DETERMINATION OF ECONOMIC COMPETITIVENESS AND OPTIMAL RESOURCE ALLOCATION IN RAINFED RICE PRODUCTION ON SMALLHOLDER FARMS: THE CASE OF AMUKURA DIVISION, BUSIA DISTRICT, KENYA.

by

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November, 1993.

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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This thesis has been submitted for examination with my approval as University Supervisor.

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Dr. S.G. MBOGOH

Dedicated to my maternal Grandmother

Elizabeth Masakhwe

who took care of me in my early years of life and was very instrumental in shaping the foundation of my education in the very very initial stages.

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Abstract

Research on rainfed rice production and its Competitiveness on Smallholder farms of Amukura Division of Busia District was carried out in February, March and April 1991. The data were collected using a structured questionnaire which was administered to fifty farmers. The specific objectives of the study were:-

(i) To describe the farming system in which rainfed rice farming is found and to determine the various farm resources available to rainfed rice producers.

(ii) To determine the relative profitability of rainfed rice production vis-a-vis other competing enterprises.

(iii) To find out if rainfed rice could feature in the optimal farm plans.

The analytical methods used to achieve the above objectives were Gross Margin Analysis and Linear Programming.

The results of the study showed that rainfed rice was excluded from the optimal farm plans for the large and aggregated farm models; rice was included in the optimal plan for the small rice farm model, but at a relatively low hectarage of about 0.18. Parametric Linear Programming showed that for rice to be profitably produced and be included in the optimal farm plans substantial increases in producer prices of paddy rice would have to be effected by the Government. Also for the farmers to put at least 1 ha under rice, which is being aimed at by the LBDA and Ministry of Agriculture, price alone is not sufficient.

The sensitivity analysis results showed that when price is increased to Ksh.8 about 0.88 ha will be planted and also when price is at Ksh.10 still 0.88 ha will be put under rice. Hence other factors of production as well as favourable prices will have to be looked into if rainfed rice productions is to be improved.

The results of the analysis of non-rice farm models showed that cotton grown in the second season, maize grown in the second season and cassava were the most profitable enterprises in the optimal farm plan for the small non-rice farm model. On the large and aggregated non-rice farm models, cassava, maize grown in the first season and sorghum grown in both the first and second seasons were the most profitable enterprises.

The study concludes that rainfed rice is unprofitable to produce at the prevailing economic conditions in the Amukura area. The study recommends that:

(i) the government should increase the producer price of rice.

(ii) ways should be found to ease the operating capital constraint by offering short term credit to farmers in the study area.

(iii) the extension staff should develop optimal plans for the non-rice farms of this area. This will enable farmers to optimize resource use.

(iv) price increases alone are not sufficient to increase rice output as shown by the results of the sensitivity analysis. Therefore, farmers should be educated on modern ways of rice production.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

1.1 Background:

Rice is a relatively minor crop in Kenya's agriculture especially when compared to maize. The demand for the commodity has been increasing relatively fast. Rice has steadily gained importance in the diet of many Kenyans. Demand for rice has outstripped supply and this has been reflected in frequent shortages of rice. Since domestic production has not been sufficient, the Government of Kenya imports rice in order to satisfy domestic demand. Table 1.1 gives recent developments in rice imports into Kenya.

Table 1.1: Rice imports into Kenya from 1980-1988

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988
Quantity of rice (tones)	1239	4573	11880	44768	509	562	61745	39129	10000
Value K£'000	233	1240	2726	10037	52	99	13310	5333	2713

Source: Government of Kenya, Central Bureau of Statistics, Statistical Abstract, 1989.

The importation of rice has implications for development. This is because the foreign exchange used to import the rice could be allocated to import other goods and services to enhance development, if the country was self-sufficient in rice production. Therefore there is need to intensify rice production locally and hence the necessity to encourage rainfed rice production.

In Kenya rice is produced under two types of production systems:

(i) rice production under irrigation, and

(ii) rice production under rainfed conditions.

To date, most of the rice produced and consumed in Kenya has been produced on irrigation schemes. Table 1.2 shows rice output from the national irrigation schemes.

Table 1.2 : Rice schemes and their output from 1981-1989.

Year	Mwea Tabere (5780ha)	Bunyala (213ha)	Ahero (800ha)	West Kano (450ha)	Total rice Output
1981	35,148	1,113	4,544	3,768	44,573
1982	32,748	1,399	4,141	3,832	42,120
1983	31,651	1,459	3,558	3,184	39,852
1984	32,236	1,420	3,490	2,561	39,707
1985	30,453	1,223	3,966	2,318	37,960
1986	29,307	1,377	4,597	2,909	38,190
1987	28,638	1,326	3,074	2,577	35,615
1988	27,153	1,290	4,117	2,258	34,818
1989	27,555	1,243	2,983	2,387	34,168

Source:Government of Kenya, National Irrigation Board.

Rice production under irrigation has not been able to supply the required amount of rice for domestic consumption. This is because of high demand for rice which has come about as a result of high population growth in the country as well as changes in tastes and preferences has played a major role. Kenya's objective of self-sufficiency in rice has created great interest in rainfed rice production on smallholder farms. Rainfed rice production is widespread on smallholder farms in three provinces of Kenya as shown in Table 1.3.

Table 1.3: Rainfed paddy rice production from 1988-1990

PROVINCE	YEAR					
	1988		1989		1990	
	Ha	Metric tons	Ha	Metric tons	Ha	Metric tons
Western	1340	1898	857	1327	1435	NA
Nyanza	772	726	780	2440	820	NA
Coast	5108	7486	5060	14920	3787	NA
Total	7220	10,110	6697	18,687	6043	NA

NA - output not available

Sources: Government of Kenya, Ministry of Agriculture: Food Crops Annual Report(1990); National Irrigation Board, and author's own calculations.

Rainfed rice has been grown for many years by farmers in Kenya, in the Coast, Nyanza and Western provinces mainly for subsistence (Acland, 1971) and the area under rainfed rice is about 6000 hacters.

Despite the large area of land under rainfed rice production in Kenya, total rice output from this land has remained relatively low. This implies that rainfed rice has not contributed significantly to food production needs of this country, probably because it has received little attention over the years or because it had not been important hitherto.

Studies done in a number of countries show that rainfed rice production is characterized by relatively low yields of between 0.5 tons and 1.9 tons per ha as compared to a yield of 3.5 tons per ha under irrigation (Fotzo and Winch 1978; De Datta 1981).The same is true for Kenya. For instance, in Busia District , an average yield of 1.8 to 2 tons per hectare has been achieved under rainfed rice production. On the other hand , a rice yield of 5 tons per ha has been achieved on the Bunyala Irrigation Scheme which is located in the same district (Busia District Annual Reports,1971-1990).

Kenya's objective of food self-sufficiency and especially self-sufficiency in rice production has necessitated intensification of rice production locally.The frequent rice shortages, lack of foreign exchange and the perceived potential of rainfed has created the need to increase rainfed rice production. This led to the inception of the West Kenya Rainfed Rice Development Project.This project aims to improve rainfed rice production locally.

This project was started under the auspices of the Lake

Basin Development Authority (LBDA) in 1987. The project areas are Kisumu, Siaya, South Nyanza, Busia, Bungoma and Kakamega. The project aims to give the farmers a package of incentives to try to increase rice output from the project area.According to the LBDA workplan for 1988-1989, the incentives include provision of seed, tractor hire services for land preparation, provision of herbicides for killing weeds in rice fields and provision of short term loans for weeding and harvesting the rice crop.

1.2 Problem Statement

Rainfed rice in Busia District is grown by small scale farmers as a cash crop. The district has a rainfed rice production potential of about 15,000 ha, but only a small fraction of this area is used for rice production each year. Rainfed rice production in this district has fluctuated and shown a declining tendency during some years. Table 1.4 shows the amount of land allocated to rainfed rice production in Busia District from 1971 to 1990.

Table 1.4: Area of land under Rainfed Rice in Busia District from 1971 to 1990.

Year	Area (ha)
1971	1098
1972	1267
1973	894
1974	402
1975	276
1976	165
1977	242
1978	63
1979	20
1980	80
1981	401
1982	1055
1983	1055
1984	990
1985	440
1986	350
1987	540
1988	520
1989	635
1990	960

Source: Ministry of Agriculture, Western Province Annual Reports, 1971-1990.

The fluctuation in area allocated to rainfed rice gives an indication of the existence of some constraints to rainfed rice production in the district. Many factors may have led to this situation and therefore a farm level study was undertaken to try to find out what has actually contributed to a situation whereby rainfed rice has continued to remain a relatively unimportant crop in the area of study.

This study addresses the following questions:

(1) What are the main constraints to rainfed rice production?

(2) What conditions need be fulfilled in order for the rice farmers to continue producing rice?

(3) What steps should be taken to make farmers shift their allocation of resources from other competing enterprises to rainfed rice?

Answers to these questions could be expected to show why the rainfed rice crop has remained relatively unimportant for many years in Busia District. Hence the need for this study.

1.3 **Objectives of the Study:**

The broad objectives of this study were to examine efficiency in resource allocation and the competitiveness of rainfed rice production, when compared to other competing enterprises on the farm. Based on the questions stated in the problem statement, the study had the following specific objectives:

(1) To describe the farming system in Busia District in which rainfed rice farming is found and to identify the various farm resources available to rainfed rice producers.

(2) To determine the relative competitiveness of rainfed rice production, in terms of profitability of rainfed

rice vis-a-vis other competing enterprises in Busia District.

(3) To find out if a rainfed rice production enterprise could feature in the optimal farm plans in the study area, and if not, conditions under which it would.

