) The dates of planting and weeding, after the onset of the rains, were emphasized earlier as major determinants of crop output. However in this analysis this relationship can not be confirmed because as the data stands, the dates of planting and weeding with respect to the rains are not available.

(5) Transportation cost is a better indicator of the ease of transportation between the holding and the nearest sizeable market than the actual distance involved. This is because transportation cost shows directly the amount by which the revenue from commodities sold is reduced, and the additional cost for purchased farm inputs. However the data does not distinguish between transportation expenses resulting from farm operations and those resulting from off-farm activities.

However, not withstanding these limitations, the data is still considered adequate to permit useful analysis. Infact, at present, the data represents one of the main sources of information for a study of farm income in the semi-arid areas in Kenya.

5.4 Choice of Specific Mathematical Model

Linear and Cobb-Douglas functions were used by Ruthenberg (29), Lagemann (19) and Moock (25) to explain the determinants of gross farm income, farm family income and maize yields of smallholders respectively. On the basis of these analyses, the two functions were fitted to the data using the Statistical Package for the Social Sciences (SPSS). The assumptions of Ordinary Least Squares Technique (OLST) were used.

Three criteria were used to select the "best" function.

(a) The first criterion is that the signs attached to the explanatory variables should be in agreement with Economic Theory and the logic of small-scale farm operation, so that the function is economically meaningful.

(b) The second criterion is that the "best" regression equation should contain as many variables as possible that are significant in explaining the variation in the dependent variable. The test of significance relating to each regression coefficient explanatory variable (βi) is made using the F ratio.

$$F = \frac{\text{Additional variance explained by X}}{\text{Unexplained variance}}$$

when H_o : $\beta i = 0$

(c) The third criterion was the value of coefficient of multiple determination (R^2). It measures the goodness of fit by showing the amount of variation in the dependent variable that is explained by changes in the explanatory variables (34, p. 130). The higher the R^2 value the higher the percentage of variation accounted for.

$$R^2 = \frac{\sum(\hat{Y}_1 - \bar{Y})^2}{\sum(Y_1 - \bar{Y})^2} = \frac{\text{Explained variation of Y}}{\text{Total variation of Y}}$$

5.5 Specific Tests for Population Regression Coefficients and Statistical Inference

The analysis of the characteristics and relationships in a sample is done to indicate the properties of the population. In regression analysis it is important that the sample selected has a good coverage of the population. That is, the sample is not selected from one or a few sections of the universe. IRS 1 is felt to fulfill this requirement owing to the method used to select the sample.

The analysis tests whether the regression coefficients for explanatory variables are significantly different from zero in the sample. This information, inferred to the population, means that the specific explanatory variables have statistically important influence on the dependent variable. Where the sample regression coefficients for explanatory variables are not significantly different from zero, it means that the population regression coefficients can be regarded as zero, and hence their influence on the dependent variable is nil.

Regression technique as a tool of statistical analysis faces the problem of distinguishing the different types of relationship between variables. In this analysis two types of relationships were considered namely:

(a) causal and

(b) associative.

The information from literature review and theoretical analysis was used to distinguish these relationships. Causal effect is taken to mean the direct relationship existing between explanatory variable and dependent variable. For example, fertilizer application is shown to have causal effect on crop yield. The more fertilizer is applied the higher the yield is expected to be, within certain limits. However if a farmer uses more fertilizer because he has more off-farm income to spend, the relationship between crop yield and off-farm income is associative.

The literature review and the theoretical analysis indicate what type of relationship is expected (causal or associative) between the dependent variables (farm income and crop output) and each explanatory variable considered. The interpretation of the results of the analysis will be done in view of these types of relationship.

5.6 Definitions of Specific Variables used in the Analysis

Definitions of Dependent Variables

From the outset it is necessary to define unambigously the dependent variables used in the analysis. These variables will be referred to and distinguished with respect to the method used to derive them so that the commentary can remain reasonably concise. However it must be emphasized that the use of the method of derivation as reference is fully dependent on the definitions given and the latter should always be borne in mind when interpreting the analysis and the results.

As pointed out in Chapter 1, the emphasis of agricultural development in Kenya, especially in marginal areas, is to increase farm productivity. Increased productivity will be reflected in higher levels of farm income. Since this study aims at determining factors that influence farm income, the dependent variable in the regression analysis will be farm income. It will be considered as gross farm income and net farm income in value terms. Gross farm income and net farm income are calculated using 3 different methods.

The first method considers gross farm income as calculated by IRS 1. It consists of total value of production which covers crop sales, milk sales and net livestock sales. Also the value of output used as seed, given to labour, fed to livestock or consumed in the household as well as crop and livestock valuation changes are included. These components are illustrated in Appendix 2 by five different gross farm income size-groups. The average value for each item is also shown for the whole sample. When total farm costs are deducted from gross farm income, net farm income is obtained. Total farm costs consist of purchased crop inputs (fertilizers, seed, sprays, machinery expenses and other minor items), total livestock expenses (feed and other minor items), wages to regular and casual labour, own produced inputs (seed, livestock feed and output given to labour) and farm repairs.

The second method of deriving gross farm income and net farm income is similar to the first method except that livestock valuation change is excluded. Livestock valuation change is omitted because it is argued that livestock in marginal areas is kept as savings rather than a production asset. The items included in the computation are illustrated in Appendix 3 by four different gross farm income size-groups. The mean of each item for the whole sample is also shown.

Since 1974/75 was a drought year farm incomes are expected to be lower than those of a normal year especially from the livestock point of view. This resulted from abnormal livestock valuation change. To take this into account the third method computes gross farm income and net farm income as in the first method but a correction factor is used as derived by Dorling (3, p. 10-12) in an analysis of income distribution in the small farm sector of Kenya as explained below.

(i) Net sales of cattle and sales of other stock on farms in the IRS 1 survey are determined by substracting purchases from value of sales.

(ii) Other disappearance values for livestock occur under output given to labour and output consumed by the household.

(iii) The formula used in the survey for assessing the overall livestock value (excluding milk) accruing to the farm (+ or -) is the familiar one:

Credit	Debit
Sales	Purchases
Consumption	Valuation change (negative)
Gifts to labour	
Valuation change (positive)	

It is necessary to explain what this procedure means in terms of components for the livestock enterprises.

(iv) The valuation change when positive is the excess of (Purchases, Stock received as Gifts, Stock Births, and Stock Appreciation) over (Sales, Stock consumed, Stock given to Labour, Stock Deaths and Thefts, Stock given away as Gifts and Stock Depreciation). When negative the excess is the other way round and constitutes a rundown in inventory value. All of the brackets items are available in selected records from the survey data file.

(v) The formula stated in (iii) simply cancels out the sales, consumption, gifts to labour, and purchases items that go into the valuation change calculation in (iv). What is left is the excess or deficit of the remaining items in the two sets of brackets in (iv), but it should be noted that this arithmetic does not take into consideration the stock appreciation and depreciation.

(vi) On this reasoning it was decided to use the following correction factor on farm size-group averages for farm operating surplus[1].

Correction Factor

(Stock Deaths and Thefts + Stock given away as Gifts) - Stock received as Gifts + Stock Births).

If this factor is positive as it stands it is added back into the existing farm operating surplus and vice-versa. In performing this adjustment estimations of income farm livestock (excluding milk) are made, based on the net result of appreciation and depreciation of stock (see (iv)). This is a much more realistic procedure it would seem, because no matter what sales, deaths, etc, occur the income assessment is solely on the basis of the gain or loss in value of the livestock whilst on the farm during the year studied. It has one slight drawback in that appreciation and depreciation are rather illusory for livestock, over which the farmer exercises no choice of disposal, i.e., loss by death and theft. But even if it were thought worthwhile to correct for, it is impossible to identify such disposals in the survey data, and so on balance the adjustment method adopted seems to be a satisfactory way of correcting for inadvertant capital stock change (3, p. 10-12).

The general analysis model is summarized below.

$$Y_i \quad = \quad (X_1,\ X_2 \ \ldots\ldots \ X_n)$$

Where Y the dependent variable is farm income calculated as explained above.

The value of gross crop output will also be used as a dependent variable because it forms 50 percent or over of gross farm income for 3 out of 4

---

1 The term 'farm operating surplus' in this quotation refers to net farm income as calculated in the first method.

gross farm income size-groups as shown in Appendix 4. Considering the whole sample it forms about 60 percent of gross farm income on the average in the study area. Moreover, many of the explanatory variables like labour, crop area and purchased crop inputs, are expected to have greater influence on crop output than on farm income.

Definitions of Explanatory variables

The explanatory variables that determine farm income are many but as previously stated only some of these have been selected for analysis in the study. They were derived as follows:

Crop area IRS 1 provided no direct measurement of this variable. As such it was approximated as the sum of the area of crops in pure stands and all mixed stands containing maize, as recorded during the twelve months review period. Given that maize occupied the largest cultivated area (16, sect. 2 p. 11), it was assumed that it will appear in most, if not all of the mixed crop stands.

Assets are computed as the sum of the opening value of the following: land, structures, farm equipment, improved and unimproved livestock.

Fertilizer expenses refer to the total cost of chemical fertilizer used on the farm.

Seed expenses refer to cost incurred purchasing seed.

Spray expenses include costs of all plant protection chemicals, either sprays or dust.

Machinery expenses refer to the cost of hiring tractors and/or ox-ploughs for farm operation. Where the farmers owned these implements the cost was imputed.

Purchased crop inputs refer to the sum of the following: fertilizer, seed, spray, machinery and any other purchased crop expenses.

Purchased farm inputs is the sum of purchased crop inputs and any cost incurred purchasing livestock inputs.

Hired labour refers to the total man-hours of casual and permanent employees used for farm work.

Family labour is the total man-hours of family members (adult and children) devoted to farm work. IRS 1 arbitrarily assigned child's labour half the value of adult labour. A child was defined as being between the ages of 4[1] and 15 years (15, p. 12).

Crop labour is man-hours of hired and family labour used on crops only.

Consumer equivalents per household is the household size adjusted according to the ages of the members. In the analysis this unit was used to measure household

---

1 Normally children of 10 and under are not considered as part of form work force. But it was not possible to exclude them in this analysis because the IRS 1 showed total man-hours of family labour without indicating what portion was contributed by children.

consumer pressure. Different age groups vary in their nutritional requirements and children require less than adults. This is shown by the nutritional consumption units of the World Health Organization (WHO) (4, p. 94) broken down by age group as follows:

Children	0 - 10 years	= 0.50	consumer equivalents
"	11 - 15 years	= 0.75	" "
Adult	over 15 years	= 1.00	" "

Here, WHO assumes that an adult is over 15 years of age. A child of 10 years or less exerts only half the consumer pressure of an adult. Children between 11 to 15 years exert only three quarters of this pressure. Household consumer equivalents were calculated using the above classification.

Off-farm income refers to net revenue a household receives from outside the farm.

District. The analysis treats Machakos and Kitui Districts as two separate geographical areas by introducing a dummy variable D1. In SPSS terminology when the district is Machakos, D1 = 0. When it is Kitui, D1 = 1.

Sex of the operator refers to the sex of manager of the holding, and in the regression analysis it appears as dummy variable D2. When the operator is a woman, D2 = 0 and when he is a man, D2 = 1.

Distance to the market is dealt with as dummy variable D3, specifying the distance in kilometres intervals[1] between the holding and the nearest sizeable market. If the distance is less than 4 kilometres, D3 = 0. If it is 4 kilometres and over, D3 = 1.

These explanatory variables are summarized below giving the labels that are used in the regression analysis:

X_1 = purchased farm inputs

X_2 = crop area in hectares

X_3 = consumer equivalent per household

X_4 = family labour

X_5 = off-farm income

X_6 = hired labour

X_7 = assets

X_8 = crop labour

X_9 = purchased crop inputs

X_{10} = machinery expenses

X_{11} = fertilizer expenses

X_{12} = spray expenses

X_{13} = seed expenses

---

1 It was not possible to treat distance as a measurement variable because IRS 1 recorded distance in 5 groups of kilometre intervals, which were reduced to 2 groups in this analysis.

D_1 = Dummy variable specifying the district

D_2 = Dummy variable specifying sex of the operator

D_3 = Dummy variable specifying the distance to the nearest sizeable market from the holding.