1.4 Justification For the Study:

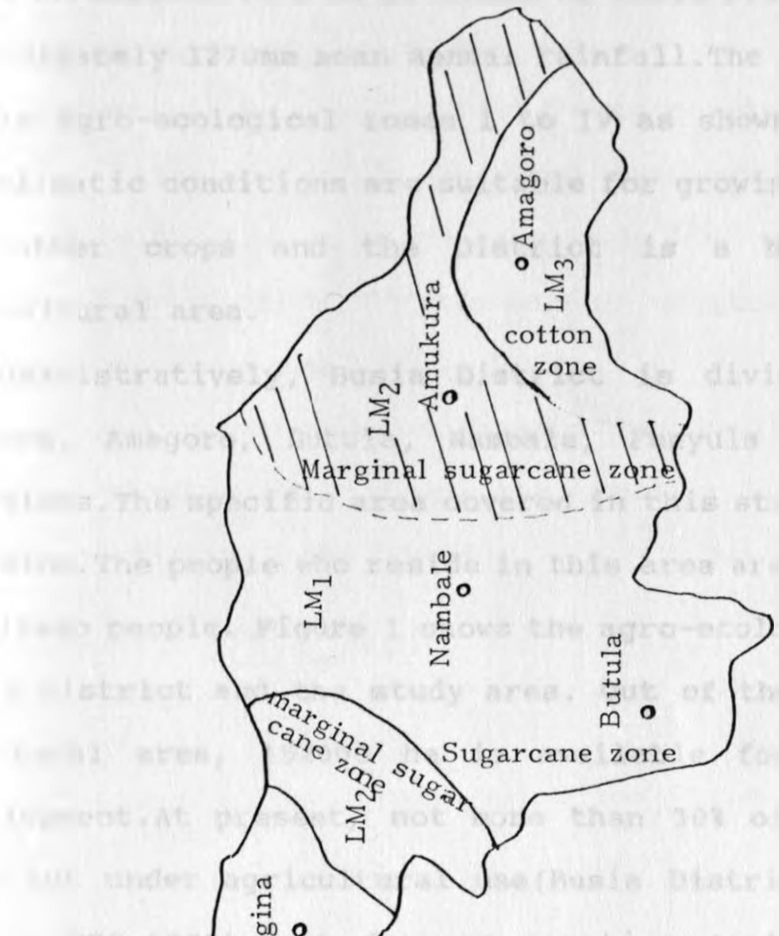
The potential of rainfed rice to contribute to rice self-sufficiency in Kenya has recently been perceived.Also the existing irrigation schemes have failed to supply enough rice to meet domestic demand.Due to this, the Government of Kenya is trying to intensify rainfed rice production.On the other hand, rainfed rice is assailed by many problems such as low yields.Busia District is one of the West Kenya Rainfed Rice Development Project areas,but farmers in this region have been reducing area under rainfed rice.For this reason a farm level study of resource allocation and the competitiveness of rainfed rice was undertaken.This was to find out what role rainfed rice plays in the farming system of the area.

1.5 The Study Area

Busia District is one of the West Kenya Rainfed Rice Development Project areas and has a high potential for rainfed rice production.The District covers an area of about 1766km^2 and falls within the Lake Victoria basin.

Therefore, the District is generally warm with a temperature

MAP OF BUSIA DISTRICT AND THE STUDY AREA



KEY

LM -- Lower Midland Zone

Study Area

Source: Farm Mgt. Hand of Kenya . Voll 11A 1982.

range of between 14^0c to 22^0c.Most of Busia District receives approximately 1270mm mean annual rainfall.The District falls within agro-ecological zones I to IV as shown in figure 1. The climatic conditions are suitable for growing rainfed rice and other crops and the District is a high potential agricultural area.

Administratively, Busia District is divided into six: Amukura, Amagoro, Butula, Nambale, Funyula and Budalangi divisions.The specific area covered in this study was Amukura Division.The people who reside in this area are predominantly the Iteso people. Figure 1 shows the agro-ecological zones of Busia District and the study area. Out of the 161025 ha of the total area, 152000 ha is available for agricultural development.At present, not more than 30% of the land has been put under agricultural use(Busia District Development Plan, 1989-1993).Most farmers practice small scale mixed farming with low levels of technical inputs. The main crops presently cultivated are maize, sorghum, fingermillet, rice, cassava, beans, groundnuts, cotton, sweet potatoes, sugarcane, tobacco, sunflower, robusta coffee and horticultural crops.

The area of study was chosen because it has a tradition of growing rainfed rice (rainfed rice has been grown in this area for the last 20 years), hence the suitability of the area for rainfed rice production studies.

1.6 Organization of the thesis

The thesis is organized into five chapters. Chapter One gives an introduction. Chapter Two deals with the review of literature on studies which have been done and are relevant to the present study. Presented in chapter three are the methodological issues of the study.

Chapter Four presents and discusses the results of the study, finally Chapter Five gives the summary, conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW ON EFFICIENCY IN RESOURCE ALLOCATION AND ENTERPRISES COMBINATION IN KENYA.

2.1 Introduction

The question of whether farmers are allocating their scarce resources efficiently is of importance to the farmer and the economy as a whole. In most least developed countries (LDC's), farmers are poor and have minimal resources at their disposal. Hence for improvement of the standard of life, scarce resources need to be used optimally, especially in agriculture which is the dominant sector in LDC's economies.Peasant farms are small in size and in Kenya they comprise about 70% of all the farms. Smallholder farms have been shown to have potential to contribute to agricultural production in this country.

The problem of resource use optimization is not obvious. It will depend on the crops grown,the suitability of the crops to the area,income effect of the crops on the farm, and how the crop fits into the existing farming system.Due to the interrelatedness of most peasant farming systems, the study of peasant farming situations is difficult. Several authors hold different views on how peasant farmers allocate their resources. Schultz (1964) contends that peasant farmers allocate their resources efficiently so that there may be no gains from reallocation of resources. Kange (1980) and

Kamunge (1989) showed that there is potential gain when farmers reallocate their resources and use them more efficiently. Various authors have undertaken farm level studies using different methods such as estimation of production functions and mathematical programming to model smallholder farming situations.This study uses linear programming (Lp). The appropriateness of Lp for the study of peasant farms is supported by many authors. Low (1978) states that the strength of linear programming in the study of peasant farming systems is its ability to handle the many interrelated variables that characterize such systems.

Peasant farming systems are characterized by a high degree of "interdependence between production and consumption, consumption and investment, investment and resource availability and social and cultural constraints". Heyer (1971) observes that while it is not worthwhile carrying out linear programming for individual farms, linear programming analysis can provide important guides to the following issues if done for a region:

(1) optimal product mixes and optimal production techniques,

(2) the effect of innovations,

(3) problems which require research and solutions,

(4) shadow prices of critical resources.

2.2 Studies Using Linear Programming Method in Kenya

Many studies have been carried out in Kenya using linear programming to study efficiency of resource allocation on small scale farms. Clayton (1963) carried out a pioneering study on planning small scale farms in Nyeri District using linear programming as a tool of analysis. The results showed that labour was a major constraint to increasing farm productivity in the area. This finding contradicts theories advanced by development economists that in LDC's there exists excess labour with marginal value product of zero. This is understandable because on smallholder farms labour supply may be fixed and farm work does not occur evenly month by month throughout the year. There are periods of peak labour demand and the availability of labour during the peak months has become important and actually influences the type of crops farmers grow on their farms and yields obtained. Rice, being a labour intensive crop, may have an influence on labour use and hence may affect the growing of other crops in the region. This brings about the need to know the performance of rainfed rice on the farms such that if rice is not profitable or cannot compete favorably with other crops, then it might be tying up labour which could be used in the production of other crops on the farms.

Heyer (1966) carried out a study in Masii Location of Machakos District to find out the constraints to improving small scale farms in a marginal area. Cotton was the only major cash crop in the area of study. The study found that the introduction of cotton in the area did not improve the income of the farmers. This was because the farmers attached very high risk to the production of this crop, leading to the favoring of food crop production by the farmers in order to meet subsistence requirements. Capital was found to be relatively unimportant, but land, labour and management all had a significant influence on the level of production. Heyer (1966) concluded that it was important to identify constraints on small scale farms and hence modify them in order to promote development in the country.

Heyer's study was carried out about 25 years ago and the effect of time could render her findings out of date. Later studies establish that capital, especially operating capital, is one of the most constraining factors to small farm production (Upton, 1973). Hence capital cannot be assumed to be unimportant in the production process on most smallholder farms in Kenya. The present study incorporates operating capital as one of the constraints to agricultural production.

Asemenew (1980) used linear programming to study efficiency of resource allocation on smallholder farms of the stargrass zone of Embu District. The study explored the possibility of increasing farm incomes by reallocation of resources in the existing farming system. The results of the study showed that when family labour alone was the major input in the production process, land and operating capital were a constraint to agricultural production on small and medium farms. On the large farms, labour was found to be the major constraint because large farmers tended to grow coffee which was labour intensive. The highest gross margins were achieved on small farms and medium farms when both family labour, hired labour and some borrowed operating capital were used. The optimal farm plans showed an increase of 27-31% in income when compared to the existing farm plans, indicating that a reorganization of the allocation of farm resources among the most profitable enterprises would result in increased farm incomes. The study concluded that there was room for farmers in the study area to increase their farm incomes by more efficient use of resources.

The present study is similar to Asemenew's, but in this study the crop of interest is rainfed rice. Also due to the variability of smallholder farming situations, what is prevailing in one region may not be the same as that in another region. Embu District is different from Busia District, in terms of both the physical environment and the economic and socio-cultural factors.

Mbai (1980) used linear programming to study the reasons why pyrethrum production was declining in Kiambu District. His findings showed that, under the prevailing conditions, pyrethrum was unprofitable to grow and was totally excluded from all the optimal farm plans. Variable price programming showed that substantial increases in prices of pyrethrum flowers of between 67.6% and 180% were required in order to give farmers an incentive to put their land under pyrethrum production. Otherwise, pyrethrum would be replaced by more profitable enterprises, such as tea, dairying and horticultural crops. The study also concluded that there existed a high potential to increase farm incomes through resource reallocation by farmers in the study area .

The present study seeks to address similar issues, but the crop of choice is rainfed rice.In Busia area, rainfed rice is grown as a cash crop. Few cash crops are grown in this area. Hence rainfed rice may have a potential to increase the farmers' income in the area. Rainfed rice has been grown by farmers in this area for many years but has remained relatively unimportant. The study sought to find out reasons why rainfed rice has remained relatively unimportant over the years.

Kamunge (1989) used linear programming to examine efficiency of resource use on a small scale irrigation scheme in Meru District. He hypothesized that resource use in the scheme was sub-optimal and that there existed a potential for raising farm incomes by allocating resources optimally. Three farming systems were studied, these being a cotton system, a tobacco system and a subsistence farming system. The study showed that there were increases in farm incomes as a result of resource use optimization. There was an increase of total farm gross margin of about 51%, 34%, and 21% for the cotton,tobacco and subsistence farming systems respectively on the optimal farm plans. These increases were significant as the study adopted an increase of above 20% to be significant. This shows that there is potential gain if farmers use their resources optimally. The shadow prices of the resources showed that water for irrigation and unirrigated land were slack throughout the year. This was because of the small land area which the irrigation scheme had allocated as the maximum area which the scheme farmers could irrigate. This implies that when the scheme was being set up the recommended irrigated land was not arrived at by using a suitable method of analysis such as linear programming.

The present study is concerned with rice production under rainfed conditions. Since the West Kenya Rainfed Rice Development Project is encouraging farmers to allocate more land to rainfed rice, it is important to use mathematical programming methods to find out if rainfed rice would be included in the optimal farm plans. This would determine the level of hectarage that is optimal for rice production on the smallholder farms.

Barasa (1989) used linear programming to study the economics of cotton production in Funyula Division of Busia District. The study was motivated by the decline in cotton output from the region. The area covered in the study was a marginal area falling in agro-ecological zone LM4 (marginal cotton zone) where cotton is the major cash crop. The results of the study showed that cotton was the least profitable enterprise on the farms. Parametric linear programming showed that substantial price increases were required if cotton was to compete favorably with other farm enterprises. Cotton grown in the second season was favoured by farmers because cotton, being labour intensive, tended to compete for labour with food crops and the farmers preferred to grow crops for food during the first season.

The present study is similar to Barasa's, but there is some essential difference in that the present study deals with rainfed rice in a high potential area of Amukura Division which lies in agro-ecological zone LM2 (marginal sugarcane zone). The need to use the available arable land optimally cannot be over-emphasized. Rainfed rice has existed in Busia District for over 20 years (Republic of Kenya, 1971 to 1988). The potential contribution of rainfed rice to rice self-sufficiency in Kenya has just been realized. The farmers are now being encouraged to produce more rainfed rice. More emphasis is being put on how to increase rice yields and total area under the crop. Since irrigation development requires substantial outlay of capital, the International Rice Research Institute (1985) points out that future rice expansion programs will have to focus on rainfed rice areas. This calls for research to assess the potential of rainfed rice in regions where it can be grown and also the constraints to rainfed rice production. Therefore, this study is a contribution towards this goal.

2.3. Conclusion

The preceding literature review indicates that linear programming can be used to study smallholder farming situations. There exists a wide scope of undertaking further studies to understand variations in farm productivity and incomes on smallholder farms.

By undertaking linear programming studies, resource constraints on the smallholder farms can be identified. The identification of constraining factors on smallholder farms is important as this will help policy makers to find out ways to modify these constraints and hence improve farm productivity as well as farm incomes.

This study examines the competitiveness of rainfed rice on the farms using linear programming as a tool of analysis. From this analysis the role of rainfed rice production and the contribution to the farming system can be identified. Also the constraints to rainfed rice production and other crops in the area can be identified from the marginal value products. This information can help in the planning of rainfed rice production and where government intervention is required in the rice improvement programs.

CHAPTER THREE

METHODOLOGY

3.1 Sampling and Field Survey

Prior to the actual data collection a reconnaissance survey was carried out for one week in the study area towards the end of January, 1991. This survey was meant to enable the author to familiarize with the area of study and the enterprises being undertaken by farmers. The information gathered during this period helped in identifying the area to be sampled. The study chose a representative location for the rainfed rice research. The Location was chosen because it had the largest number of farmers growing rainfed rice. The sampling frame consisted of all small scale farmers in Asinge and Chakol Sub-Locations of West Teso Location, Amukura Division, Busia District.

The sample consisted of 50 farmers. Of these 50 farmers, twenty five were rice farmers and 25 were non-rice farmers. To sample the twenty five non-rice farmers, a list of farmers was compiled from the Busia District Land Registry. Simple random sampling using a table of random numbers was done. To sample the 25 rice farmers, a list of the farmers who grew rice in 1990 was obtained from the Divisional Agricultural Office. This list was used to sample 25 rice farmers using a table of random numbers.

The study required both secondary and primary data. Secondary data were obtained from the Ministry of Agriculture Annual Reports and Farm Management Guidelines for Busia District. The primary data were generated through a field survey using a structured questionnaire (Appendix 1). The questionnaire was structured so as to generate data on land availability, land committed to various enterprises, labour availability and use, operating capital availability and use, subsistence food requirements and problems facing farmers in their farming activities. The farm survey was carried out in the months of February, March and April, 1991. The study covered the 1990 cropping season.

The questionnaire was pre-tested by administering it to five farmers from the area, before the farm survey was carried out. Subsequently enumerators were trained. Agricultural Technical Assistants assisted in the identification of the farmers' fields. The single visit method of data collection was used. If a farmer was not on the farm during the first visit, he or she would be visited again; this was repeated until all the fifty sampled farmers were interviewed.

3.3 Model for Data Analysis

Linear Programming (LP) technique was the major tool of analysis. The use of LP in studying resource use optimization on smallholder farms has been supported by many authors (Low, 1978;Heyer, 1971). The LP model is suitable for studying the farming situation on smallholder farms as it can handle many interrelated variables which characterize most smallholder farms.

Linear programming model consists of three components: the objective function, the activities for attaining the objective function and resource constraints (according to Agrawal and Heady, 1972). The standard linear programming model is given in a matrix notation as follows:

$$\text{Maximize} \quad Z = P'X$$

subject to

$$AX \leq B$$

$$X \geq 0$$

where:

$Z = P'X$ is the objective function.

P is an n x 1 vector of gross margins per hectare.

X is an n x 1 vector of activities or control variables.

A is an m x n matrix of technical coefficients.

B is an m x 1 vector of resource availabilities or other restrictions.

The actual model used for data analysis was specified as follows:

$$\text{Max } Z = \sum_{j=1}^{n} P_j X_j$$

subject to:

subject to:

$\Sigma\, a_{sj}\, X_j \leq$ Ls:Land constraint (Hectares).

$\Sigma\, M_{ij}X_j \leq M_i$: labour constraint (Manhours).

$\Sigma\, b_jX_j \leq B$: operating capital constraint (Ksh).

$X_j \geq D$: subsistence cassava requirement constraint(ha).

$X_j \geq E$: subsistence maize requirement constraint (ha).

x_j, Ls, M_i, B, D, E ≥ 0 } Non-negativity constraint.

where:

Z = Total gross margins.

X_j = Number of hectares of the j^{th} activity.

P_j = Gross margin per hectare for the j^{th} activity.

n = total number of activities.

Ls = land available for farming in the 1st and 2nd season , s=1 for land in the first season and s=2 for land in the second season.

M_i = Amount of labour available in the i^{th} month.

M_{ij} = Amount of labour required per hectare in the i^{th} month for the j^{th} activity.

b_{ij} = The amount of operating capital per hectare required for the j^{th} activity.

a_j = amount of land per hectare for the j^{th} activity.

B = total amount of operating capital available on the farm in the farming year.

D = total amount of land for growing subsistence cassava.

E= total amount of land for growing subsistence

3.3.1 The objective function:

The objective function is difficult to determine in peasant agriculture (Heyer, 1971; Clayton, 1963). This is because risk tends to dominate the production process. This is true for the lp model due to the linearity assumption. The problem of risk can be overcome by use of modified lp models such as quadratic programming. Farmers may also have numerous objectives, such as attaining enough food for subsistence, maximization of cash income or even environmental conservation. Even though the farmers' motive may not always be profit maximization, this objective can still be used as a basis for farm planning. Peasant farmers maximize farm incomes after attaining self sufficiency in subsistence food (Mbai, 1984; Kange, 1980). Therefore, the objective function in this study was assumed to be maximization of total gross margins. Gross margin entails subtracting variable costs of an enterprise from the total revenue of that enterprise(Upton, 1973). The gross margins for all real activities on the farm models were calculated and used in the LP problem as the coefficients P_j of the objective function. Gross margin calculations are given in Appendix 2.

3.3.2 Activities:

In a linear programming problem, the term "activity" denotes anything being produced, an enterprise undertaken or a method of production characterized by a specific portion of various resources (Agrawal and Heady, 1972). There are three types of activities: real activities, disposal activities and artificial activities. Disposal activities are included in LP to allow non-use of resources. Artificial activities are included in solving an LP problem for constraints that have either no disposal activity (i.e an equal to restriction) or a disposal activity with a coefficient of -1.

Real activities are those which are produced for sale in the market or in the case of resources, are purchased from the market and used on the farm. In this study , real activities on the farm model included rainfed rice, maize, cotton, fingermillet, cassava, sorghum and fingermillet/ sorghum mixture. Some of the activities were undertaken in both the first and the second seasons, for example maize and sorghum production, while others were undertaken in only one season. Cassava can be planted any time within the calendar year. For the purpose of this study, cassava planted from January to march 1990 was taken as cassava grown in the first season. This made it easier to allocate labour to the cassava enterprise.

3.3.3 Resource Constraints:

The resource constraints specified in the farm models were land, labour, operating capital and subsistence food requirements. Land was treated as a homogeneous resource because data on soil type and fertility levels were not available. The only differentiation made was land available for crop activities during the first and the second season. The total land available for agricultural production was calculated by summing up all the land committed to the various enterprises on the farm. Land under homestead, fallow land and land unsuitable for cultivation were not considered.

Labour was also treated as a homogeneous resource, but using a weighting system that discounted labour of older adults and children and \ or students.

The weighting system used is shown in Table 3.1.

Table 3.1: Labour Weighting System:

Labour class	Age in years	Man-equivalents
Young child/student	less than 10 years	0.00
Older child/student	10-20 years	0.50
Adults	21-65 years	1.00
Adults	Over 65 years	0.50

Source: Adapted from Norman (1973).

The respondents indicated that there was no difference in wage rate payments between adult male and adult female labour, hence there was no differentiation made between adult male labour and adult female labour. The average working day in the study area is 5 hours[1], hence one man-day was equal to 5 hours.

Labour was standardized by converting the total number of days worked on the farm per month into man-hours. The total labour available on the farm was arrived at by considering the total number of days available for farm work excluding Sundays and other known public holidays. School children were assumed to be available for farm work during the months of April, August and December. The farming calendar (Appendix 3) of the area was used to allocate labour to the various enterprises on the farms.

The third constraint was operating capital. The operating capitai constraint was calculated by summing up all the expenditure on farm inputs purchased by the farmer. These were calculated by taking into account expenditure on seed, fertilizer, hiring of oxen for land preparation and labour for carrying out farm operations such as weeding, harvesting, threshing or shelling and bagging of cereals, processing in case of cassava and sorting in case of cotton. This approach is supported by Pandey and Kaushal (1980) and has been used in the recent past by Mbai (1984), Kamunge (1989) and Barasa (1989). This is justified due to the fact that on small scale farms, the household is closely related to the farm business and it is difficult to separate the various items of

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[1]Due to the climatic influences, the average working day is five hours.

operating capital from the other expenditures. Therefore, the total variable cost on the farm is the best indicator of the total operating capital on the farm during the farming year.

In addition to the three constraints, subsistence food requirements constraint was incorporated in the farm models. The small scale farmers fulfil their subsistence food requirements before any output can be marketed. This is also in line with the Kenya Government's policy of food self sufficiency and food security. The minimum hectarage of the food crops had to be in the optimal farm plans to ensure that the farmers' subsistence needs are met (Table 4.2).

3.3.4 Technical Coefficients for Each Activity ("A" Matrix).

Crop enterprises were represented on a per hectare basis, so that each a_{kj} coefficient is equal to one.

The total variable cost per enterprise per hectare (b_{ij}) was calculated. This was estimated from the expenditures on seeds, fertilizers, pesticides, land preparation, weeding and harvesting.

For each enterprise, the coefficient M_{ij} represents the labour requirement in the i^{th} month for the j^{th} activity for the various operations such as land preparation, planting, weeding, spraying and dusting (in case of cotton), threshing, shelling (in the case of cereal crops), harvesting, sorting (in case of cotton) and processing (in case of cassava).

3.4 Farm Model Specification

The farm models synthetic farms generated by pooling and averaging all resource constraints and input-output data for the selected farms. Hence the synthetic farms were average farms. The average farm approach is supported by Upton (1973) and has been used by several authors in the recent past (Mbai, 1984; Kamunge,1989 and Barasa,1989). The use of average farm is more representative than a specific farm due to the large number of widely distributed farms involved in calculating the average farm.