CHAPTER 6

EMPIRICAL RESULTS AND RELEVANT OBJECTIVES

6.1 Introduction

Out of the complete sample of 132 holdings selected from the ecological zone, Lower Cotton East of the Rift, 43 of them had negative net farm income . This was caused entirely by extremely high negative change in the value of livestock. In the national sample this feature was noticed particularly in Eastern Province where drought was experienced during the survey period. Hence, it is suggested that drought was partly responsible, because it reduced the value of herds and may also have caused livestock to be moved off the holding, before the peak of the drought which coincided with closing valuation. However the IRS 1 Basic Report (15, p. 50) explains further that drought alone does not account for this observation, and the user is cautioned about the interpretation of these figures.

A view expressed by designer of IRS 1 questionaire (22) emphasized that at the time of compiling survey data, any respondent showing negative net farm income was regarded as showing unusual results, which could easily be misinterpreted if the basis of data calculation was not fully understood. Nevertheless the nature of the survey for the period concerned made it impracticable to treat negative net farm incomes on a selective basis, thus necessitating its inclusion in the whole body of survey data. This is infact an argument for at least looking at the data on adjusted basis.

Smith (30, p. 30) made the adjustment by excluding all those households showing negative household income, from his analysis of factors affecting total household income per adult equivalent, using the IRS 1 national sample arguing that:

> Most of these, on the average, had attributes which suggested that they were normally relatively well off, but had either suffered particular misfortune that year (there was substantial drop in cattle valuations for this group) or had given particularly misleading information to the enumerators (30, p. 30).

A comparison of the correlation between farm income and designated explanatory variables[1] using samples sizes 89 and 132 shows that the latter has lower correlation coefficients[2] in general. For

---

1 These variables are explanatory with respect to regression analysis. In correlation analysis they will be referred to as designated explanatory variables.

2 Simple correlation was used to select independent variables in relation to dependent variables in the regression models because selection had to start somewhere. However, partial correlation is likely to have resulted in a more rigorous selection because the relationship between two variables would have been analysed while adjusting for the effects of the other variables.

example at 130 degrees of freedom (D.F) and 0.01 level of significance (L.O.S.), the only variables significantly correlated with net farm income derived in the first method are purchased farm inputs, crop area and off-farm income (Appendix 5a). At the same D.F. and L.O.S. only purchased farm inputs, crop area and assets are significantly correlated with gross farm income computed in the second method.

Table 6.2[1] shows that only off-farm income and hired labour are not significantly correlated with net farm income computed in the first method at 0.01 L.O.S. and 87 D.F. Similarly only off-farm income is not significantly correlated with gross farm income as derived in the second method at this L.O.S. and D.F.

Moreover, although non-significant, the correlation coefficients for hired labour and assets with respect to net farm income in the three methods, are negative contrary to theoretical analysis, when sample size 132 is used. The only exception is the positive correlation coefficient between net farm income calculated by the second method and assets. For these reasons the analysis that follows is based on the 89 respondents who had positive net farm income as calculated by IRS 1.

---

1 Table 6.2 is not shown on the following page because the use it is put to on this page is felt to be of less importance than illustrating the association between variables as explained in pages 79- 83 inclusive.

6.2 Main Features of the Sample

None of the 98 respondents received farm credit during the survey period. As such its effect on farm income can not be analysed.

The main features of the sample discussed in this section are illustrated in Appendix 6. Farm inputs either for crops, livestock or for both were purchased by 84 percent of the respondents. Although the emphasis in the study area is to improve crop output by using technological inputs like fertilizer and seed, 46 percent of the respondents did not purchase any crop inputs. The minimal dependence of farmers on purchased crop inputs is emphasized by the fact that 79, 97, 72 and 99 percent of the respondents did not incur any machinery, fertilizer, seed and spray expenses respectively. The likely reason is that since crop failure is common in marginal areas, farmers are unwilling to incur the extra cost of purchased crop inputs, because in so doing they have more to lose if the crops failed. As might be expected, these small-scale farmers did not depend entirely on hired labour. Infact 53 percent of them hired no labour either because they could not afford it or their families met all the farm labour requirements.

On the average the value of livestock made the largest contribution, 34 percent, to the total value of assets (Appendix 7). This seems to show the importance of livestock in the study area. Taking net farm income derived by the second method to indicate the farm income level of the holding, it is evident that as farm income increases, livestock continues to account for a greater proportion of the value of assets. One possible explanation is that "rich" farmers keep more cattle which explains their higher total value. Alternatively, they can keep fewer animals but of higher value (cross breeds). Compared to the other components of assets, livestock is particularly suited to marginal areas as a store of value because it is readily realizable.

Structures are the next important component of assets accounting for 33 percent of its value (Appendix 7). Generally, the importance of the value of structures and land declines with increase in farm income. Equipment tend to account for a higher proportion of asset value as farm income increases.

Negative off-farm income was reported by 11 percent of the respondents. IRS 1 (15, p. 50) points out that this may be explained by the reluctance of farmers to reveal the full extent of their off-farm income.

Women operated 18 percent of the holdings while 79 percent were operated by men. For 3 percent of the holdings the sex of the operator was not indicated.

6.3 Correlation Results

Pearson correlation coefficients were computed between the designated dependent variables and designated explanatory variables, as well as among the designated explanatory variables themselves. The purpose of this exercise was two fold:

(1) To measure the strength of linear relationship between the designated dependent variables and designated explanatory variables

(2) To detect cases of serious multicollinearity requiring attention in subsequence regression analysis.

For this study, only correlation coefficients that differed significantly from zero at 0.01 L.O.S. or better are discussed. A correlation coefficient is significant if it is equal to or greater than the critical value at n-2 D.F. Snedcor and Cochran (31, p. 557) give the critical values at 0.01 L.O.S. for 80 and 90 D.F. as r = 0.283 and r = 0.267 respectively. By interpolation the critical value at 0.01 L.O.S. and 87 D.F. is r = 0.272.

Serious multicollinearity is judged to occur where the correlation coefficients between any two designated explanatory variables is high. In this analysis the critical value is arbitrary put at r = 0.600. One of the assumptions of OLST is that the explanatory variables are not perfectly linearly correlated. Complete lack of linear correlation between explanatory variables is not possible in practice. It is therefore sufficient to deal with only those cases that show serious multicollinearity. One method of doing this is leaving out one of the two explanatory variables from the regression analysis.

This method was used in this study.
The designated explanatory variables considered for net farm income and gross farm income in the correlation analysis are purchased farm inputs, crop area, consumer equivalents, family labour, off-farm income, hired labour and assets. Table 6.1 shows that only one case of serious multicollinearity was detected. It occurred between hired labour and assets (r = 0.623). The likely explantion is that those farmers who are well off as indicated by high asset levels are also the people who can afford to hire labour. They also have more land therefore they require more labour. Hired labour will be included in the regression analysis and assets excluded unless its correlation with designated dependent variable is non-significant.

The correlation analysis results will be discussed in more detail under three sub-headings, net farm income, gross farm income and gross crop output.

Net farm income

The general relationship between designated explanatory variables and the three farm incomes computed in the three methods will be discussed first, followed by the main distinguishing features among them.

TABLE 6.1: PEARSON CORRELATION MATRIX OF DESIGNATED EXPLANATORY VARIABLES FOR FARM INCOME

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1 Purchased farm Inputs	1.000						
X_2 Crop area	0.337	1.000					
X_3 Consumer equivalent	0.250	0.246	1.000				
X_4 Family labour	0.369	0.347	0.498	1.000			
X_5 Off-farm income	-0.068	0.024	0.116	-0.182	1.000		
X_6 Hired labour	0.085	0.138	-0.006	-0.063	0.395	1.000	
X Assets	0.418	0.292	0.240	0.435	0.179	0.623	1.00

SOURCE: Author's analysis

Purchased farm inputs featured as the most important factor in relation to the three net farm incomes. The strength of this linear relationship is r = 0.489, 0.732 and 0.392 as shown in Table 6.2. This is probably an indication that although only few farmers use purchased farm inputs, especially purchased crop inputs, those who do are likely to increase their net farm income owing to the following reasons:

First, soils in the study area have serious erosion problems resulting in deficiency in plant nutrients, which are remediable by fertilizers.

Second, Katumani maize seed is an important component of purchased farm inputs, because its drought resistant characteristic makes it particularly suited to marginal areas.

Crop area shows the second strongest relationship with net farm income. The correlation coefficients are r = 0.475, 0.396 and 0.460 for net farm income computed in the three different methods. Since crop area is the product of the size of cultivated area and the number of croppings achieved in one year, this observation seems to suggest that farm income can be improved by expanding the cultivated area and/or increasing the number of croppings per year.

Family labour is the third strongest factor in relation to net farm income. It was previously

TABLE 6.2: PEARSON CORRELATION COEFFICIENTS OF NET FARM INCOME AS COMPUTED IN THE THREE METHODS AND DESIGNATED EXPLANATORY VARIABLES

DESIGNATED EXPLANATORY VARIABLES	NET FARM INCOME		
	1ST METHOD	2ND METHOD	3RD METHOD
X_1 Purchased farm inputs	0.489**	0.732**	0.392**
X_2 Crop area	0.475**	0.396**	0.460**
X_3 Consumer equivalent	0.356**	0.316**	0.333**
X_4 Family labour	0.331**	0.498**	0.346**
X_5 Off-farm income	-0.112	-0.283**	-0.055
X_6 Hired labour	0.116	-0.027	0.114
X_7 Assets	0.272**	0.389**	0.219

** Variables significant at 0.01 L.O.S. and 87 D.F.

SOURCE: Author's analysis.

mentioned that nearly 50 percent of the respondents do not hire labour. This means that for these farmers the capacity of family labour will determine, at least partly, the size of cultivated area and timeliness of farm operations.

Consumer equivalents has the fourth strongest relationship with net farm income. This relationship suggests that small-scale farmer's decision making may not only be influenced by physical inputs like land and labour available, but also the subsistence requirements of the family. A farmer with more mouths to feed might be expected to have a stronger incentive to work harder on the farm, other things remaining equal.

Assets show only slight positive relationship with net farm income. This is contrary to what was anticipated if it is assumed that the level of assets is an indicator of the wealth status of a farmer. The wealthy ones are likely to purchase more farm inputs and hire labour without jeopardizing their subsistence if the crops failed. Hence they can achieve higher farm income.

Hired labour shows non-significant correlation with net farm income although nearly 50 percent of the farmers used it. One likely explanation is that man-hours is not an adequate indicator of the contribution hired labour makes to farm income, because it ignores the quality of labour and the timeliness of the farm operations the labour is used for.

The correlation between off-farm income and net-farm income contradicts the observation made by Smith (30, p. 36) about the importance of off-farm income. The off-farm income correlation coefficients with respect to net farm income as calculated in the first and third method (r = -0.112 and -0.055 respectively) indicate that the size of the farmer's off-farm income has little relationship with farm income. If such a relationship does exist as shown by the correlation coefficient (r = -0.283) between off-farm income and net farm income as derived in the second method, then the possible explanation is that off-farm income has negative influence on farm income. This is plausible because off-farm occupation competes for labour with farming.

When net farm income as computed in the first and the second method are compared with respect to the correlation coefficients for individual designated explanatory variables, it becomes clear that generally net farm income derived by the second method shows stronger linear relationship with these variables than net farm income calculated by the first method.

The difference between net farm income in the first method and second method is that the latter disregards livestock valuation change as part of farm production. Livestock valuation change was mainly negative owing to drought conditions.

Net farm income derived by the third method is assumed to represent net farm income of a year with average rainfall. The correlation coefficients for the designated explanatory variables have the same order of importance for net farm income derived by the first and the third method. In addition, the values of the individual correlation coefficient are more or less the same. A possible explanation of this very close similarity is that there is little difference between the association of net farm income with the factors considered, whichever of the two methods is used to calculate net farm income.

Gross farm income

Table 6.3 shows that generally the correlation coefficients of designated explanatory variables with respect to the three gross farm incomes are higher than their corresponding values with net farm incomes. This is expected because after deducting farm costs from gross farm income, the resulting net farm income is lower and therefore less strongly related to the variables considered.