Data were collected based on whether a farm grew rice or not, as earlier specified. This was done in order to facilitate comparisons between the farms. Since resource endowments, subsistence food requirements and other socio-economic variables tended to vary considerably among the farms, the farms were classified into various groups according to farm size and whether a farm grew rice or not. For the purpose of this study, the farm groupings were:

(a) small rice farm = 2.4 ha

(b) large rice farm = 4.0 ha

(c) aggregate rice farm = 3.0 ha

(d) small non-rice farm = 1.2 ha

(e) large non-rice farm = 2.5 ha

(f) aggregate non-rice farm = 1.5 ha

It should be kept in mind that all the farms in Amukura Division are small scale, and they do not fall within the "large" farms category as specified by official publications of the Government of Kenya. According to the Central Bureau of Statistics (1981-1982), small farms vary between 0.52 to 10 ha and most large farms have an average area of 700 ha, even though one may find smaller units within this group. Therefore, this classification is valid for the study area only.

3.5 Data Analysis

The data obtained from the farm survey were analyzed in several ways, as discussed hereafter. Gross margin analysis was done in order to estimate returns to each enterprise and hence the relative profitability of each enterprise. Linear programming was carried out to assess the position of rice in the optimal farm plans for the rice farm models and to come up with optimal farm plans for the rice and non-rice farm models.

Identification of resource constraints in different farm models was an important part of the analysis. The marginal value products[2] (shadow prices) of land (in the first and the second seasons), labour and capital were obtained. These were examined to find out which resources were a constraint to the production of rice and other crops in the study area.

Parametric programming or sensitivity analysis was done to find out what effect the changing prices would have on the output of rice and in which direction resources would

[2] Marginal value product measures by how much revenue will be increased when one more unit of a resource is used in the production process.

be mobilized by the farmers. According to Agrawal and Heady (1972), sensitivity analysis (variable price or resource programming) can be used to determine the normative supply functions[3] and also allows the analyst to determine the effect of changes in technical coefficients and price or resource constraints on optimal solutions.

Simulated rice prices of Ksh. 5.00, Ksh. 6.00, Ksh. 8.00 and Ksh. 10.00 were used to calculate the resulting gross margin per hectare, other things remaining the same. Optimal solutions for each farm model were obtained under these new values and were used to show response of farmers to changed prices. The levels of these prices were arrived at after considering the producer price received by farmers in 1991, which was Ksh 3.20 per kilogram, and the consumer price for " sindano " rice, which was Ksh 15.00 per kilogram.

3.6 Linear Programming Assumptions:

The final solution of the linear programming problem is based on the following assumptions, which are adopted from Agrawal and Heady (1972):

(i) Additivity: the sum of resources used by different activities must equal the total quantity of resources used by each activity for all the resources, individually and collectively. This implies absence of any interaction among the activities and the resources.

(ii) Linearity: the objective function is assumed to be linear, and that there is a linear relationship between activities and resources.

(iii) Divisibility: it is assumed that resources can be used in quantities which are fractional units and that resources and products are

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[3]Normative supply function is derived by an optimizing procedure such as linear programming. The supply function so obtained is normative in that it is based on the assumption of a single goal of profit maximization for all farmers.

considered to be continuous and to be infinitely divisible. For example, fertilizer applied to the various enterprises (such as maize, rice, sorghum) may be applied in fractional units to produce a given level of output.

(iv) Finiteness: It is assumed that there is a limit to the number of alternatives and the resource constraints which limit the combination of activities which are feasible. For example, land available for growing crops is limited, hence crops can only be grown on a limited area. Also labour required for the various activities or enterprises is limited. Therefore, the farmer may only allocate a given amount of labour to each enterprise.

(v) Single valued expectations: Linear programming assumes that resource supplies, input-output coefficients and prices are known with certainty. As a result, enterprises are treated as though they were without risks. For example, the prices of crops such as rice and maize are known with certainty. For other enterprises(such as sorghum, millet and cassava), the prices existing in the local markets tend to vary from season to season and average prices were computed.

Some of the above assumptions tend to limit the applicability of linear programming to farming situations. Consequently, the results have to be interpreted with caution by those using them.

CHAPTER FOUR

ANALYSIS,RESULTS AND DISCUSSION

The data obtained from the farm survey were analyzed using the analytical tools set out in Chapter Three in order to achieve the objectives of the study. The results of the analysis are presented and discussed below.

The farms under analysis were classified according to farm sizes as shown in Table 4.1.

Table 4.1: Farm Size Classification

Description		Rice farm model			Non-rice farm model		
Class	Farm size (ha)	No.	%	Average* farm size (ha)	No.	%	Average* farm size (ha)
Small	0.8 - 5.83	18	72	2.4	20	80	1.2
Large	6.0 - 10.00	7	28	4.0	5	20	2.5
Aggregate	0.8 - 10.00	25	100	3.0	25	100	1.5

* The mean size was calculated by pooling and averaging the area under different crop enterprises on the farms in each class. This gave an indication of the land available for agricultural production.

Source: Author's work, 1991.

In the study area, most farms were found to fall within the small size category; 72% for the rice farms and 80% for the non-rice farms. Large farms were few and accounted for 28% and 20% for the rice farms and non-rice farms respectively. The average area under crops was 40% for the small farms, 39% for the large farms and 50% for the aggregate farm. This concurs with what has already been observed for Busia District, that not more than 30% of the land suitable for crop activities has been put under cultivation (Busia District Development Plan, 1989-93). Most of the land in the study area is under fallow and the major reason forwarded by farmers was lack of capital to clear and prepare land for crop production.

It was also found necessary to estimate the subsistence food requirements of the farm families. Data generated from questions put to the respondents (the farmers) indicated the types of crops grown for family use. These crops were maize and cassava. Data were obtained from the farmers about how much of these crops they consumed per month. From these data the yearly requirements per household were estimated. These figures were pooled and averaged to give the total amount of the crop in kilograms of each crop required per farm group. These amounts were converted to land equivalents and entered into the model as subsistence food requirements constraint. Table 4.2 shows the minimum amount of land required to grow subsistence food for the various farm models.

Table 4.2 Area of land for growing subsistence food in each farm model

Farm model	Subsistence maize (ha)	Subsistence cassava(ha)
Small rice farm	0.45	0.50
Large rice farm	0.52	0.32
Aggregate rice farm	0.35	0.40
Small non-rice farm	0.34	0.40
Large non-rice farm	0.29	0.32
Aggregate non-rice farm	0.35	0.35

Source: Author's work, 1991

4.1 Gross Margin Analysis:

In order to find out the relative profitability of rice, gross margin analysis was done. The gross margin is defined as the difference between the value of total revenue and variable costs of producing each enterprise (Upton,1973) . In the calculation of the gross margin, the procedure followed can be represented by the equation:

$$GM_i = TR_i - TVC_i$$

$$i = 1, 2, \ldots\ldots\ldots, n$$

where:

GM_i = Gross margin per hectare for the i^{th} enterprise.

TR_i = Total revenue per hectare for the i^{th} enterprise.

TVC_i = total variable cost per hectare for i^{th} enterprise.

From the gross margins calculated the cropping patterns in the farms were analyzed for profitability.

Table 4.3: Existing Cropping Pattern in the Small Rice Farm Model (2.4 ha).

Enterprise[1]	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Rice 1	0.76	3423	2601.48
Maize 1	0.37	3221	1191.77
Fingermillet 1	0.48	3150	1512.00
Cassava 1	0.43	4000	1720.00
Sorghum 1	0.10	2700	270.00
Fingermillet/ Sorghum 1	0.20	3920	784.00
Cotton 2	0.5	5300	2650.00
Sorghum 2	0.2	3240	648.00
Maize 2	0.55	2850	1567.50
Total farm gross margin per year			= 12944.75

Source: Author's work, 1991

The gross margin analysis shows that for the small rice farm model, under the existing conditions, the most profitable enterprise is cotton grown in the second season as

[1] 1 and 2 indicate the season when the crop is grown:
1 stands for first season crop
2 stands for second season crop

by cassava grown in the first season and sorghum grown in the first season. This is indicated by the gross margin per hectare. The total gross margin achieved on the small rice farm model was Ksh 12944.75.

For the large rice farm model (Table 4.4), the most profitable enterprise was cotton grown in the second season followed by cassava grown in the first season and rice grown in the first season.Under the existing cropping pattern, the total gross margin achieved by the large rice farm model was Ksh 21280.75. Given the gross margin as an indication of profitability, farmers would grow cotton in the second season, followed by cassava in the first season and rice grown in the first season.

Table 4.4: Existing Cropping Pattern in the Large Rice Farm Model (4.0 ha).

Enterprise	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Rice 1	1.00	5506	5506.00
Maize 1	1.07	1765	1888.55
Finger millet1	0.9	3360	3024.00
Cassava 1	0.4	5792	2316.80
Sorghum 1	0.2	1620	324.00
Finger millet/ Sorghum 1	0.1	3210	321.00
Cotton 2	0.8	6758	5406.40
Sorghum 2	0.6	3780	2268.00
Maize 2	0.2	1130	226.00
Total for gross margin per year			= 21280.75

Source: Author's work, 1991.

On the aggregate rice farm model, the most profitable enterprise was cotton grown in the second season, followed by cassava grown in the first season and finger millet grown in the first season, as shown in Table 4.5. On the aggregate rice farm model, the total gross margin achieved was Ksh. 16526.12.

Table 4.5: Existing Cropping Pattern in the Aggregate Rice Farm model (3.0 ha).

Enterprise	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Rice 1	0.92	3461	3184.12
Maize 1	0.39	3417	1332.63
Finger millet 1	0.63	3631	2287.53
Cassava 1	0.49	4286	2100.14
Sorghum 1	0.19	2970	564.30
Finger millet/			
Sorghum 1	0.15	2500	375.00
Cotton 2	0.52	8195	4261.40
Sorghum 2	0.4	3240	1296.00
Maize 2	0.5	2250	1125.00
Total farm gross margin per year		=	16526.12

Source: Author's work, 1991.

On the small non-rice farm model, the gross margins show that the most profitable enterprises were cotton grown in second season followed by cassava grown in the first season and maize grown in the first season as shown in Table 4.6. The total farm gross margin for the small non-rice farm model was Ksh 5435.20, which is low when compared to Ksh 12944.75 on the small rice farm model.

Table 4.6: Existing cropping pattern in the small non-rice farm model (1.2 ha).

Enterprise	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Maize 1	0.25	3540	885.00
Finger millet 1	0.30	2938	881.40
Cassava 1	0.40	4275	1710.00
Sorghum 1	0.15	1350	202.50
Finger millet/ Sorghum 1	0.10	1950	195.00
Cotton 2	0.32	4298	1375.36
Sorghum 2	0.06	810	48.60
Maize 2	0.07	1962	137.34
Total farm gross margin per year			= 5435.20

Source: Author's work, 1991.

The gross margins show that on the large non-rice farm model, the most profitable enterprise was cotton grown in the second season followed by cassava grown in the first season and maize grown in the first season. The total farm gross margin achieved in the year was Ksh. 14800.60 (Table 4.7). This is lower than the gross margin of Ksh.21280.75 achieved on the large rice farm model (Table 4.4).

Table 4.7: Existing Cropping Pattern in the Large Non-rice farm model (2.5 ha)

Enterprise	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Maize 1	0.4	5312	2124.80
Finger millet 1	0.6	3617	2170.20
Cassava 1	0.8	6100	4880.00
Sorghum 1	0.24	2160	518.40
Finger millet/ sorghum 1	0.4	3910	1564.00
Cotton 2	0.4	6878	2751.20
Sorghum 2	0.2	2700	540.00
Maize 2	1.2	2100	252.00
Total farm gross margin per year		=	14800.60

Source: Author's work, 1991.

For the aggregate non-rice farm model, the most profitable enterprise was cassava grown in the first season, followed by cotton grown in the second season and maize grown in the first season (Table 4.8). The total gross margin achieved was Ksh.8319.25. This is lower than the gross margin of Ksh. 16526.12 achieved on the aggregate rice farm model.

Table 4.8 Existing Cropping Pattern in the Aggregate Non-rice Farm Model (1.5 ha).

Enterprise	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Maize 1	0.30	3540	1062.00
Fingermillet 1	0.4	3140	1256.00
Cassava 1	0.50	5410	2705.00
Sorghum 1	0.10	1485	148.50
Finger millet/			
Sorghum 1	0.20	1810	362.00
Cotton 2	0.33	5105	1684.65
Sorghum 2	0.5	1890	945.00
Maize 2	0.08	1962	156.96
Total farm gross margin per year		=	8319.25

Source: Author's work, 1991.

Gross margin per man-hour:

The gross margin per man-hour was calculated by dividing the total gross margin per hectare of each enterprise by its labour requirements. This was done to assess the returns to labour from each enterprise. The gross margin per man-hour was calculated for the rice farm models only, because rice was the crop of greatest interest in this study.

Table 4.9: Gross margin per man-hour for each enterprise on the rice farm models.

Enterprise	Farm Model		
	Small rice farm	Large rice farm	Aggregate rice farm
Rice 1	2.7	4.40	2.77
Maize 1	4.00	2.19	5.56
Finger millet 1	3.73	3.98	4.30
Cassava 1	6.90	9.99	7.39
Sorghum 1	5.19	3.12	5.70
Finger millet/ sorghum 1	8.34	6.83	5.32
Cotton 2	5.30	6.76	8.20
Sorghum 2	9.52	11.12	3.57
Maize 2	4.52	1.79	9.52

Source: Author's work, 1991.

For the small rice farm model, rice had the lowest returns per man-hour. Sorghum grown in the second season had the highest returns to labour, followed by finger millet grown in the first season, cassava grown in the first season and cotton grown in the second season. For the large farm model, sorghum grown in the second season had the highest returns per man-hour, followed by cassava grown in the first season, and finger millet grown in the first season. On the aggregate farm, maize grown in the second season had the highest returns to labour, followed by cotton grown in the second season and cassava grown in the first season.

Gross Margin per Operating Capital:

The gross margin per operating capital was computed by dividing the gross margin per hectare of each enterprise by its operating capital. This was done to show the returns to operating capital spent by the farmer.

Table 4.10: Gross margin per operating capital for each enterprise on the rice farm models.

	Farm Model		
Enterprise	Small rice farm	Large rice farm	Aggregate rice farm
Rice 1	1.2	1.74	1.3
Maize 1	6.09	1.89	2.16
Finger millet 1	1.4	3.5	2.95
Cassava 1	8.0	7.06	3.37
Sorghum 1	-	-	-
Finger millet/ Sorghum 1	19.6	3.34	12.50
Cotton 2	3.0	5.2	3.98
Sorghum 2	-	-	-
Maize 2	7.13	9.4	2.25

Source: Author's work, 1991.

Rice had the lowest returns per operating capital for all the three farm models. The enterprises with the highest returns to operating capital were finger millet/sorghum grown in the first season, cassava grown in the first season, maize grown in the second season and maize grown in the first season for the small rice farm model. For the large rice farm model, maize grown in the second season had the highest returns to operating capital, followed by cassava grown in the first season and cotton grown in the second season. For the aggregate rice farm model, finger millet/sorghum mixture had the highest returns per operating capital, followed by cotton grown in the second season and cassava grown in the first season.

From the above analysis, it is clear that even though rice is relatively profitable in terms of gross margin per hectare, its returns to labour and operating capital are low for all the three farm models.

Linear Programming Results

Linear programming was done to determine optimal farm plans in both the rice farm models and non-rice farm models, and to show the position of rice on the optimal farm plans. The constraints to the farming system were also identified from the generated marginal value products (shadow prices).

Optimal Cropping Pattern in the Small Rice Farm Model (2.4 ha)

The optimal farm plan for the small rice farm was dominated by cassava grown in the first season followed by maize grown in the second season, and cotton grown in the

4.2 Linear Programming Results

Linear programming was done to determine optimal farm plans in both the rice farm models and non-rice farm models, and to show the position of rice on the optimal farm plans. The constraints to the farming system were also identified from the generated marginal value products (shadow prices).

Optimal Cropping Pattern in the Small Rice Farm Model (2.4 ha)

The optimal farm plan for the small rice farm was dominated by cassava grown in the first season followed by maize grown in the second season, and cotton grown in the second season. Rice appears in the optimal farm plan but at relatively low hectarage of 0.18, thus making the lowest contribution to the total farm gross margin (Table 4.11). The gross margin achieved on the optimal farm plan was Kshs. 17136.74 compared to Kshs. 12944.76 in the exsisting farm plan. This shows an increase of about 32% in total gross margin on the farm, if optimal farm plans are adopted by farmers in this farm category.

Table 4.11: The Optimal Cropping Pattern in the Small Rice Farm Model

Enterprise	Unit (ha)	Enterprise gross margin (Kshs/ha)	Gross margin contribution per enterprise (Ksh)
Sorghum 2	0.22	3240	712.80
Finger millet/ Sorghum 1	0.19	3920	744.80
Maize 2	1.18	2850	3363.00
Cotton 2	1.00	5300	5300.00
Rice 1	0.18	3423	616.14
Cassava 1	1.60	4000	6400.00
Total farm gross margin per year			= 17136.74

Source: Author's work, 1991.

For the small rice farm model, the constraints to agricultural production were as shown in Table 4.12 below.

Table 4.12: Limiting resources for the small rice farm model:

Resource	Unit	Amount available	Amount used	Slack	MVP Ksh.
Land 2	ha	2.4	2.4	0	1761.10
March labour	man-hour	356	356	0	24.30
July labour	man-hour	342	342	0	1.37
October labour	man-hour	325	325	0	6.92
December labour	man-hour	344	344	0	3.77
Operating capital	Ksh	3528	3528	0	6.72

Source: Author's work, 1991.

The most limiting resource in the small rice farm model was found to be land in the second season. The marginal value product (MVP) of land in the second season was Ksh. 1761.10, which implies that if land was increased by one hectare the farm gross margin would increase by Ksh. 1761.10. Labour was also a limiting resource during the months of March, July, October and December, with MVPs of Ksh 24.30, Ksh 1.37, Ksh 6.92 and Ksh 3.77, respectively. Compared with the wage rate of Ksh. 15 per day in the study area, it would be economical for farmers in this group to hire labour only during the month of March. Operating capital was also a constraint to crop production in this farm model, having a marginal value product of Ksh. 6.72. This implies that every shilling borrowed by the farmer would generate Ksh. 6.72. Hence it would be profitable for farmers in this category to acquire credit to assist them in their farming.

Optimal cropping pattern in the large rice farm model (4.0 ha)

In the large rice farm model, the optimal farm plan was dominated by cassava grown in the first season and cotton grown in the second season (Table 4.13). Rice was excluded from the optimal farm plan in the large rice farm model. The exclusion of rice from the optimal farm plan could be due to its low competitiveness as it is both labour and capital intensive compared to the other crops. The gross margin achieved on the optimal farm plan was Ksh. 29863.63 compared to Ksh. 21280.75 on the existing farm plans. This signifies an increase of about 40.3% in total gross margin if farmers adopted the optimal farm plan.

Table 4.13: The Optimal Cropping Pattern in the Large Rice Farm Model

Enterprise	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Sorghum 2	0.39	3780	1474.20
Cotton 2	1.39	6758	9393.62
Maize 2	0.52	1130	587.60
Cassava 1	3.792	5792	21963.26
Total farm gross margin per year			= 33418.73

Source: Author's work, 1991.

For the large rice farm model, constraints to agricultural production were identified to be the as shown in Table 4.14.

Table 4.14: Limiting resources for the large rice farm model

Resource	unit	amount available	amount used	slack	MVP Ksh
January labour	man-hours	399	399	0	58.03
October labour	man-hours	356	356	0	13.28
December labour	man-hours	466	466	0	5.70

Source: Author's work, 1991.

For the large rice farm model, limiting resources were found to be January labour, with marginal value product (MVP) of Ksh 58.03, October labour with MVP of Ksh 13.28 and December labour with MVP of Ksh 5.70. Land and operating capital were not a constraint to the production of rice and other crops in the large rice farm model. Comparing the marginal value product of labour and the wage rate per day, it would be economical for farmers to hire more labour in the month of January. January coincides with land preparation for first season crops and harvesting of some second season crops. Rice has been omitted from the optimal farm plan and for it to enter the basis for production its gross margin would have to increase from Ksh 5506 to Ksh 9284.40 (an increase of about 68%).

Optimal cropping pattern for the aggregate rice farm model (3.0 ha)

The optimal cropping pattern for the aggregate farm model are given in Table 4.15.

Table 4.15: Optimal Cropping Pattern for the Aggregate Rice Farm Model

Enterprise	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Sorghum 1	1.272	2970	3777.86
Sorghum 2	0.911	3240	2951.64
Cotton 2	1.23	8195	10079.85
Maize 2	0.35	2250	787.50
Cassava 1	0.40	4286	1714.40
Total farm gross margin per year			= 19311.25

Source: Author's work, 1991.

The aggregate rice farm model was dominated by sorghum in the first season, cotton grown in the second season and sorghum grown in the second season (Table 4.15). Rice was excluded in the optimal farm plan. For rice to be included in the basis for production, its gross margin would have to increase from Ksh. 3461 per hectare to Ksh 8613.941 per hectare. The gross margin achieved on the optimal farm plan on the aggregate rice farm model was Ksh. 19311.25 compared to Ksh. 16526.12 on the existing farm plan. This signifies an increase of about 17% in total farm gross margin, if the optimal farm plan is adopted by farmers in this farm category.

The limiting resources for the aggregate rice farm model are given in Table 4.16.