TABLE 6.3: PEARSON CORRELATION COEFFICIENTS BETWEEN GROSS FARM INCOME DERIVED BY THE THREE METHODS AND DESIGNATED EXPLANATORY VARIABLES

DESIGNATED EXPLANATORY VARIABLES	GROSS FARM INCOME		
	1ST METHOD	2ND METHOD	3RD METHOD
X_1 Purchased farm inputs	0.594**	0.804**	0.578**
X_2 Crop area	0.498**	0.429**	0.493**
X_3 Consumer equivalent	0.335**	0.306**	0.333**
X_4 Family labour	0.363**	0.513**	0.413**
X_5 Off-farm income	-0.032	-0.200	0.010
X_6 Hired labour	0.311**	0.157	0.328**
X_7 Assets	0.469**	0.550**	0.487**

** Variables significant at 0.01 L.O.S. and 87 D.F.

SOURCE: Author's analysis.

Purchased farm inputs and crop area have the strongest linear relationships with gross farm income as indicated by correlation coefficients shown in Table 6.3. This indicates that whether farm income is considered as net farm income or gross farm income its strong positive association with purchased inputs and crop area remains unaltered.

Further, Table 6.3 shows that assets have the third strongest relationship with gross farm income. This is contrary to the weak positive association found between assets and net farm income. This observation is credible because the level of assets and gross farm income are indicators of the size of the operation, and are therefore closely related. However, net farm income indicates the efficiency rather than the size of the operation. Hence it is less closely associated with the level of assets.

Although the relationship between off-farm income and gross farm income was non-significant it was negative. This seems to give further evidence that if a relationship does exist between farm productivity and off-farm income it is negative. This is inline with Mbithi's (23, p. 13) observation in the same area.

Generally, gross farm income calculated by the second method has higher correlation coefficients than the one derived by the first method. Similar results were mentioned earlier with respect to net farm income. Further, the correlation coefficient of individual designated explanatory variable show close similarity with respect to net farm income derived by the first and the third method.

Gross crop output

Table 6.4 shows the Pearson correlation matrix of designated explanatory variables for gross crop output. These are purchased crop inputs, consumer equivalents, off-farm income, assets, crop labour and crop area. Purchased crop inputs is further sub-divided into fertilizer, seed, spray and machinery expenses.

It is important to note that purchased crop inputs are considered from two aspects. First, they are pooled together as one variable and then broken down to the main components cited in Chapter 5.

TABLE 6.4: <u>PEARSON CORRELATION MATRIX OF DESIGNATED EXPLANATORY VARIABLES FOR GROSS CROP OUTPUT</u>

	X_2	X_3	X_5	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_2 Crop area	1.000									
X_3 Consumer equivalent	0.246	1.000								
X_5 Off-farm income	0.025	0.116	1.000							
X_7 Assets	0.292	0.240	0.179	1.000						
X_8 Crop labour	0.424	0.361	0.075	0.668	1.000					
X_9 Purchased crop inputs	0.292	0.181	-0.014	0.366	0.193	1.000				
X_{10} Machinery expenses	0.294	0.147	-0.162	0.227	0.110	0.905	1.000			
X_{11} Fertilizer expenses	0.054	0.116	0.162	0.462	0.410	0.319	0.014	1.000		
X_{12} Spray expenses	-0.007	0.177	0.040	0.073	-0.002	-0.001	-0.044	-0.017	1.000	
X_{13} Seed expenses	0.013	-0.045	0.310	0.085	-0.033	0.321	0.090	-0.058	0.152	1.000

<u>SOURCE</u>: Author's analysis

Serious multicollinearity occurs between the variable assets and crop labour. The latter is chosen for consideration in regression analysis.

The correlation between gross crop output and designated explanatory variables is shown in Table 6.5.

When all purchased crop inputs are treated as one variable, they form a factor which has the strongest positive linear relationship with gross crop output (r = 0.700). This is expected from the correlation of purchased farm inputs with net farm income and gross farm income that was observed earlier. Purchased crop inputs on the average form 66 percent of the total purchased farm inputs, while gross crop output on the average form 56 percent of gross farm income. It therefore seems that farmers in the study area can improve the crop output by using more purchased crop inputs.

Assets are the second strongest variable correlated with gross crop output (r = 0.573). Earlier, assets were cited as buffers against drought and famine. Farmers owning high asset levels are less susceptible to these calamities and are therefore expected to grow crops that are high yielding although less drought resistant. Assets are also pointed out as indicators of past economic performance and success of a farmer. Successful farmers have the

TABLE 6.5: PEARSON CORRELATION COEFFICIENTS BETWEEN GROSS CROP OUTPUT AND DESIGNATED EXPLANATORY VARIABLES

DESIGNATED EXPLANATORY VARIABLES	CORRELATION COEFFICIENTS
X_2 Crop area	0.446**
X_3 Consumer equivalent	0.257
X_5 Off-farm income	0.131
X_7 Assets	0.573**
X_8 Crop labour	0.514**
X_9 Purchased crop inputs	0.700**
X_{10} Machinery expenses	0.741**
X_{11} Fertilizer expenses	0.220
X_{12} Spray expenses	0.016
X_{13} Seed expenses	-0.046

** Variables significant at 0.01 L.O.S. and 87 D.F.

SOURCE: Author's analysis.

possibility of purchasing crop inputs and thus improve the crop output.

Crop labour, family and/or hired, is the third strongest factor associated with gross crop output ($r = 0.514$). As discussed earlier the importance of labour stems from the influence the amount of labour available and the effect timeliness of planting and weeding has on crop output.

Treating the components of purchased crop inputs individually, it is noticed that only the correlation between gross crop output and machinery expenses ($r = 0.741$) is significant. Non-significant correlation of gross crop output with fertilizer and spray expenses can be blamed on the fact that only 3 and 1 percent of the respondents used these inputs respectively. Although 28 percent of the respondents incurred seed expenses, this variable failed to show any significant association with gross crop output. One possible reason is that although farmers bought the seed for example hybrid maize seed, they failed to plant on time for the rains. Only 21 percent of the respondents incurred machinery expenses, this variable shows the strongest positive association with gross crop output. The likely reason is that the farmers who took advantage of tractor hire and/or ox-ploughing facilities prepared more land for planting and did it on time for the rains. Ox-ploughs could also be used to reduce labour shortage during inter-row weeding.

6.4 Regression Results

Only those designated explanatory variable which have significant correlation coefficients with net farm income, gross farm income and gross crop output are considered in regression analysis[1]. Serious multicollinearity is treated as previously mentioned. Three other designated explanatory variables which are; sex of the operator of the holding, distance from the holding to the nearest sizeable market and geographical location as specified by district, are included in regression analysis as dummy variables. They are excluded from correlation analysis because they are non-continous variables. Geographical location as specified by district and the sex of the operator of the holding are discrete variables. Distances from the holdings to the nearest sizeable markets are grouped either as less than 4 kilometres or as 4 kilometres and over.

Multiple linear regression and Cobb-Douglas functions were fitted for each dependent variable, using the Forward Stepwise Regression Method (FSRM).

---

1 See footnote 2 page 72.

This means that the first explanatory variable fitted in the equation is that which explains the largest variation in the dependent variable. The variable included in the next step is that which, together with the first variable, explains the largest variation in the dependent variable. This process is continued until all the variables are considered.

Each function has two equations for each dependent variable. One of them includes only those explanatory variables that are significant at least at 0.05 L.O.S. with 1 and N-k-1[1] D.F. (28, p. 337). This means that an individual explanatory variable has to have an F ratio greater or equal to the critial F ratio for that specific equation. The other equation[2] include non-significant and significant explanatory variables at 0.05 L.O.S. with 1 and N-k-1 D.F. The F ratio of any variable included in the equation must be at least 0.01. This is the lowest F ratio for an individual explanatory variable to be included in the regression equation by FSRM of the SPSS (28, p. 346).

---

1 Where N = sample size and k = number of explanatory variables in the equation.

2 The following discussion of the regression coefficients and their signs is based on the equations containing significant variables only. As such the other equations will only be mentioned in passing because they are largely self-explanatory in showing how R^2 changes when significant and non-significant variables are put together.

The explanatory variables in the following equations are given in order of the percentage variation they explain in the dependent variable as indicated by their components of R^2 (see Appendix 9).

The numbers in parentheses below each regression coefficient are the standard errors and they are related to the F ratio of the specific explanatory variables (See sect. 5.4 (b)). Where there is one degree of freedom in the numerator of F ratio as in all these cases, $F = t^2$. The individual F ratio is used to test whether the regression coefficient is significant at a chosen level of significance with 1 and N-k-1 D.F.

Considering the criteria given in Chapter 5, the multiple linear regression equations fits the data better than the Cobb-Douglas equations for each dependent variable. As such linear regression equations are used to discuss the results of regression analysis. The Cobb-Douglas equations are provided in Appendix 8. Additional details of the multiple linear regression equations not given in the following discussion are provided in Appendix 9.

Net farm income

Net farm income derived by the first method

When this variable is used as the dependent variable, equation 6.1 shows that purchased farm inputs (X_1) and crop area (X_2) were significant at 0.01 L.O.S.

with 1 and 85 D.F. while consumer equivalent is significant at 0.05 L.O.S. with 1 and 85 D.F. This is expected from correlation analysis and the possible explanation of these relationships is as discussed in that section.

$$(6.1)\quad Y = -157.35 + \underset{(0.85^{**})}{3.07X_1} + \underset{(67.44^{**})}{230.46X_2} + \underset{(80.72^{*})}{176.18X_3}$$

$$R^2 = 0.38$$

$$(6.2)\quad Y = -657.22 + \underset{(0.91^{**})}{2.92X_1} + \underset{(69.61^{**})}{234.39X_2} + \underset{(91.09^{*})}{189.10X_3}$$

$$+ \underset{(599.11)}{708.99D_2} + \underset{(474.19)}{455.56D_3} - \underset{(571.22)}{341.86D_1}$$

$$- \underset{(0.22)}{0.09X_4}$$

$$R^2 = 0.40$$

For the description of the variables see Chapter 5[1].

** Significant at 0.01 L.O.S. with 1 and N-k-1 D.F[1].

* Significant at 0.05 L.O.S. with 1 and N-k-1 D.F[1].

The numbers in parentheses are the standard errors of estimated coefficients[1].

The R^2 value is fairly low ($R^2 = 0.38$) indicating that there are other more important factors influencing net

---

1 The explanation below equation 6.2 applies to all pairs of equations that follow, that is 6.3 - 6.16 inclusive. As such it will be not be repeated but

farm income that are not included in equation 6.1. Two of these are suspected to be rainfall and management. The latter can be said to include parameters like time of planting and weeding with respect to the rains. The importance of these factors in influencing crop output and hence farm income in marginal areas was stressed earlier.

An increase of crop area by 1.0 hectare increases net farm income by KShs. 230.00 (equation 6.1), while an increase of subsistence requirements by 1.00 consumer equivalent seems to be associated with an increase of KShs. 176.00. It is disappointing to note that for KShs. 1.00 used in purchasing farm inputs, net farm income increases by KShs. 3.00 only. A higher regression coefficient was expected because this is one of the major farm inputs recommended to improve farm productivity. This regression coefficient is low probably because the farmers failed to plant in time for the rains although they purchased farm inputs. It was shown previously that 84 percent reduction in yield can result from late planting. The R^2 value increases by 0.2 above that obtained in equation 6.1 when significant and non-significant variables are included (equation 6.2).

<u>Net farm income derived by the second method</u>

As shown in equation 6.3, purchased farm inputs (X_1), family labour (X_4) and off-farm income are significant at 0.01 L.O.S. with 1 and 85 D.F. in explaining 63 percent of the total variation in net farm income derived using the second method.

$$(6.3)\quad Y = 120.27 + \underset{(0.78^{**})}{7.02X_1} + \underset{(0.17^{**})}{0.54X_4} - \underset{(0.10^{**})}{0.29X_5}$$

$$R^2 = 0.63$$

$$(6.4)\quad Y = 127.73 + \underset{(0.84^{**})}{5.90X_1} + \underset{(0.21)}{0.18X_4} - \underset{(0.11^{**})}{0.34X_5} + \underset{(61.95)}{108.34X_2}$$

$$- \underset{(507.65)}{867.18D_1} - \underset{(427.94)}{687.73D_3} + \underset{(82.81)}{123.45X_3}$$

$$+ \underset{(0.04)}{0.05X_7} + \underset{(600.74)}{788.69D_2}$$

$$R^2 = 0.68$$

See footnote 1 page 94 for significance levels **, *.

The influence of off-farm income (X_5) on net farm income is unexpected because the correlation coefficient ($r = -0.283$) is one of the lowest and barely significant at 0.01 L.O.S. with 1 and 85 D.F. Although crop area (X_2), assets (X_7) and consumer equivalents (X_3) have higher correlation coefficients with respect to net farm income (r = 0.396, 0.389 and 0.316 respectively), they do not account significantly for its variation.

For KShs. 1.00 spent purchasing farm inputs (X_1), net farm income increases by KShs. 7.00, while a man-hour of family labour (X_4) increases Y_2 by KShs. 0.50 only. Off-farm income (X_5) seems to be associated with a decrease of net farm income at the ratio of 0.29:1. The negative relationship between off-farm income and farm income seems to emphasize the adverse effect off-farm employment has on farming in this area.

The highest variation in net farm income (63 percent) is explained by the factors considered above when it is calculated by the second method. Equation 6.4 illustrates an example where the inclusion of significant and non-significant variables using FSRM, reduce the significance of some of these variables. In equation 6.3, where only significant variables are considered, family labour is significant at 0.01 L.O.S. with 1 and 85 D.F. As cited earlier, equation 6.4 includes significant and non-significant variables, and it implies that the contribution made by family labour to net farm income is not significant.

Net-farm income derived by the third method

The factors that are found important in equation 6.1 are the same factors that are significant in determining net farm income as shown in equation 6.5. These are crop area (X_2), consumer equivalents (X_3) and purchased farm inputs (X_1). They explain 38 and 31 percent of the variation in equations 6.1 and 6.5 respectively.

$$(6.5)\quad Y = -91.12 + \underset{(71.51^{**})}{246.06X_2} + \underset{(0.90^{*})}{2.12X_1} + \underset{(85.59^{*})}{174.02X_3}$$

$$R^2 = 0.31$$

$$(6.6)\quad Y = -466.69 + \underset{(74.64^{**})}{238.07X_2} + \underset{(0.98)}{1.88X_1} + \underset{(97.68)}{153.85X_3}$$

$$+ \underset{(0.24)}{0.11X_4} + \underset{(642.47)}{308.58D_2} - \underset{(612.56)}{223.48D_1}$$

$$+ \underset{(508.50)}{101.78D_3}$$

$$R^2 = 0.32$$

See footnote 1 page 94 for significance levels **, *.

This close similarity seems to point out further that the same factors are important in explaining the variation in net farm income, regardless of which of the two methods is used to compute it. Net farm income as computed by the second method seems to be the best method of estimating net farm income as indicated by the R^2 value in equation 6.3.

Gross farm income

Gross farm income computed by the first method

In equation 6.7 crop area (X_2), consumer equivalent (X_3), purchased inputs (X_1) and hired labour (X_6) were significant in accounting for 53 percent of the variation in gross farm income. Equation 6.8 shows significant and non-significant variables.

$$(6.7)\quad Y = -189.28 + \underset{(0.86^{**})}{4.65X_1} + \underset{(68.83^{**})}{234.26X_2} + \underset{(0.26^{**})}{0.80X_6} + \underset{(81.87^{*})}{163.70X_3}$$

$$R^2 = 0.53$$

$$\begin{aligned}(6.8)\quad Y = -1137.17 &+ \underset{(0.92^{**})}{4.30X_1} + \underset{(70.32^{**})}{224.92X_2} + \underset{(0.27^{**})}{0.94X_6} + \underset{(91.33)}{155.36X_3} \\ &+ \underset{(636.15)}{923.05D_2} + \underset{(475.74)}{575.45D_3} - \underset{(575.10)}{415.65D_1} \\ &+ \underset{(0.22)}{0.03X_4}\end{aligned}$$

$$R^2 = 0.55$$

See footnote 1 page 94 for significance levels **, *.

With the exception of hired labour (X_6), these are the same variables that are found significant in equations 6.1 and 6.5. Hired labour and purchased farm inputs use up farmer's cash savings which are limited.

Equation 6.7 shows that for KShs. 1.00 spent on purchased inputs, gross farm income improves by KShs. 4.60 other factors remaining equal. An additional man-hour of hired labour increases gross farm income by KShs. 0.80. Thus, the net return from purchased farm input and hired labour does not seem to be an adequate incentive for farmers to risk the extra cost. A higher regression coefficient was expected for hired labour under the assumption that the labour is used to plant and weed the crop in time.

Gross farm income computed by the second method

Purchased farm inputs (X_1), assets (X_7), the sex of the operator of the holding (D_2) and crop area (X_2) explained 75 percent of the total variation in gross farm income derived by the second method. The levels of significance for these variables are shown in equations 6.9 and 6.10.

$$(6.9)\quad Y = -911.47 + \underset{(0.77^{**})}{7.84X_1} + \underset{(0.03^{**})}{0.13X_7} + \underset{(494.38^{**})}{1518.91D_2} + \underset{(58.12^{*})}{135.25X_2}$$

$$R^2 = 0.75$$

$$(6.10)\quad Y = -1051.72 + \underset{(0.80^{**})}{7.35X_1} + \underset{(0.03^{**})}{0.11X_7} + \underset{(530.17^{**})}{1403.12D_2} + \underset{(59.22)}{110.94X_2}$$

$$+ \underset{(0.20)}{0.25X_4} - \underset{(485.50)}{627.19D_1} - \underset{(405.08)}{414.83D_3} + \underset{(77.36)}{30.59X_3}$$

$$R^2 = 0.76$$

See footnote 1 page 94 for significance levels **, *.

The regression coefficient of the dummy variable specifying the sex of operator of the holding, shows that other things being equal, holdings operated by men have KShs. 1519.00 higher gross farm income than those operated by women. This is contrary to what Moock (25, p. 251) observed in Vihiga about women as farm managers. The findings seem to support the point of view expressed by the Study Team of the Ministry of Agriculture (16, sect. 7 p. 28). One possible explanation is that given earlier, which suggests that women have only limited time to spend on farm operations due to numerous household chores. It is also likely that they operate with lower purchased farm inputs.

Assets show the least influence on the variation of gross farm income although the correlation coefficient is fairly high ($r = 0.550$). A change of KShs. 1.00 in the value of assets causes only a minor change (KShs. 0.13) in gross farm income.

Gross farm income computed by the third method

Purchased farm inputs (X_1), crop area (X_2) and hired labour are significant at 0.01 L.O.S. with 1 and 84 D.F. in explaining the variation in gross farm income. Family labour is significant at 0.05 L.O.S. with 1 and 84 D.F. Altogether they explain 53 percent of the total variation in gross farm income in equation 6.11.

$$(6.11)\quad Y = -509.41 + \underset{(0.93^{**})}{4.43X_1} + \underset{(74.43^{**})}{230.96X_2} + \underset{(0.27^{**})}{0.96X_6} + \underset{(0.20^{*})}{0.47X_4}$$

$$R^2 = 0.53$$

$$(6.12)\quad Y = -1234.71 + \underset{(0.98^{**})}{4.21X_1} + \underset{(75.26^{**})}{225.60X_2} + \underset{(0.29^{**})}{1.06X_6} + \underset{(0.24)}{0.28X_4}$$

$$+ \underset{(97.75)}{125.01X_3} + \underset{(680.84)}{694.58D_2} + \underset{(509.15)}{266.52D_3}$$

$$- \underset{(615.49)}{297.40D_1}$$

$$R^2 = 0.54$$

See footnote 1 page 94 for significance levels **, *.

Three of these variables together with consumer equivalent explan 53 percent of the total variation in farm income in equation 6.7. This close similarity seems to indicate that regardless of the method used to compute gross farm income the same variables are important in explaining its variation.

Gross crop output

Purchased crop inputs (X_9), crop labour (X_8), geographical location as specified by district (D1) and the sex of the operator of the holding (D2) explained 69 percent of the total variation in gross crop output. As shown in equations 6.13 and 6.14, all these variables were significant at 0.01 L.O.S. with 1 and N-k-1.

$$(6.13)\quad Y = -799.89 + \underset{(0.57^{**})}{5.11X_9} + \underset{(0.16^{**})}{1.04X_8} - \underset{(287.91^{**})}{849.32D_1} + \underset{(300.42^{**})}{819.16D_2}$$

$$R^2 = 0.69$$

$$(6.14)\quad Y = -839.69 + \underset{(0.58^{**})}{4.93X_9} + \underset{(0.18^{**})}{0.92X_8} - \underset{(292.40^{**})}{790.40D_1} + \underset{(300.32^{**})}{815.93D_2} + \underset{(37.96)}{58.43X_2} + \underset{(260.75)}{47.43D_3}$$

$$R^2 = 0.70$$

See footnote 1 page 94 for significance levels **, *.

The coefficient of D_1 indicates that other factors remaining equal, Kitui District has lower gross crop output (-KShs. 849.32) than Machakos District. This probably reflects the difference in soils as well as climate especially rainfall. The observation was expected because as mentioned previously, Kitui District is more arid than Machakos District.

The coefficient of D_2 shows that farms managed by men have KShs. 819.16 higher gross crop output than those managed by women, other factors remaining equal. The same reasons as discussed for equation 6.9 can be used to explan this observation.

Treating purchased crop inputs individually, machinery expenses is the only one that shows significant influence on gross crop output. This was expected from the correlation analysis. Crop labour (X_8), geographical location as specified by district (D_1) and machinery expenses (X_{10}) explain 76 percent of the variation in gross crop output as shown in equation 6.15

$$(6.15) \quad Y = -277.44 + \underset{(0.56^{**})}{6.63X_{10}} + \underset{(0.14^{**})}{1.14X_8} - \underset{(249.16^{**})}{687.74D_1}$$

$$R^2 = 0.76$$

$$
\begin{aligned}
(6.16)\quad Y = -609.39 &+ \underset{(0.58^{**})}{6.34X_{10}} + \underset{(0.08^{**})}{1.08X_8} - \underset{(256.32^{**})}{723.74D_1} \\
&+ \underset{(267.25)}{422.50D_2} + \underset{(33.65)}{34.23X_2} + \underset{(228.66)}{33.37D}
\end{aligned}
$$

$R^2 = 0.77$

See footnote 1 page 94 for significance levels **, *.

Since ox-ploughs are more widely used than hired tractor, there is reason to suggest that incurring ox-ploughing expenses enabled the farmers to plant and weed early. The importance of this input cannot be over stressed in marginal areas as discussed previously.

6.5 Results in Relation to Levels of Purchased Crop Inputs and Sex of the Operator of the Holding

Purchased Crop Inputs

As cited earlier 46 percent of the respondents purchased no crop inputs. The sample is divided into two groups (Table 6.6). Group 1 consists of the respondents who did not purchase any crop inputs, while

TABLE 6.6: <u>MEAN VARIABLE INPUTS PER HOLDING ACCORDING TO LEVELS OF PURCHASED CROP INPUTS</u>

VARIABLE INPUTS	MEAN VALUE OF PURCHASED CROP INPUTS		LEVEL OF SIGNIFICANCE FOR DIFFERENCES BETWEEN THE MEANS
	ZERO	ABOVE ZERO	
Purchased farm inputs (KSHs)	44.71	300.98	Significant at 0.01
Purchased crop inputs (KShs)	0.00	225.00	"
Assets (KShs)	4381.19	8779.62	"
Crop area (ha)	3.00	3.60	Not significant at 0.05
Machinery expenses (KShs)	0.00	153.33	Significant at 0.01
Crop labour (man-hours)	1327.00	1632.23	Not significant at 0.05
Sample size	41	48	

<u>SOURCE</u>: Author's calculation.

Group 2 includes those farmers that purchased crop inputs. These two groups show non-significant differences in the means of crop area and crop labour at 0.05 L.O.S. However, the means of purchased farm inputs, assets and machinery expenses show significant differences at 0.01 L.O.S. Equation 6.9 is used to calculate the gross farm income of these two groups, using the mean levels of the variables in the equation (purchased farm inputs, crop area and assets), and assuming that the farm operator is a man. This equation is chosen because it indicates how the factors considered explain the largest variation in farm income. Group 1's income is only 42 percent of that obtained by Group 2. This is not due to differences in crop area because these are not significant. It is likely to be the result of significant differences in the levels of purchased farm inputs and assets used.

The implication from these findings is the following: In order to improve the level of farm incomes such as in Group 1, it seems necessary to increase the use of purchased input. This is justified by the evidence that purchased farm inputs is a major factor in increasing farm income. With higher farm incomes, surpluses will be generated which can be invested in improving and increasing the assets of the holding.