Table 4.16: Limiting resources for the aggregate rice farm model

Resource	Units	Amount available	Amount used	Slack	MVP (Ksh)
March labour	Man-hour	375	375	0	16.50
October labour	Man-hour	334	334	0	18.00
Operating capital	Ksh	3390	3390	0	2.54

Source: Author's work, 1991.

The limiting resources in the aggregate rice farm model were found to be March labour, October labour and operating capital. It would be profitable for farmers in this category to hire labour in the months of March and October because the returns to each unit of labour would be higher than the wage rate.

Optimal cropping pattern in the small non-rice farm model (1.2 ha)

The optimal farm plan on the small non-rice farm model was dominated by cassava grown in the first season, followed by maize grown in the second season and cotton grown in the second season as shown in Table 4.17.

Table 4.17: Optimal Cropping Pattern in the Small Non-Rice Farm Model

Enterprise	Unit (ha)	Enterprise gross margin (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Cotton 2	0.09	5105.00	459.45
Maize 2	1.101	1962.00	2160.16
Cassava 1	1.20	4275.00	5130.00
Total farm gross margin per year			= 7749.61

Source: Author's work, 1991.

The total gross margin achieved on the optimal small non-rice farm model was Ksh. 7749.61 compared to Ksh. 5435.20 on the existing farm plan. This shows an increase of about 43% on the total farm gross margin, if farmers in this farm category adopted the optimal farm plan.

Table 4.18: Limiting resources for the small non-rice farm model

Resource	Unit	Amount Available	Amount used	Slack	MVP Ksh
Land 1	ha.	1.2	1.2	0	3035.79
Land 2	ha.	1.2	1.2	0	1433.27
Operating capital	Ksh	1325	1325	0	1.835

Source: Author's work, 1991.

Limiting resources for the small non-rice farm model were land in the first and the second seasons. If one unit of land was brought into production it would increase farm gross margin by Ksh 3025 in the first season and by Ksh 1433.20 in the second season. Operating capital was also a constraint to crop production. Labour was not a constraint in the production process. Labour was a slack with MVP of zero throughout the year.

Optimal cropping pattern in the large non-rice farm model (2.5 ha)

The optimal cropping pattern in the large non-rice farm model was dominated by sorghum in the second season. In the first season, maize was the major enterprise, followed by sorghum and cassava respectively as shown in Table 4.19 below.

Table 4.19: Optimal Cropping Pattern for the Large Non-Rice Farm Model

Enterprise	Unit (ha)	Gross margin per hectare (Ksh/ha)	Gross margin contribution per enterprise (Ksh)
Sorghum 1	0.42	2160.00	907.72
Sorghum 2	1.97	2700.00	5319.00
Maize 1	1.76	5312.00	9349.12
Cassava 1	0.36	6100.00	2196.00
Total farm gross margin per year			= 17771.84

Source: Author's work, 1991.

The total farm gross margin achieved on the optimal farm plan was Ksh. 17771.84 compared to Ksh. 14800.60 on the existing farm plan. This shows an increase of about 20 per cent in total farm gross margin,if the enterprises shown in the optimal farm plan are adopted by farmers in this farm category.

The most limiting resources for the large non-rice farm model were found to be land in the first season with MVP of Ksh 2160. Labour in the month of October was also found to be a constraint to the production of crops in the large non-rice farm model and had a marginal value product of Ksh 15. Farmers should hire labour during the months of October. October coincides with the period of weeding of the second season crops (such as cotton, maize and sorghum) and the harvesting of the first season cassava. Operating capital was also found to be a constraint. It would be profitable for farmers to obtain credit at the official interest rates of 12% charged by AFC and most co-operatives as each shilling borrowed would increase total gross margin on the farm by Ksh 3.36 as shown in Table 4.20.

Table 4.20: Limiting resources for the large non-rice farm model

Resource	Unit	Amount available	Amount used	Slack	MVP (Ksh)
Land 1	ha	2.50	2.50	0	2160.00
October labour	Man-hours	364.00	364.00	0	15.00
Operating capital	Ksh	2000.00	2000.00	0	3.36

Source: Author's work, 1991.

Optimal cropping pattern in the aggregate non-rice farm model (1.5 ha).

The optimal farm plan for the aggregate non-rice farm model was dominated by cassava in the first season and sorghum in the second season followed by maize in the second season. The total gross margin achieved on the optimal farm plan was Ksh. 10778.95 compared to Ksh. 8319.25 achieved on the existing farm plan. This shows an increase of about 30% in total farm gross margin if the farmers in this farm category adopted the optimal farm plan.

Table 4.21: Optimal cropping pattern in the aggregate non-rice farm model

Enterprise	Unit	Gross margin per hectare (Ksh/ha)	Gross margin(ha) contribution per enterprise (Ksh)
Sorghum 2	1.15	1890	2173.50
Cassava 1	1.45	5410	7844.50
Maize 2	0.35	1962	686.7
Sorghum 1	0.05	1485	74.25
Total farm gross margin per year			= 10778.95

Source: Author's work, 1991.

The limiting resources for the aggregate non-rice farm model were found to be land in the first and second seasons with MVPs of Ksh 1485 and Ksh 1890 respectively. Operating capital was also a constraint on farming in the aggregate non-rice farm model, with a marginal value product of Ksh 4.41. This implies that farmers should acquire credit to help them in their farming activities as each shilling borrowed would increase total farm gross margin by Ksh 4.41. Labour was found to be a slack in all the months of the year in this farm model, with a marginal value product of zero as shown in Table 4.22.

Table 4.22: Limiting resources for the aggregate non-rice farm model

Resource	Unit	Amount available	Amount used	Slack	MVP (Ksh)
Land 1	ha	1.5	1.5	0	1485
Land 2	ha	1.5	1.5	0	1890
Operating capital	Ksh	1420	1420	0	4.41

Source: Author's work, 1991.

4.3 Parametric Linear Programming Results:

The variable price programming was done to assess the effect of price changes on the production of rice. On the small rice farm model, rice had been included on the optimal farm plan at the existing price and level of technology but at very low hectarage of about 0.18 hectare. On the large and aggregate rice farm models, rice had been excluded from the optimal farm plans at the existing price and level of technology.

Table 4.23: Simulated price changes and calculated gross margin of rice per hectare

Price	Price	Gross margin per hectare		
		Small rice farm	Large rice farm	Aggregate rice farm
Ksh/kg	Ksh/bag	Ksh/ha	Ksh/ha	Ksh/ha
(3.40)	289	3424	5506	3461
5.00	425	6279.00	9286.00	6317.00
6.00	510	8064.00	11836.00	8102.00
8.00	680	11634.00	16936.00	11672.00
10.00	850	15204.00	18572.00	15242.00

Figures in brackets represent the existing price level.

Source: Author's work, 1991.

At each gross margin on all the farm models, an optimal farm plan was obtained. This was done to enable the author to find out the effect of price changes on the area of land put under rice by farmers on the various farm models. The results are given in Table 4.24.

Table 4.24: Area Responses (ha) to Changes in Rice Prices.

Price Ksh./kg	% price change	Area cropped: Small rice farm model (ha)	Large rice farm model (ha)	Aggregate rice farm model (ha)
(3.40)	0	0.180	0.000	0.000
5.00	47%	0.250	0.005	0.000
6.00	76%	0.720	0.050	0.000
8.00	135%	0.740	1.035	0.886
10.00	194%	0.890	1.035	0.889

Source: Author's work, 1991.

From Table 4.24, it can be seen that on the small rice farm model, if hectarage of rice has to increase to 0.89 ha, the price has to be increased to Ksh. 10.00 per kilogram. This signifies an increase of about 194% over the existing price of Ksh. 3.40 per kilogram.

On the large rice farm model, the hectarage put under rice is 1.035 ha when the price is increased to Ksh. 8.00. Even if the price is increased to ksh. 10.00, the same land area of 1.035 hectares will be put under rice. This implies that price alone cannot be expected to increase the production of rice in terms of area and output. Other factors (such as yield increasing technologies) have to be examined and implemented. Also farmers have to adopt new and improved farming methods in rice production, such as the use of nitrogen fertilizers and high yielding varieties (which do not exist at present). At present, farmers are still using traditional methods of production. Husbandry practices for rice are relatively poor in the area of this study.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY AND CONCLUSIONS:

This study on the economic competitiveness of rainfed rice production was carried out in West Teso Location of Amukura Division of Busia District. The sampling frame consisted of all small scale farmers in Asinge and Chakol Sub-locations. These were the areas in the location where rainfed rice production was concentrated. The sample consisted of 50 small scale farmers. Of these farmers, 25 were non-rice growers and 25 were rice growers. Data were collected using a structured questionnaire.

The results of the gross margin analysis showed that in the existing cropping patterns, rice was less competitive than cotton grown in the second season and cassava grown in the first season, in the small and aggregate rice farm models. On the large rice farm model, cotton grown in the first season had the highest gross margin per hectare , followed by cassava grown in the first season and rice grown in the first season. Looking at the gross margin per hectare alone on all the farm models, rice would be considered a profitable enterprise. However, the gross margin per man-hour and gross margin per operating capital showed that rice had the lowest returns per man-hour and lowest returns to operating capital.

The linear programming results showed that rice was excluded from the optimal farm plan in both the large and aggregate rice farm models. Even though rice was included in the optimal farm plans in the small rice farm model, it was at a relatively low hectarage (at 0.18 hectares). In order to have rice included in the optimal farm plans in both large and aggregate farm models, substantial increases in price would be required, ranging from 134 per cent to 194 per cent. The optimal farm plans (cropping patterns) were dominated by cassava grown in the first season and cotton grown in the second season for both the small and the aggregate rice farm models. On the large rice farm model, optimal cropping pattern was dominated by cassava grown in the first season and cotton grown in the second season.

The limiting resources on the small rice farm model were operating capital, labour in the months of March, July, October and December and land in the second season. Comparing the labour shadow prices (MVP) with the daily wage rate of Ksh. 15 in the study area, it would be economical for farmers on the small rice farm category to hire extra labour in the month of March. For the large rice farm model, the most limiting resource to crop production was labour in the months of January, October and December, with marginal value products of Ksh 58.03, Ksh 13.28 and Ksh 5.70 respectively. It was found that it would be profitable for farmers to hire extra labour in the month of January at the existing wage rate. The most limiting resources on the aggregate rice farm model were labour in the months of March and October and operating capital. For this farm model, it would be profitable for farmers to hire extra labour as the marginal value product exceed the wage rate. Operating capital constraint could be eased by advancing farmers loans to improve their farming.

The parametric linear programming showed that for rice to be included in the basis for production in the large and aggregate rice farm models, substantial price increases would need to be effected. For small and aggregate farm models, the one hectare of land per farmer which the West Kenya Rainfed Rice Development Project is aiming to get the farmers put under rice may not be reached, even if the prices increased from Ksh. 3.40 to Ksh. 10.00 (an increase of about 194%). To enable the farmers to put more area under rice, and improve the output from the study area, and for farmers to generate higher incomes from their farms, other factors (such as yield-increasing technologies) have to be considered. Price increases alone are not sufficient.