This means that farmers in Group 1 should be encouraged to intensify their production on the crop area they have already. When this is achieved then the crop area can be expanded.

This argument is further emphasized by equation 6.15 which shows that machinery expenses, crop labour and geographical location of the holding as specified by district are significant in determining gross crop output. Assuming that the farmers come from the same district and using the average levels of machinery expenses and crop labour for each group, it is found that Group 1 has only 29 percent of the gross crop output obtained by Group 2. The difference is not due to differences in the amount of labour used because these are non-significant, but it arises from significant differences in machinery expenses incurred.

Sex of the Operator of the Holding

The literature review gave contradicting information on the performance of women as managers of small-scale farms. In Vihiga which is a high potential area, women managers were found to be more competent than men managers. The contrary was observed in marginal areas of Machakos District by the Ministry of Agriculture Team (16, sect. 7 p. 28). However, it was pointed out that this may be the result of women managers utilizing lower crop input levels and spending less time on the farm due to other domestic duties than actual differences in the managerial capability between sexes per se.

Equation 6.9 verifies that women operators of small-scale farms are associated with lower farm incomes. In fact, farms managed by men have KShs. 1519.00 higher gross farm income than those operated by women. This argument is enhanced by equation 6.13 which shows that women operated farms have KShs. 819.00 lower gross crop output than those managed by men.

However Table 6.7 shows that only three explanatory variables have significant difference between the means[1] of the two operator groups. These are family labour, hired labour and off-farm income. It is interesting to note that although women-operated-farms had significantly lower family labour and significantly higher hired labour, the difference between the means of crop labour (family and hired) was not significant. In this analysis, it is assumed that the contribution made by a man-hour of family

---

1 Although the men operators were 73 in number, the test for significant differences between the mean was done using the t-test, because the women operators were only 16. It is important to note that the resultant test for significant differences in the mean is more strict than that which operates when both sample sizes are at least 30. This means that only very large significant differences in the means of these variables will be detected.

TABLE 6.7: MEAN VARIABLE INPUTS PER HOLDING ACCORDING TO SEX OF THE OPERATOR OF THE HOLDING

VARIABLE INPUTS	OPERATOR OF HOLDING		LEVEVEL OF SIGNIFICANCE OF DIFFERENCES BETWEEN THE MEANS	MEAN VARIABLE INPUT OF WOMEN OPERATED HOLDING / MEN OPERATED HOLDING x 100
	WOMEN	MEN		
Purchased farm inputs (KShs)	134.94	193.43	Not significant at 0.05	69.96
Purchased crop inputs (KShs)	97.50	126.58	"	77.03
Assets (KShs)	9026.68	6255.12	"	144.31
Crop area (ha)	3.57	3.27	"	109.17
Machine expenses (KShs)	40.00	92.04	"	43.46
Crop labour (man-hours)	1407.88	1509.97	"	93.24
Family labour (man-hours)	2105.56	3190.81	Significant at 0.01	65.99
Hired labour (man-hours)	1128.00	251.92	Significant at 0.01	447.76
Consumer equivalents	5.36	5.59	Not significant at 0.05	96.23
Off-farm income	4176.81	1187.36	Significant at 0.01	351.77
Sample size	16	73		

SOURCE: Author's calculation.

or hired labour is identical. However it seems plausible to suggest that family labour may contribute more to the labour capacity on small-scale farms because its availability does not depend on cash income. In addition the hired labour may not be available at the wage rate the farmer can afford to pay. Its flexibility is also limited. On these bases farms operated using family labour are likely to be more successful than those which rely mainly on hired labour. Probably this contributes to the low farm incomes achieved by women managers.

In equation 6.3 is was established that net farm income decreases as off-farm income increases. Table 6.7 shows that women managers on the average enjoyed significantly higher off-farm income than men managers. In fact, they have 351 percent higher off-farm income than men operators. This originates primarily from the remittances made by absentee husbands employed outside the area especially in large towns. Hence off-farm income is likely to be an important factor in explaining why women operators achieve lower farm incomes. It is reasonable to suggest that if the family's subsistence needs are met from off-farm income, the incentive to farm may be lessened as the return to labour may be very low.

In the literature review it was pointed out that Smith (30) suggested that the size of off-farm income will mainly delimit the amount of purchased farm inputs and hired labour that will be used on the farm. Table 6.7 shows that this is actually the case with respect to hired labour. Women operators have significantly higher off-farm income and significantly more hired labour (447.76 percent) than men operators. However this is not true with respect to purchased farm inputs or purchased crop inputs, because there was no significant difference between the average levels of these inputs for the two groups. In fact women operators used approximately 30 and 23 percent less purchased farm inputs and purchased crop inputs than men respectively.

Equation 6.15 identifies machinery expenses as the most prominent component of purchased crop input influencing gross crop output. It is interesting to note that although the means were not significantly different, women operators incurred only approximately 43 percent of the machinery expenses incurred by men operators. This observation is even more emphasized when it is considered that crop area and crop labour for these two groups were not significantly different. Probably this implies that women managers do not avail themselves of the advantages accruing from machinery, for example the capacity to prepare land

and plant early for the rains and timely inter-row weeding.

6.6 Results in Relation to specific Objectives

The analysis aimed at finding out the relationship between the dependent variables, net farm income, gross farm income and gross crop output, and the explanatory variables, purchased farm inputs, crop area, labour (hired or family), assets, off-farm income, geographical location as specified by district, sex of the operator of the holding and the ease of transportation as indicated by the distance from the market to the holding. The major findings with respect to these factors are summarized below in order of importance.

(1) Factor purchased farm inputs. Virtually all the regression equations indicate that purchased farm inputs is the most important factor determining farm income. Machinery expenses stand out as the most prominent component of purchased crop inputs, influencing gross crop output. The analysis shows further that only a limited number of farmers used fertilizers and sprays. Only 28 percent of the respondents purchased seed. The analysis indicates that the influence of purchased seed on crop output is non-significant. This is likely to be the result of

low seed rates and the poor climatic conditions (drought) experienced during the survey year.

(2) Factor Crop area. The regression analysis denotes that crop area was positive influence on gross farm income and net farm income. However, crop area makes non-significant contribution to gross crop output. The possible explanation is that this was caused by the problems encountered in measuring crop area in a situation where mixed cropping is the convention. Infact, some plots can contain even more than four different crops.

(3) Factor labour. The effect of labour with respect to gross farm income and net farm income is considered from two points of view: that is, family labour and hired labour. Both show positive significant influence on farm income. This is emphasized even more by the positive contribution crop labour (family and hired) makes to gross crop output. Thus availability of labour limits farm productivity in marginal areas. However, the analysis suggests that family labour contributes more to farm income than the same capacity of hired labour.

(4) Factor off-farm income. The results of regression analysis lead to the conclusion that off-farm income has negative influence. This supports Mbithi's (23, p. 36) observation that farm productivity decreases as

off-farm income levels increase in marginal area. Contrary to what Smith (30, p. 36) suggested, high off-farm income level does not seem to be associated with increased purchased farm inputs. It is associated with higher hired labour and lower family labour. However, the analysis implies that hired labour might contribute less than the same amount of family labour.

(5) Factor sex of the Operator of the holding By distinguishing the sex of the operator of the holding, the analysis aimed at determining whether there is any small-scale farm management capability differences between sexes. Contradicting views are given in the literature. This analysis shows that low gross crop output and low farm income are associated with women operators. As discussed earlier, this observation may be explained by the fact that women managers had significantly higher off-farm income than men. Moreover, they used lower purchased crop inputs on similar crop area.

(6) Factor Assets The capability of the farmer to acquire capital inputs and hired labour is assumed to be indicated by the level of assets. The relatively high correlation between assets and hired labour (r = 0.623) and the moderate one between assets and purchased crop inputs (r = 0.418) seem to support this point of view. The correlation coefficients

between assets and gross farm income as well as gross crop output indicates a fairly strong positive association which is highly significant. Although the variable assets was excluded from most of the regression equations owing to serious multicollinearity, its contribution is significantly positive in explaining gross farm income (equations 6.9 and 6.10).

(7) Factor Consumer equivalents Household size and structure in terms of consumer equivalents is used to indicate the pressure exerted by subsistence requirements. The literature indicates that meeting the subsistence needs of the family is the major objective in small-scale farming. The significant regression coefficients shown by this variable for net farm income (equations 6.1, 6.5 and 6.7) indicate that higher consumer equivalents are associated with higher farm income. However, this trend was not confirmed by the relationship between consumer equivalents and gross crop output. Probably consumer equivalents as calculated in this analysis, do not represent adequately the subsistence requirements of the family.

(8) Factor Transportation The distance from the holding to the nearest sizeable market is used to show the effect of ease of transportation on farm income. It is found non-significant in explaining

between assets and gross farm income as well as gross crop output indicates a fairly strong positive association which is highly significant. Although the variable assets was excluded from most of the regression equations owing to serious multicollinearity, its contribution is significantly positive in explaining gross farm income (equations 6.9 and 6.10).

(7) Factor Consumer equivalents Household size and structure in terms of consumer equivalents is used to indicate the pressure exerted by subsistence requirements. The literature indicates that meeting the subsistence needs of the family is the major objective in small-scale farming. The significant regression coefficients shown by this variable for net farm income (equations 6.1, 6.5 and 6.7) indicate that higher consumer equivalents are associated with higher farm income. However, this trend was not confirmed by the relationship between consumer equivalents and gross crop output. Probably consumer equivalents as calculated in this analysis, do not represent adequately the subsistence requirements of the family.

(8) Factor Transportation The distance from the holding to the nearest sizeable market is used to show the effect of ease of transportation on farm income. It is found non-significant in explaining

variation in farm income and crop output. There are two plausible reasons for this observation. First, distance may not be an adequate measure of the ease of transportation, because a long distance might have suitable roads and be served better by transportation facilities, than a shorter distance with impassable roads especially during the wet season. Second, the distance intervals taken in the analysis (less than 4 kilometres and 4 kilometres and over) may be too close to indicate the impact of the distance on farm income. Probably, if the intervals taken were for instance less than 10 kilometres and 10 kilometres and over, the variable might have shown positive contribution.

(9) <u>Factor Natural Environment</u> The differences in soils and climate especially rainfall, are broadly categorised by district ignoring intra-district variations. This dummy variable is found significant in explaining variation in gross crop output. Kitui District has lower crop output than Machakos District. Since on the average approximately 60 percent (Appendix of gross farm income is formed by gross crop output, it can be concluded that Kitui District has lower farm income although this is not apparent in the regression equations.

Finally, the analysis also aimed at determining whether relationships between farm income and the above factors, depended on the method used to calculate farm income. As pointed out in the discussion of correlation and regression coefficients, the relative importance of these factors and the nature of their influence, positive or negative, is more or less maintained whether the income is considered

(a) as gross farm income or net farm income,

(b) with or without livestock valuation change,

(c) adjusted or unadjusted for drought year bias.

As it was expected, gross farm income showed stronger relationship with these variables than net farm income.

CHAPTER 7

CONCLUSIONS AND RECOMENDATIONS

7.1 Conclusions

The major conclusions of the study are summarized in this section.

Correlation and regression analysis implied that purchased farm input is one of the most important factors determining farm income in marginal areas. Crop output contributes over half of the farm income. Therefore purchased crop input is the major component of purchased farm inputs, and it was highly significant in determining gross crop output.

Regarding specific purchased crop inputs, machinery expenses was the most important factor determining gross crop output. This means that ox-plough and tractor hire facilities have significant impact on the crop productivity in marginal areas. The ox-plough is more commonly used probably because of the following reasons:

First, assuming that the farmer has oxen and he buys the plough, it is available for farm operation in every season without resorting to cash revenue, unlike tractor hire.

Second, untimely planting may not be eliminated by tractor hire service, because owing to inefficiencies in the organisation, farmers have been known to wait for their turn to come even after the rains have started.

Third, the ox-plough is more flexible because it can be used for ploughing as well as inter-row weeding. Hired tractors have not been used for weeding in the area.

Only a limited number of farmers used chemical fertilizers. The analysis did not indicate any significant relationship between gross crop output and fertilizer. This seems to suggest that fertilizer recommendations with respect to marginal areas should be reconsidered.

The association between seed expenses and gross crop output was also non-significant. It is plausible to suggest that this was the result of the drought experienced in the area during the review period.

Crop area (cultivated area X number of croppings per year) was observed to influence gross crop output as well as farm income. But, farmers using no purchased crop inputs had on the average 58 percent lower gross farm income and about 70 percent lower gross crop output than those who used these inputs on comparable crop area. The conclusion reached from this consideration is that although increasing crop area will increase crop output and hence farm income, there is the opportunity to increase the income by intensifying production on the prevalent crop area. This can be attained by the use of purchased crop inputs, especially those that enable early planting and weeding (machinery expenses).

The study indicated that labour capacity (family and hired) affect farm income and crop output. Nevertheless, it also denoted that two groups of farmers commanding the same amount of crop labour, but varying in the proportion of family labour, had significantly different farm income and crop output. Those who had a bigger proportion of family labour were more successful than those who had significantly more hired labour. The observation seems to suggest that family labour contributes more to farm productivity in marginal areas than an equivalent amount of hired labour. Further research work is recommended here to confirm this implication.

Off-farm income was found to be negatively associated with farm income and gross crop output. Contrary to expectations, high off-farm income was not positively related to purchased crop inputs. However, the farmers who commanded higher off-farm income utilized significantly more hired labour. Off-farm occupation reduced family labour significantly. The likely consequences of substituting hired labour for family labour was outlined above. It is therefore deduced that off-farm income is detrimental to farm productivity in marginal areas, because it seems to reduce dependency on farm output as the main source of livelihood.

With respect to sex of the operator of the holding, the analysis indicated that farms managed by women achieved lower farm income and crop output. It is concluded that this was the result of women managers operating with signficantly lower family labour and relying on significantly higher off-farm income. Moreover, although non-significant, they purchased less crop inputs especially those related to machinery (ox-plough and tractor hire).

Assets were shown to be positively associated with farm income and gross crop output. The analysis did not examine at length the reasons likely to lead to this association. However it indicated that "rich" farmers, as measured by the level of assets, were also the people who utilized more purchased inputs.

Finally, the conclusion was also reached that the importance of the influence of the above factors on farm income did not depend on the method used to calculate it. Generally, the same factors were important when the calculation took into account livestock valuation change or ignored it. The attempt to remove the drought bias on farm income of the review period, using a correction factor, did not affect the importance of these factors. The prominence of these factors as determinants of farm productivity was confirmed even further by their relationship with gross crop output.

7.2 Recommended additional research

In order to achieve the Government objectives of increasing farm income in marginal areas, the following are the major recommendations for further research arising from the study.

(1) It is generally recommended that farmers should use purchased farm inputs especially fertilizer, seed and sprays, but this study has shown that there is minimal dependence on these inputs and that they have negligible influence on farm income. Further research work should establish the reasons for this trend. By considering the physical environment of the semi-arid areas and the socio-economic constraints that influence the farmers , it is possible to find out whether using fertilizer, seed and sprays increase yield significantly. It would also be useful to establish whether the increase in yield is large enough to influence the farmer to take the risk of purchasing the inputs even when the scarcity of cash income and frequency of crop failure is taken into account. It is also likely that increased yield per se does not increase the net income due to the cost

of the inputs. In addition the farmers have to cope not only with the risk of unpredictable rainfall but also with the risk of unpredictable availability of these inputs.

Machinery expenses seem to be the most important component of purchased farm inputs that influences farm income and crop output. It was suggested that incurring machinery expenses enabled the farmers to plant and weed in time for the rains. Further research should confirm this assertion. Since some delay is involved when arranging for hired tractors to plough the land it is important to find out whether tractor hiring lessens the problem of late planting. It also important to compare the economics and flexibility of using an ox-plough in small-scale farms of marginal areas with that of hired tractor.

(2) The analysis has also indicated that farmers operating similar crop areas can have large differences in the crop output and farm income. Land shortage is anticipated in the semi-arid areas owing to rapid population growth rates and in-migration of the landless from high potential areas. It is recommended that ways and means be made available to the farmers so that they can expand the farm output without increasing the cropped area. One possibility is to

exploit the two rain seasons that occur in this area each year.

(3) High levels of assets have been shown to be associated with those farmers who purchase farm inputs and hire labour. It is suggested that future studies should find out the possibilities of improving farm productivity of the farmers owning low asset levels. In addition it should be ensured that once such programmes are started the problems that induce these farmers to drop out are researched on and solved.

(4) With respect to labour and off-farm income the following is recommended. First, more studies should confirm whether hired labour contributes less to farm productivity than the same amount of family labour in small-scale farming. Second, since this analysis indicates that off-farm income has negative effect on farm income in marginal areas, further research should confirm this and establish the causes. Probably it is the competition for labour with off-farm employment and for the reduced interest in farming when there is an alternative to meet subsistence needs.

(5) As long as most men from marginal areas have to look for off-farm employment, a substantial number of farms will be managed by women. As such, it is important for other researchers to investigate more

thoroughly than has been possible in this analysis, the cause of low farm income and crop output in holdings operated by women. The characteristics of women operators outlined by this analysis seem to suggest that women managers form a section of the farming community in semi-arid areas which might have special problems affecting the farm productivity. If this is the situation, it is important to find out the special constraints facing this group of farmers. It would be useful to find out how the opinions of the absentee husbands influence the decisions that affect farm productivity for example asking for credit, purchasing fertilizer, seed, sprays and ox-ploughs.

REFERENCES

1. Acland, J.D. — East African Crops. FAO United Nations, Rome, 1971.

2. Ambrose, H.B. — The Case for Intensified Agricultural Research in the Medium Potential Areas of Kenya. Unpublished Paper (Mimeographed). Kenya, Ministry of Agriculture, Nairobi, 1964.

3. Dorling, M.J. — Income Distribution in the Small Farm Sector of Kenya. Department of Agricultural Economics, University of Nairobi, June 1979.

4. Heyer, J. — Agricultural Development and Peasant Farming in Kenya. Ph.D. Thesis, University of London, 1966.

5. Heyer, J. — Alternative Development of Lowland Machakos Farms. Discussion Paper No. 35. Institute for Development Studies, University of Nairobi, 1966.

6. Heyer, J. et al — (ed) Agricultural Development in Kenya. Oxford University Press, 1976.

7. Hunt, D.M. — Growth Versus Equity: An Examination of the Distribution of Economic Status and Opportunity in Mbere, Eastern Kenya. Occasional Paper No. 11. Institute for Development Studies, University of Nairobi, 1975.

8. Hunt, D. — Chaynov's Model of Peasant Household Resource Allocation and Its Relevance to Mbere Division Eastern Kenya. Working Paper No. 276. Institute for Development Studies, University of Nairobi, 1976.

9. International Labour Officer. Employment Incomes and Equity; A Strategy for Increasing Productive Employment in Kenya. Geneva, 1972.

10. Kenya. Ministry of Agriculture. The Soils of the Nairobi, Thika - Yatta-Machakos Areas. Nairobi, Government Printer, 1963.

11. Kenya. Ministry of Agriculture. The Ecology of the North Machakos-Thika Area, Nairobi, Government Printer, 1963.

12. Kenya. Ministry of Agriculture. Annual Report of the Research Division, 1966. Nairobi, Government Printer, 1960.

13. Kenya. Ministry of Finance and Planning, Statistics Division. Population Census, 1969. Volume 1. Nairobi, Government Printer, 1970.

14. Kenya. Ministry of Agriculture. Annual Report of the Research Division, 1970. Nairobi, Government Printer, 1970.

15. Kenya. Ministry of Finance and Planning, Central Bureau of Statistics. Integrated Rural Survey 1974-75 Basic Report. Nairobi, 1970.

16. Kenya. Ministry of Agriculture Marginal/ Semi-Arid Lands Study Team. Interim Resource Inventory Reports Volume 1 Mid Point Review November 29, December 2, 1977. Nairobi, 1977.

17. Kenya. Ministry of Economic Planning Development and Community Affairs. Development Plan 1979-1983. Nairobi, Government Printer, 1979.

18. Kenya. Ministry of Agriculture. Annual Report Kitui District, (1960 to 1978). Nairobi, Government Printer, 1960 to 1978.

19. Lagemann, J. Traditional African Farming Systems in Eastern Nigeria. Munchen, Wertforum Verlag, 1977.

20. Luning, H.A. Land Suitability Evaluation on the Basis of Reconnaissance Soil Surveys. Kenya, Ministry of Agriculture, National Agricultural Laboratories, Nairobi, 1973.

21. Lynam, J.K. An Analysis of Population Growth, Technical Change, and Risk in Peasant Semi-Arid Farming Systems. A Case Study of Machakos District Kenya. Ph.D. Thesis, Stanford University, U.S.A., 1978.

22. Marchant, T. et al. Private Communication. March, 1979.

23. Mbithi, P. Non-Farm Occupation and Farm Innovation in Marginal, Medium and High Potential Regions of Eastern Kenya and Buganda. Staff Paper No. 114. Institute for Development Studies, University of Nairobi, 1971.

24. Mbithi, P.W. and Wisner, B. Drought and Famine in Kenya: Magnitude and Attempted Solutions. Discussion Paper No. 144. Institute for Development Studies, University of Nairobi, 1972.

25. Moock, P.R. Managerial Ability in Small-farm Production: An Analysis of Maize Yields in the Vihiga Division of Kenya. Ph.D. Thesis, Colombia University, 1973.

26. Mosher, A.T. Getting Agriculture Moving: Essential for Development and Modernization. Frederic A. Praeger Inc., Publishers for the Agricultural Development Council Inc., 1966.

27. Nadar, H.M. and Rodewald, G.E. Katumani Maize and the Long Rains in the Machakos Area. USDA/USAID/KARI. Kenya, Ministry of Agriculture, Nairobi, 1978.

28. Nie, H.H. et al Statistical Package For The Social Sciences (SPSS). New York, McGraw Hill, 1975.

29. Ruthenberg, H. (Ed) Smallholders Farming and Smallholders Development in Tanzania. Munchen, Wertforum Verlag, 1968.

30. Smith, L.D. Low Income Smallholder Marketing and Consumption Pattern - Analysis and Improvement Policies and Programmes. (Mimeo). Kenya, Ministry of Agriculture, Nairobi, 1978.

31. Snedecor, G.W. and Cochran, W.G. Statistical Methods, (6th ed). Ames, Iowa State University Press, 1967.

32. Upton, M. Agricultural Production Economics and Resource-Use. Oxford University Press, 1976.

33. Wilde, J.C. de. Experiences with Agricultural Development in Tropical Africa Volume 11. Baltimore, John Hopkins Press, 1967.

34. Wonnacott, R. and Wonnacott, T. Econometrics. New York, John Wiley and Sons Inc., 1970.

APPENDIX 1: DEFINITION OF TERMINOLOGY IN THE ANALYSIS.

The following terms are important for the Study and unless otherwise stated the definition strictly follows that given in the IRS 1 Basic Report.

Agro-Ecological Zone - Definition of zones used for stratification of the national sample is based on the main cash crop grown in each zone. Where this criterion was not applicable a "special area criterion" or rainfall criterion was used.

Farm - This term was used strictly in the IRS 1 to describe only registered farms on the land registration lists in the District Land Offices. However the normal unit of definition and reference is the Holding (see below).

Household - A person or group of persons living together under one roof or several roofs within the same compound or homestead area and sharing a community of life by their dependence on a common holding as a source of income and food, which usually but not necessarily involves them eating from a 'common pot'.

Holder - The person with overall control over the management of the holding. In cases where the Holder lives with the rest of the household, he/she will also be the Head of Household.

Operator - The person who is charged with day to day running operations of the holding. The operator need not be a member of the household and may be employed by the holder as a paid manager.

Holding - The land associated with a household being used wholly or partially for agricultural purposes and being managed as a single economic unit under the overall control and direction of a holder.

Farm Operating Surplus - A gross margin derived from agricultural operations of the holding. In context of IRS terminology it would be referred to as Holding Operating Surplus. Since payment to family labour was not included, this term really refers to Net Farm Family Income. In this study it will be referred to by the more familiar yet strictly defined term Net Farm Income (Appendix 3,4).

Total Production - This is derived by adding up the values of the following: all crops sold or consumed by the household, sales of milk, net livestock sales, output used for seed, fed to stock or given as wages to labour, and the valuation change of crops and livestock. Henceforth it will be referred to by the more common term Gross Farm Income (Appendix 3, 4).