This study thus concludes that rainfed rice was unprofitable to produce at the present level of yields, prices and prevailing economic conditions in Busia District, the area of the study.

5.2 RECOMMENDATIONS:

From this study, the following recommendations are made:

(i) The Government should increase the producer price of rainfed rice in order to offer rainfed rice farmers an incentive to put more land under rice and hence increase rice output from the study area.

(ii) Due to the fact that the operating capital was a limiting resource to crop production and especially to rice on the small and aggregate farm models, the Government of Kenya should look into ways to ease the capital constraint in the study area. Farmers in the area should be offered short term credit to enable them to purchase farm inputs, such as fertilizers, and also meet necessary expenditure when undertaking land preparation, weeding and harvesting of crops.

(iii) Price increases alone are not sufficient to increase rainfed rice output from the study area as shown by the results of the sensitivity analysis.Therefore farmers should be educated on modern ways of rainfed rice production.Farmers should be convinced to use yield increasing technologies such fertilizers, high yielding rice varieties and other superior agronomic practices in rainfed rice production.

(iv) The extension staff should draw up simple optimal farm plans for the non-rice farms of this area. This will enable farmers to optimize resource use.

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APPENDIX 1:

Questionnaire for smallholder farmers in West Teso Location of Busia District, 1990 cropping season

IDENTIFICATION:

Farmer number....................................
Location ....
Sub-location ....
Village ....
Date of Interview ....
Enumerator ....

B. BACKGROUND INFORMATION:

1. What is the total area of your farm ......acres ....hectares

2. Do you operate other piece(s) of land?
Yes .... No ....(Tick the right one)

If yes fill in this table

piece(s) of land	owned	portion farmed	rented	portion farmed	location	distance from household
1						
2						
3						
4						
5						

3. Do you have any other subsidiary occupation apart from farming?

Yes .... No ....(Tick the correct one)

If yes fill in the table

Occupation	Earnings per month	Total Earnings per year

4. What level of education did you reach?
(i) None
(ii) upto std.7 (Primary)
(iii)secondary
(iv) university
(Tick the one applicable)

5. Have you ever attended farmer training?
Yes .... No .... (Tick correct)

If yes, state which institution and year attended.

Institution	Year attended

C: **ENTERPRISES:**

(1) CROPS

What crop and crop mixtures did you have on your farm during the last long rains/short rains (1990)?

Crop or mixture	Season*	Area units	Yield units	To be sold or sold	Price	Amount left for seed	Amount left for consumption

*1 - for 1st season or long rains
2 - for 2nd season or short rains.

(1) **LIVESTOCK**

(i) State the livestock heads you had last year (1990).

No.of Cattle	No.of Cows in milk	No.of Bulls	No.of Sheep	No.of Goats	No.of Poultry

(2) How much did you spend on buying animal feeds per month?

Type of feed	Cost per unit	Total Value

(3) How much did you spend on dipping per month?

Total number of animals taken to dip	Number of times taken to dip per month	Cost per animal	Total Cost

(4) How much do you spend on veterinary charges? Ksh. .... per month?

(5) How much milk do you produce per day (Gorogoro) ....

(6) How much milk did you sell:

No. of treetop bottles ....price

No. of 1/2 treetop bottles ....price

(7) How much milk was consumed at home?

Amount ....(units).

(8) How much time did you spend on the various livestock activities?

Activity	Time (Hrs/day)	No. of days per month	Total amount of time (manhours)
Grazing			
Dipping			
Milking			

(8) What problems do you encounter with your livestock? (Tick applicable).

(a) Diseases
(b) Lack of market
(c) Ticks
(d) Others (specify).

D. ENTERPRISES AND INPUTS:

What inputs did you use during the last long/short rains and on which crops?

		Fertilizer				Seed			Pesticides			
Crop/crop mixture	Season*	Name	Amount used	Price/ unit	Total cost	Amount used	Price /unit	Total cost	Name	Amount used	Price /unit	Total cost

* 1 - 1st season
2 - 2nd season

Other variable cost items (inputs)

Enterprise ....

Land preparation:

(a) casual labour: area (acres) .... Total cost ....
(b) tractor : area (acres) .... " ....
(c) oxen : area (acres) .... " ....
(d) planting : area (acres) .... " ....
(e) weeding : area (acres) .... " ....
(f) harvesting : area (acres) .... " ....

E: **LABOUR AVAILABILITY:**

1) How many family members are available for farm work and how many hours do they work per day?

Family member	Number	Age(yrs)	Number of hrs worked per day	Number of days available for farmwork per week	Month when available for farmwork

2) How many permanent labourers do you have? ....

3) How much do you pay them per month (Ksh.) ....

4) Do you employ casual labourers?

Yes .... No .... (Tick correct one)

5) If no state reasons why you do not employ:

....

....

....

....

6) In which months do you employ casual labourers and for which operations?

Month	Number	CASUAL No. of days worked	Rates paid/day	Total amount paid
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

F: LABOUR UTILIZATION:

1) How long does it take a man working 5 hrs per working day to carry out the following operations: (Ploughing, planting, weeding, spraying & dusting, harvesting, sorting/threshing/processing.

Enterprise	Operation	No. of days	Month when operation is done

G: MARKETING OF RICE:

1) Where do you market your rice?
(i) NCPB
(ii) Millers
(iii)LBDA
(iv) Others (Specify)

2) What is the distance to the market where you sell your rice?
..............kms. (if bought from the farm, the distance is zero).

3) How long does it take for you to receive your payments after delivering your rice to NCPB or LBDA?......................

4) What improvements would you like to be made in the marketing facilities for rice?

....

....

H: EXTENSION SERVICES

1) Do you receive visits from the MoA extension staff?

Yes .... No .... (Tick correct one)

2) If yes, state the frequency of the visits per month.

....

3) What improvements would you like to see in the extension?

....

....

I: CREDIT

1) Did you borrow anything for your farm needs during last year (1990)?
Yes .... No ....

2) If yes, state the items borrowed and source.

Items borrowed	Source (From whom borrowed)	Purpose	Remarks

3) Do you plan to get more loans in the future?

Yes .... No .... (Tick correct one)

4) If no, give reasons ....

....

J: SUBSISTENCE FOOD REQUIREMENTS:

1) Are there any crops which you must grow for family use?

Yes .... No .... (Tick correct one)

2) If yes, state the crops:

(i) ....
(ii) ....
(iii)..................

3) How much of the following crops does your family need per month or year?

maize ....
sorghum ....
millet ....
cassava ....

H: EXTENSION SERVICES

1) Do you receive visits from the MoA extension staff?

Yes .... No .... (Tick correct one)

2) If yes, state the frequency of the visits per month.

....

3) What improvements would you like to see in the extension?

....

....

I: CREDIT

1) Did you borrow anything for your farm needs during last year (1990)?
Yes .... No ....

2) If yes, state the items borrowed and source.

Items borrowed	Source (From whom borrowed)	Purpose	Remarks

3) Do you plan to get more loans in the future?

Yes .... No .... (Tick correct one)

4) If no, give reasons ....

....

J: SUBSISTENCE FOOD REQUIREMENTS:

1) Are there any crops which you must grow for family use?

Yes .... No .... (Tick correct one)

2) If yes, state the crops:

(i) ....
(ii) ....
(iii)..................

3) How much of the following crops does your family need per month or year?

maize ....
sorghum ....
millet ....
cassava ....

K: PROBLEMS FACING THE FARMER:

What are the major problems facing you in the use of the various farm inputs:

Input	Problem experienced by the farmer
Fertilizer	
Pesticides	
Labour	
Credit	
Land	
Machinery	
Other (specify)	

APPENDIX 2: GROSS MARGIN CALCULATIONS

2A: Gross margins calculations on the rice farm models

2.1A : Gross margin calculation for the maize crop on rice farms (Ksh/ha)

	Small rice farm		Large rice farm		Aggregate rice farm	
Maize	1st season	2nd season	1st season	2nd season	1st season	2nd season
Yield/ha	15 bags	13 bags	13 bags	5 bags	20 bags	13 bags
Pricer per bag(Ksh)	250	250	250	250	250	250
Gross output (Ksh)	3750	3250	3250	1250	5000	3250
Total*variable costs	529	400	1485	120	1583	1000
Gross margin	3221	2850	1765	1130	3417	2250

*Variable costs included expenditure on farm inputs such as seed; pesticides and fertilizers. It also included cost of hiring oxen for land preparation; casual labour charges on weeding; spraying; harvesting; threshing and shelling cereals and sorting cotton.

2.2A: Gross margin calculation for the rice crop on rice farms (Ksh/ha)

Rice	small rice farm	1st season Large rice farm	Aggregate rice farm
Yield/ha	21 bags	30 bags	21 bags
Price/bag	289	289	289
Gross output (Ksh)	6069	8670	6069
Total variable costs	2646	3164	2608
Gross margin (Ksh/ha)	3423	5506	3461

2.3A: Gross margin calculation for the finger millet crop on rice farms (Ksh/ha)

Finger millet	Small rice farm	1st season Large rice farm	Aggregate rice farm
Yield (bags/ha)	10	8	9
Price/bag (Ksh/bag)	540	540	540
Gross output (Ksh)	5400	4320	4860
Total variable costs (Ksh)	2250	960	1229
Gross margin (Ksh)	3150	3360	3631

2.4A: Gross margin calculation for fingermillet-sorghum crop mixture on rice farms (Ksh/ha)

Finger millet/ sorghum	1st season Small rice farm	Large rice farm	Aggregate rice farm
Fingermillet	6 bags	7 bags	3 bags
Yield/ha			
price/bag			
(Ksh)	540	540	540
Gross output			
(Ksh)	3240	3780	1620
Sorghum			
Yield/ha	4 bags	5 bags	4 bags
Price/bag	270	270	270
(Ksh)			
Gross output	1080	1350	1080
Total variable			
costs (Kshs/ha)	400	1920	200
Gross margin	3920	3210	2500

2.5A: Gross margin calculation for the cassava crop on rice farms

Cassava	1st season Small rice farm	Large rice farm	Aggregate rice farm
Yield/ha	1500 kgs	2204 kgs	1852 kgs
Price/kg (Ksh)	3.00	3.00	3.00
Gross output (Ksh)	4500	6612	5556
Total variable costs	500	820	1270
Gross margin (Ksh/ha)	4000	5792	4286

2.6A: Gross margin calculation for the sorghum crop on rice farms (Ksh/ha)

Sorghum	Small rice farm 1st season	Small rice farm 2nd season	Large rice farm 1st season	Large rice farm 2nd season	Aggregate rice farm 1st season	Aggregate rice farm 2nd season
Yield/ha	11 bags	10 bags	6 bags	14 bags	11 bags	12 bags
Price/bag (Ksh)	270	270	270	270	270	270
Gross output(Ksh)	2970	270	1620	3780	2970	3240
Total variable costs	0*	0	0	0	0	0
Gross margin/ per hectare	2970	2700	1620	3780	2970	3240

* Family inputs such as labour; seed were used by farmers. These family inputs were assigned a value of zero. Therefore no variable costs were involved in the production of sorghum in both the first season and the second season.