Non-Farm Operating Surplus - A gross margin derived from non-agricultural enterprises conducted by the household. In the context of IRS terminology it would be Non-Holding Operating Surplus.

Non-Farm Income - It refers to the sum of Non-farm Operating Surplus, regular and casual employment earnings of members of the household, remittances from relatives and other gifts. An example is given in Appendix 4. In the study it will be referred to by the more accurate term Off-Farm Income.

Total Household Income - It is obtained by adding up Net-Farm Income and Off-farm Income.

Total Farm Costs - This refers to the sum of the following expenses: seed, machinery, fertilizers, sprays, other purchased crop inputs, purchased feed, other livestock costs, wages to labour, own produce used as seed, fed to stock or given to labour and farm repairs.

Gross Crop Output - This term refers to the sum of the following: all crop sales, crop output used as seed, given to labour, fed to stock or consumed by the household and crop valuation change.

Crop Valuation Change - It reflects the change in value of crops during the course of the survey. It includes the value of both crops in store and the planted crops. Planted crops were assigned a value equal to the value of the inputs, including labour which had been used on the crop at the time of valuation. Crops in store were valued on the basis of local market prices at the time of valuation.

Livestock Valuation Change - It refers to the change in value of livestock during the course of the survey. Only holder's livestock found on the holding at the time of valuation was considered. Age, Sex and breed of the animals were taken into account in the valuation which was based on the current local market prices.

APPENDIX 2: DERIVATION OF GROSS FARM INCOME AND NET FARM INCOME BY NET FARM INCOME GROUPS[1]

	SHILLINGS PER HOLDING					
N	22	21	17	17	12	89
GROUP (KShs)	0-500	500 - 1000	1000 - 2000	2000 - 4000	> 4000	WHOLE SAMPLE
Sale of export crop	115.00	6.19	193.53	650.59	2274.17	497.75
Sale of food crop	81.91	145.33	206.76	486.06	409.58	242.10
Milk sales	11.23	78.48	10.82	46.65	95.58	45.16
Net cattle sales	238.55	216.33	195.00	1159.59	1815.75	613.57
Net other stock sales	144.91	121.86	305.47	513.29	973.33	352.20
TOTAL FARM SALES	591.59	568.19	911.59	2856.18	5568.42	1750.79
Home consumption	719.05	944.67	634.71	1505.76	2307.50	1120.62
Home produced inputs	81.73	95.10	65.59	158.88	421.58	142.36
Wages in kind	94.45	29.71	18.76	146.65	38.42	67.13
Crop valuation change	-151.68	-45.00	140.24	199.41	-224.58	-13.51
Cattle valuation change	-508.64	-370.48	-164.71	1090.29	1190.83	-292.30

APPENDIX 2 (continued)

	SHILLINGS PER HOLDING					
N	22	21	17	17	12	89
GROUP (KShs)	0-500	500-1000	1000-2000	2000-4000	>4000	WHOLE SAMPLE
Other stock valuation change	-64.86	-90.33	-28.89	-158.12	-216.25	-102.11
GROSS FARM INCOME	761.64	1131.86	1577.89	5799.05	9085.92	2672.97
TOTAL FARM COST	497.64	363.95	138.59	709.35	1162.42	527.58
NET FARM INCOME	264.00	767.91	1439.30	5089.70	7923.50	2145.38

SOURCE: Author's calculation

1 The gross farm income and net farm income totals in this table are derived from the same procedure used in the IRS 1 and as fully explained in the text p. 62 . Total farm sales are composed of the items shown and gross farm income is obtained when additional items as listed are allowed for.Net farm income is obtained when total farm cost is deducted from gross farm income. The items included under total farm costs are detailed in the text p. 63.

APPENDIX 3: DERIVATION OF GROSS FARM INCOME , NET FARM INCOME, GROSS CROP OUTPUT AND NON-FARM INCOME BY NET FARM INCOME GROUP[1]

		SHILLINGS PER HOLDING			
N	23	25	22	19	89
GROUP (KShs)	< 0-500	500-1500	1500-4000	4000-1400	WHOLE SAMPLE
Sale of export crop	3.48	36.40	247.27	1993.16	497.75
Sale of food crop	71.39	205.96	313.45	413.68	242.10
Milk sales	1.39	11.60	53.73	132.37	45.16
Net cattle sales	-4.65	13.40	325.32	2485.42	613.57
Net other stock sales	-27.96	95.44	332.23	1173.37	352.20
TOTAL FARM SALES	43.65	362.80	1272.00	6198.00	1750.79
Home consumption	410.26	671.44	1385.45	2264.89	1120.60
Home produced inputs	26.83	38.12	185.73	369.16	142.36
Wages in kind	21.65	87.24	78.95	82.05	67.13
Crop Valuation Change	-135.30	24.52	119.59	-70.26	-13.52
GROSS FARM INCOME 2	367.09	1184.12	3041.73	8843.84	3067.38

APPENDIX 3 (continued)

	SHILLINGS PER HOLDING				
N	23	25	22	19	89
GROUP (KShs)	<0-500	500-1500	1500-4000	4000-1400	WHOLE SAMPLE
Wages	169.57	210.80	121.82	163.68	168.09
Wages in kind	21.65	87.24	78.95	82.05	67.13
Home produced inputs	26.83	38.12	185.73	369.16	142.36
Purchased crop inputs	55.22	30.40	131.36	309.47	121.35
Stock expenses	0.70	10.64	21.27	37.37	16.40
Farm Repairs	36.09	2.0	8.18	1.58	12.25
TOTAL FARM COST	310.04	379.20	547.32	963.32	527.58
NET FARM INCOME	57.05	804.92	2494.41	7880.52	2439.80
Regular Employment	1166.91	135.00	370.00	118.42	456.22
Casual Employment	433.13	144.52	81.23	63.84	186.24
Other Gifts	54.78	71.88	102.77	89.53	78.87
Remittances from Relatives	1148.13	336.44	301.18	577.21	588.89
Non-farm Operating Surplus	282.74	716.44	502.64	89.79	417.73
NON-FARM INCOME	3082.39	1404.24	1357.59	928.32	1724.79
HOUSEHOLD INCOME	3139.44	2209.16	3852.00	8808.84	4164.59
GROSS CROP OUTPUT	443.26	897.60	1889.45	4455.84	1785.00

---

1 Gross farm income and net farm income in this table are adjusted income figures according to the procedure explained in the text p. 63. As such they compensate in some measure for the distortion that is made by negative livestock inventory during the period of study. Gross crop output is that portion of gross farm income (derived by the second method) remaining after all livestock activities are excluded.

APPENDIX 4 : NET FARM INCOME AND GROSS CROP CROP OUTPUT AS PERCENTAGES OF GROSS FARM INCOME[1]

GROSS FARM INCOME GROUP (KShs)	< 0-500	500-1500	1500-4000	4000-14000	Average
$\frac{\text{NET FARM INCOME}}{\text{GROSS FARM INCOME}} \times 100$	15.54	67.98	82.01	89.11	79.54
$\frac{\text{GROSS CROP OUTPUT}}{\text{GROSS FARM INCOME}} \times 100$	12.07	75.80	62.12	50.38	56.23

SOURCE: Author's calculation.

---

1 Gross farm income, net farm income and gross crop output are derived by the second method explained in the text.

APPENDIX 5a: CORRELATION COEFFICIENTS BETWEEN FARM INCOME AND DESIGNATED EXPLANATORY VARIABLES FOR SAMPLE SIZE 132

DESIGNATED EXPLANATORY VARIABLES	DEDENDENT VARIABLES					
	NET FARM INCOME			GROSS FARM INCOME		
	1ST METHOD	2ND METHOD	3RD METHOD	1ST METHOD	2ST METHOD	3RD METHOD
X_1 Purchased Farm Inputs	.369**	.660**	.303**	.509**	.785**	.506**
X_2 Crop Area	.256**	.252**	.230**	.362**	.386**	.380**
X_3 Consumer Equivalent	.115	.238**	.100	.178	.295**	.179
X_4 Family Labour	.146	.401**	.151	.180	.422**	.217**
X_5 Non-Farm Income	-.333**	-.271**	-304**	-.160	-.090	-.131
X_6 Hired Labour	-.145	-.210	-.129	.135	.082	.168
X_7 Assets	-.112	.152	-.129	.219**	.420**	.103

** Variables significant at 0.01 L.O.S. with 130 D.F.

SOURCE: Author's calculation.

APPENDIX 5b: CORRELATION COEFFICIENTS BETWEEN GROSS CROP OUTPUT AND DESIGNATED EXPLANATORY VARIABLES FOR SAMPLE SIZE 132

DESIGNATED EXPLANATORY VARIABLES	DEPENDENT VARIABLE GROSS CROP OUTPUT
X_2 Crop Area	.469**
X_3 Consumer Equivalent	.237**
X_5 Non-Farm Income	.053
X_7 Assets	.525**
X_8 Crop Labour	.481**
X_9 Purchased Crop Inputs	.598**
X_{10} Machine Expenses	.705**
X_{11} Fertilizer Expenses	.223**
X_{12} Spray Expenses	.054
X_{13} Seed Expenses	-.004

** Variables significant at 0.01 L.O.S. with 130 D.F.

SOURCE: Author's calculation.

APPENDIX 6: ABSOLUTE AND RELATIVE FREQUENCY DISTRIBUTIONS OF EXPLANATORY VARIABLES USED IN THE ANALYSIS

ABS = ABSOLUTE

REL = RELATIVE

A

Purchased Inputs (Shs)	FREQUENCY	
	ABS	REL
0	14	15.7
0-50	33	13.1
50-200	20	22.4
200-600	11	12.3
600-1600	11	12.3
	89	100

B

Purchased Crop Inputs (Shs)	FREQUENCY	
	ABS	REL
0	41	46.1
0-50	20	22.5
50-200	9	10.1
200-400	9	10.1
400-1200	10	11.1
	89	100

APPENDIX 6 (continued)

C

Machine Expenses (Shs)	FREQUENCY	
	ABS	REL
0	70	78.7
100-150	2	2.2
150-200	3	3.4
200-400	7	7.9
400-600	4	4.5
600-800	2	2.2
1000-1200	1	1.1
	89	100

D

Fertilizer Expenses (Shs)	FREQUENCY	
	ABS	REL
0	86	96.6
5-10	1	1.1
10-20	2	2.2
	89	100

APPENDIX 6 (continued)

E

Seed Expenses (Shs)	FREQUENCY	
	ABS	REL
0	64	71.9
>0-20	12	13.5
20-50	4	4.4
50-300	9	10.0
	89	100

F

Spray Expenses (Shs)	FREQUENCY	
	ABS	REL
0	88	98.9
>0-20	1	1.1
	89	100

APPENDIX 6 (continued)

G

Family labour (Man-hours)	FREQUENCY	
	ABS	REL
0-2000	29	32.6
2000-4000	42	47.2
4000-7000	18	20.2
	89	100

H

Hired labour (Man-hours)	FREQUENCY	
	ABS	REL
0	47	52.8
> 0-500	25	28.0
500-4000	17	19.2
	89	100

APPENDIX 6 (continued)

I

Crop Labour (Man-hours)	FREQUENCY	
	ABS	REL
0-500	2	2.2
500-1000	20	22.5
1000-1500	31	34.8
1500-2000	20	22.5
2000-5000	16	17.9
	89	100

Assets (Shs)	FREQUENCY	
	ABS	REL
0-1000	20	22.5
1000-4000	23	25.9
4000-10000	24	26.9
10000-40000	22	24.7
	89	100

APPENDIX 6 (continued)

K

Crop area (Hectares)	FREQUENCY	
	ABS	REL
0-0.5	10	11.2
0.5-1.0	17	19.1
1.0-1.5	10	11.2
1.5-2.0	9	10.1
2.0-4.0	21	23.6
4.0-10.0	17	19.1
10.0-18.0	5	5.6
	89	100

L

Off-farm income (Shs)	FREQUENCY	
	ABS	REL
<0	10	10.9
0-2000	53	59.6
2000-4000	18	20.2
4000-14000	8	8.9
	89	100

APPENDIX 6 (continued)

M

Consumer Equivalent (Adult equivalent)	FREQUENCY	
	ABS	REL
0 - 2	9	10.1
2 - 4	28	31.5
4 - 6	20	22.5
6 - 8	13	14.6
8 - 18	19	19.0
	89	100

N

Distance to Market (Kilometres)	FREQUENCY	
	ABS	REL
< 6.4 (miles)	50	56.2
6.4 and over	39	43.8
	89	100

APPENDIX 6 (continued)

O

Geographical location (District)	FREQUENCY	
	ABS	REL
Embu	12	13.5
Kitui	24	29.0
Machakos	53	59.6
	89	100

P

Sex of operator of the holding	FREQUENCY	
	ABS	REL
Male	70	78.9
Female	16	18.0
Male or Female Relative or non relative	3	3.3
	89	100

APPENDIX 7: PERCENTAGE BREAKDOWN OF COMPONENTS OF VARIABLE ASSET BY NET FARM INCOME[1] GROUP

	< 0-500	500-1500	1500-4000	4000-14000	Average
Value of land	35.4	42.1	35.5	17.2	29.5
Value of structures	47.8	32.0	27.1	32.1	33.1
Value of livestock	15.3	23.9	33.0	45.8	33.7
Value of equipment	1.5	2.0	4.4	4.8	3.7
Value of assets	100.0	100.0	100.0	100.0	100.0

SOURCE: Author's calculation

1 Net farm income in this table is derived by the first method.

APPENDIX 8: THE COBB-DOUGLAS FUNCTIONS OF FACTORS INFLUENCING NET-FARM INCOME, GROSS FARM INCOME AND GROSS CROP OUTPUT

	0.78	0.36	0.28		
(9.1) Y = 1.23	X_4	X_2	D_3		$R^2 = 0.31$
	(0.27)**	(0.12)**	(0.11)*		
	0.49	0.39	0.27	0.28	
(9.2) Y = 2.69	X_4	X_2	D_3	D_2	
	(0.34)	(0.14)**	(0.11)*	(0.15)	
	0.24	-0.82	0.11	-0.05	
	X_3	X_1	X_7	D_1	$R^2 = 0.35$
	(0.27)	(0.09)**	(0.14)	(0.16)	
	1.06	-0.28	0.28		
(9.3) Y = 2.75	X_4	X_5	X_1		$R^2 = 0.28$
	(0.43)*	(0.08)**	(0.11)*		

APPENDIX 8 (continued)

	0.75	-0.24	0.12	0.36	
(9.4) Y = 0.219	X_4	X_5	X_1	X_7	
	(0.56)	(0.09)**	(0.15)	(0.23)	
	0.43	-0.24	-0.08	-0.16	
	D_2	D_1	D_3	X_3	
	(0.27)	(0.26)	(0.19)	(0.46)	
	0.07				
	X_2				R^2 = 0.32
	(0.24)				
	0.38				
(9.5) Y = 645.65	X_2				R^2 = 0.05
	(0.17)*				

APPENDIX 8 (continued)

	0.39	0.20	0.31	-0.18	
(9.6) Y = 42.66	X_2	D_3	X_4	X_1	
	(0.27)	(0.18)	(0.51)	(0.13)	
	-0.21	0.19	0.30		
	D_1	D_2	X_3		$R^2 = 0.12$
	(0.24)	(0.23)	(0.41)		
	0.38	0.89	0.08		
(9.7) Y = 0.83	X_2	X_4	X_6		$R^2 = 0.50$
	(0.10)**	(0.19)**	(0.03)**		
	0.38	0.61	0.08	0.16	
(9.8) Y = 3.24	X_2	X_4	X_6	D_3	
	(0.10)**	(0.24)*	(0.04)*	(0.08)	

APPENDIX 8 (continued)

	0.06	0.14	0.14	-0.04	
	X_1	D_2	X_3	D_1	
	(0.06)	(0.11)	(0.20)	(0.12)	R^2 = 0.54
	0.43	0.74	0.17	-0.60	
(9.9) Y = 0.07	X_7	X_4	X_1	X_3	
	(0.12)**	(0.30)*	(0.07)*	(0.24)*	
	0.28	0.29			
	X_2	D_2			
	(0.12)*	(0.13)*			R^2 = 0.55

APPENDIX 8 (continued)

	0.43	0.74	0.12	-0.57	
(9.10) $Y = 0.10$	X_7	X_4	X_1	X_3	
	(0.12)**	(0.30)*	(0.08)	(0.24)*	
	0.29	0.31	-0.16	-0.04	
	X_2	D_2	D_1	D_3	
	(0.12)*	(0.13)	(0.14)	(0.10)	$R^2 = 0.56$
	0.39	0.94	0.08		
(9.11) $Y = 0.59$	X_2	X_4	X_6		
	(0.10)**	(0.20)**	(0.03)**		$R^2 = 0.51$
	0.38	0.69	0.08	0.13	
(9.12) $Y = 2.00$	X_2	X_4	X_6	D_3	
	(0.10)**	(0.25)**	(0.04)*	(0.09)	

APPENDIX 8 (continued)

	0.06	0.12	0.11	-0.03	
	X_1	D_2	X_3	D_1	
	(0.06)	(0.11)	(0.20)	(0.12)	R^2 = 0.54
	0.18	0.83	-0.25	0.23	
(9.13) Y = 1.047	X_9	X_8	D_1	X_2	
	(0.03)**	(0.17)**	(0.07)**	(0.07)**	
	0.23				
	D_2				
	(0.08)**				R^2 = 0.68
	0.18	0.84	-0.25	0.23	
(9.14) Y = 0	X_9	X_8	D_1	X_2	
	(0.03)**	(0.18)**	(0.07)**	(0.08)**	

APPENDIX 8 (continued)

		0.23	-0.01			
		D_2	D_3			
		(0.08)**	(0.07)			$R^2 = 0.68$
		0.22	0.94	0.23	-0.16	
(9.15)	Y = 0.66	X_{10}	X_8	X_2	D_1	
		(0.03)**	(0.15)**	(0.07)**	(0.07)*	
		0.14				
		D_2				
		(0.07)*				$R^2 = 0.72$
		0.22	1.00	0.21	-0.18	
(9.16)	Y = 0.46	X_{10}	X_8	X_2	D_1	
		(0.03)**	(0.17)**	(0.07)**	(0.07)*	

APPENDIX 8 (continued)

	0.14	-0.06	
	D_2	D_3	
	(0.07)*	(0.06)	$R^2 = 0.73$

For the description of the variables see Chapter 5.

** Significant at 0.01 L.O.S. with 1 and N-k-1

* Significant at 0.05 L.O.S. with 1 and N-k-1

The figures in parentheses are the standard errors of the regression coefficients.

SOURCE: Author's calculation.

---

1 In equation 9.1 and 9.2 Y is net farm income derived by the first method.
In equation 9.3 and 9.4 Y is net farm income derived by the second method.
In equation 9.5 and 9.6 Y is net farm income derived by the third method.
In equation 9.7 and 9.8 Y is gross farm income derived by the first method.
In equation 9.9 and 9.10 Y is gross farm income derived by the second method.
In equation 9.11 and 9.12 Y is gross farm income derived by the third method.
In equation 9.13 to 9.16 Y is gross crop output.

APPENDIX 9: THE INDIVIDUAL EXPLANATORY VARIABLES' CONTRIBUTION TO R^2 IN LINEAR REGRESSION EQUATIONS

EQUATION	DEPENDENT VARIABLE	EXPLANATORY VARIABLE	EXPLANATORY VARIABLE'S CONTRIBUTION TO R^2	F	STD ERROR
		X_1	0.24		
1a	Net farm income 1st method	X_2	0.11		
		X_3	0.03	17.52**	2170.27
		X_1	0.24		
1b	Net farm income 1st method	X_2	0.11		
		X_3	0.03		
		D_2	0.01		
		D_3	0.01		
		D_1	0.002		
		X_4	0.001	7.77**	2187.54

APPENDIX 9 (continued)

EQUATION	DEPENDENT VARIABLE	EXPLANATORY VARIABLE	EXPLANATORY VARIABLE'S CONTRIBUTION TO R^2	F	STD ERROR
2a	Net farm income 2nd method	X_1	0.54		
		X_4	0.06		
		X_5	0.04	49.12**	2011.85
2b	Net farm Income 2nd method	X_1	0.54		
		X_4	0.06		
		X_5	0.04		
		X_2	0.01		
		D_1	0.01		
		D_3	0.01		
		X_3	0.01		
		X_7	0.01		
		D_2	0.01	19.00**	1939.65

APPENDIX 9 (continued)

EQUATION	DEPENDENT VARIABLE	EXPLANATORY VARIABLE	EXPLANATORY VARIABLE'S CONTRIBUTION TO R^2	F	STD ERROR
3a	Net farm	X_2	0.21		
	income	X_1	0.06		
	3rd method	X_3	0.03	12.64**	2301.22
3b		X_2	0.21		
	Net farm	X_1	0.06		
	Income	X_3	0.03		
	3rd method	X_4	0.004		
		D_2	0.001		
		D_1	0.001	5.23**	2345.84
		D_3	0.0003		

APPENDIX 9 (continued)

EQUATION	DEPENDENT VARIABLE	EXPLANATORY VARIABLE	EXPLANATORY VARIABLE'S CONTRIBUTION TO R^2	F	STD ERROR
	Y	X_1	0.35		
4a	Gross farm	X_2	0.10		
	Income	X_6	0.05		
	1st method	X_3	0.02	23.33**	2198.28
		X_1	0.35		
4b	Gross farm	X_2	0.10		
	Income	X_6	0.05		
	1st method	X_3	0.02		
		D_2	0.01		
		D_3	0.01		
		D_1	0.003		
		X_4	0.0001	12.31**	2191.06

APPENDIX 9 (continued)

EQUATION	DEPENDENT VARIABLE	EXPLANATORY VARIABLE	EXPLANATORY VARIABLE'S CONTRIBUTION TO R^2	F	STD ERROR
5a	Gross farm Income 2nd method	X_1	0.65		
		X_7	0.06		
		D_2	0.03		
		X_2	0.02	61.94**	1870.45
5b	Gross farm Income 2nd method	X_1	0.65		
		X_7	0.06		
		D_2	0.03		
		X_2	0.02		
		X_4	0.01		
		D_1	0.004		
		D_3	0.003		
		X_3	0.0005	32.15**	1855.30

APPENDIX 9 (continued)

EQUATION	DEPENDENT VARIABLE	EXPLANTORY VARIABLE	EXPLANATORY VARIABLE'S CONTRIBUTION TO R^2	F	STD ERROR
		X_1	0.33		
6a	Gross farm	X_2	0.10		
	Income	X_6	0.06		
	3rd method	X_4	0.03	23.28**	2328.43
		X_1	0.33		
	Gross	X_2	0.10		
6b	Farm	X_6	0.06		
	Income	X_4	0.03		
	3rd method	X_3	0.01		
		D_2	0.01		
		D_3	0.002		
		D_1	0.001	11.83**	2344.96

APPENDIX 9 (continued)

EQUATION	DEPENDENT VARIABLE	EXPLANATORY VARIABLE	EXPLANATORY VARIABLE'S CONTRIBUTION TO R^2	F	STD ERROR
7a	Gross crop Output	X_{10}	0.55		
		X_8	0.19		
		D_1	0.02	89.63**	1009.19
7b	Gross crop Output	X_{10}	0.55		
		X_8	0.19		
		D_1	0.02		
		D_2	0.01		
		X_2	0.003		
		D_3	0.0001	45.60**	1006.74

APPENDIX 9 (continued)

EQUATION	DEPENDENT VARIABLE	EXPLANATORY VARIABLE	EXPLANATORY VARIABLE'S CONTRIBUTION TO R^2	F	STD ERROR
		X_9	0.49		
8a	Gross crop	X_8	0.15		
	Output	D_1	0.02	47.10**	1150.26
		D_2	0.03		
		X_9	0.49		
8b	Gross crop	X_8	0.15		
	Output	D_1	0.02		
		D_2	0.03		
		X_2	0.01	31.94**	1147.73
		D_3	0.0001		

** F ratio significant at 0.01 with k and N-k-1 degrees of freedom (28, p. 335).

SOURCE: Author's calculation.

1. The data results from running SSSP Programme for Foward Stepwise Regression Method.

2. The F column refers to the F ratio for the overall regression equation. It is tested for significance at a chosen level with k and N-k-1 degrees of freedom.

   k = number of explanatory variables in the equation.

   N = sample size.

3. STD ERROR = Standard error of the estimate. The column shows the standard deviation of actual Y from the predicted Y_1 values (28, p. 325).