2.7A: Gross margin calculation for the cotton crop on rice farms (Ksh/ha)

Cotton	First season Small rice farm	Large rice farm	Aggregate rice farm
Yield	750 kgs	856 kgs	1091 kgs
Price/kg (Ksh/kg)	9.40'	9.40	9.40
Gross output (Ksh)	7050	8046	10255
Total variable costs	1750	1288	2060
Gross margin	5300	6758	8195

* This is the price which the farmers actually received after some deduction of 0.60/= as cess. The official price is 10 Ksh per kilogram.

2B: Gross margin calculations on non-rice farm model

2.1B: Gross margin calculation for the sorghum crop on non-rice farms (Ksh/ha)

Sorghum	Small non-rice farm		Large non-rice farm		Aggregate non-rice farm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Yield(bags)	5	3	8	10	5.5	7
price/bag (Ksh/kg)	270	270	270	270	270	270
Gross output (Ksh)	1350	810	2160	2700	1485	1890
Total variable costs	0	0	0	0	0	0
Gross margin	1350	810	2160	2700	1485	1890

2.2B: Gross margin calculation for the maize crop on non-rice farms (Ksh/ha)

Maize	Small non-rice farm		Large non-rice farm		Aggregate non-rice farm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Yield/ha	18 bags	9 bags	25 bags	10 bags	19 bags	9.5 bags
Price/bag (Ksh)	250	250	250	250	250	250
Gross output (Ksh)	4500	2250	6250	2500	4750	2375
Total variable costs	960	288	938	400	926	367
Gross margin/ha (ksh/ha)	3824	2008	5312	2100	3540	1962

2.3B: Gross margin calculation for the sorghum crop on non-rice farms (Ksh/ha)

Sorghum	Small non-rice farm		Large non-rice farm		Aggregate non-rice farm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Yield(bags)	5	3	8	10	5.5	7
price/bag (Ksh/bag)	270	270	270	270	270	270
Gross output (Ksh)	1350	810	2160	2700	1485	1890
Total variable costs	0	0	0	0	0	0
Gross margin	1350	810	2160	2700	1485	1890

2.4B: Gross margin calculation for the cassava crop on non-rice farms (Ksh/ha)

Cassava	1st season Small non-rice farm	Large non-rice farm model	Aggregate non-rice farm model
Yield (kg)	1650	2400	2100
price/kg (Ksh/	3.00	3.00	3.00
Gross output	4950	7200	6300
Total variable costs	675	1100	890
Gross margin (Ksh/ha)	4275	6100	5410

2.5B: Gross margin calculation for the fingermillet crop on non-rice farms (Ksh/ha)

Finger millet	1st season Small non-rice farm model	Large non-rice farm model	Aggregate non-rice farm model
Yield (bags)	8.5	9	8.5
Price/bag (ksh/bag)	540	540	540
Gross output	4590	4860	4590
Total variable costs	1652	1243	1450
Gross margin	2938	3617	3140

2.6B: Gross margin calculation for the cotton crop on non-rice farms (Ksh/ha)

Cotton	Second season Small non-rice farm model	Large non-rice farm model	Aggregate non-rice farm model
Yield (kg)	670	1088	809
Price per kg (Ksh/kg)	9.40	9.40	9.40
Gross output	6298	10227	7605
Total variable costs	2000	3350	2500
Gross margin	4298	6878	5105

2.7B: Gross margin calculation for the fingermillet/sorghum crop mixture on non-rice farms (Ksh/ha)

Fingermillet/ Sorghum	1st season Small non-rice farm	Large non-rice farm	Aggregate non-rice farm
Fingermillet			
Yield	3 bags	8 bags	3 bags
Price/bag	540	540	540
Gross output	1620	4320	1620
Sorghum			
Yield 5 bags	7 bags	5 bags	
price/bag		270	270
Gross output	1350	1890	1350
Total variable costs	1000	2300	1160
Gross margin (Ksh/ha)	1970	3910	1810

ppendix 3:CALENDAR OF FARMING ACTIVITIES IN AMUKURA DIVISION OF BUSIA ISTRICT;KENYA.

terprise	MONTH OF THE YEAR JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
ce 1	LAND PREPARATION & PLANTING	LAND PREPARATION	WEEDING	BIRD SCARING	BIRD SCARING	HARVESTING	----------	---->	THRESHING & BAGGING	-	-	-
ize 1	LAND PREPARATION	LAND PREPARATION &PLANTING	1ST WEEDING	2ND WEEDING	-	-	HARVESTING	SHELLING	-	-	-	
ize 2	HARVESTING & SHELLING	SHELLING	-	-	-		LAND PREPARATION	LAND PREPARATION	PLANTING		-	WEEDING
otton 2	HARVESTING HARVESTING & SORTING	HARVESTING & SORTING	HARVESTING & SORTING	-	LAND PREPARATION	LAND PREPARATION & PLANTING	PLANTING WEEDING & SPRAYING	WEEDING & SPRAYING	----------	----------	----------	---->
inger- illet 1	LAND PREPARATION	PLANTING	WEEDING	-	-	HARVESTING	HARVESTING	THRESHING				-
orghum 1	LAND PREPARATION	PLANTING	PLANTING & WEEDING	WEEDING	-	HARVESTING & THRESING	----------	---->			THRESHING	-
orghum 2	HARVESTING	---->	-	-	-	-		LAND PREPARATION	PLANTING		WEEDING	WEEDING
inger- illet/ orghum 1	LAND PREPARATION	PLANTING	WEEDING	-	-	HARVESTING	---->	THRESHING	---->		-	-
assava 1	LAND PREPARATION & PLANTING	LAND PREPARATION & PLANTING	WEEDING	WEEDING	-	-		-	-		-	HARVESTING

ource: Author's Work, 1991.

APPENDIX 4: TECHNICAL COEFFICIENTS.

4.1: TECHNICAL COEFFICIENTS FOR THE LARGE RICE FARM

ENTERPRISE	M1	SORGH 1	FM 1	-FM/SORG 1	CAS 1	SORG 2	COT 2	M2
GROSS MARGIN	5312	2160	3617	3910	6100	2700	6878	2100
CONSTRAINTS LAND 1	1	1	1	1	1	0	0	0
LAND 2	0	0	0	0	0	1	1	1
JANUARY LABOUR	125	60	150	90	90	20	70	15
FEBRUARY LABOUR	120	10	35	10	70	20	70	15
MARCH LABOUR	190	180	180	130	150	0	70	0
APRIL LABOUR	190	50	0	0	180	0	0	0
MAY LABOUR	0	0	0	0	0	0	160	0
JUNE LABOUR	0	40	150	40	0	0	90	120
JULY LABOUR	60	40	150	40	0	60	90	160
AUGUST LABOUR	60	70	90	30	0	10	70	40
SEPTEMBER LABOUR	60	70	90	30	0	10	100	40
OCTOBER LABOUR	0	0	0	0	30	180	100	40
NOVEMBER LABOUR	0	0	0	0	30	0	100	100
DECEMBER LABOUR	0	0	0	0	30	40	240	40
OPERATING CAPITAL	938	0	1243	2300	1100	0	3350	400

4.2: TECHNICAL COEFFICIENTS FOR THE AGGREGATE NON-RICE FARM MODEL

ENTERPRISE	M1	SORG 1	FM 1	FM/SORG 1	CAS 1	SORG 2	COT 2	M2
GROSS MARGIN	3824	1485	3140	1810	5410	1890	5105	2008
CONSTRAINTS LAND 1	1	1	1	1	1	0	0	0
LAND 2	0	0	0	1	1	1	1	1
JANUARY LABOUR	125	60	150	90	90	20	70	15
FEBRUARY LABOUR	120	10	35	10	70	20	70	15
MARCH LABOUR	190	180	180	130	150	0	70	0
APRIL LABOUR	190	50	0	0	180	0	0	0
MAY LABOUR	0	40	0	0	0	0	160	0
JUNE LABOUR	0	40	150	40	0	0	90	120
JULY LABOUR	60	70	150	40	0	60	90	160
AUGUST LABOUR	60	70	90	30	0	10	70	40
SEPTEMBER LABOUR	60	0	90	30	0	10	100	40
OCTOBER LABOUR	0	0	0	0	30	180	100	100
NOVEMBER LABOUR	0	0	0	0	30	0	100	100
DECEMBER LABOUR	0	0	0	0	30	40	240	40
OPERATING CAPITAL	926	0	1450	1160	890	0	2500	367

4.3: TECHNICAL COEFFICIENTS FOR THE SMALL RICE FARM

ENTERPRISE	R1	M1	FM1	CAS1	SORG 1	FM/SORG 1	COT 2	SORG 2	M2
GROSS MARGIN	3423	3221	3150	4000	2700	3920	5300	3240	2850
CONSTRAINTS LAND 1	1	1	1	1	1	1	0	0	0
LAND 2	0	0	0	0	0	0	1	1	1
JANUARY LABOUR	160	125	150	90	60	90	70	20	15
FEBRUARY LABOUR	190	120	35	70	10	10	70	20	15
MARCH LABOUR	120	190	180	150	180	130	70	0	0
APRIL LABOUR	0	190	0	180	50	0	0	0	0
MAY LABOUR	180	0	0	0	0	0	0	0	0
JUNE LABOUR	180	0	150	0	40	40	90	0	120
JULY LABOUR	240	60	150	0	40	40	90	60	160
AUGUST LABOUR	180	60	90	0	70	30	70	10	40
SEPTEMBER LABOUR	0	60	90	0	70	30	100	10	40
OCTOBER LABOUR	0	0	0	30	0	100	100	180	100
NOVEMBER LABOUR	0	0	0	30	0	0	100	0	100
DECEMBER LABOUR	0	0	0	30	0	0	240	40	100
OPERATING CAPITAL	2646	529	2250	500	0	400	1750	0	400

4.4: TECHNICAL COEFFICIENTS FOR THE LARGE RICE FARM MODEL

ENTERPRISE	R1	M1	FM1	CAS1	SORG1	FM/SORG1	COT2	SORG2	M2
GROSS MARGIN	5506	1765	3360	5792	1620	3210	6758	3780	1130
CONSTRAINTS LAND 1	1	1	1	1	1	1	0	0	0
LAND 2	0	0	0	0	0	0	1	1	1
JANUARY LABOUR	160	125	150	90	60	90	70	20	15
FEBRUARY LABOUR	190	120	35	70	10	10	70	20	15
MARCH LABOUR	120	190	180	150	180	130	70		0
APRIL LABOUR	0	190	0	180	50	0	0	0	0
MAY LABOUR	180	0	0	0	0	0	0	0	0
JUNE LABOUR	180	0	150	0	40	40	90	0	120
JULY LABOUR	240	60	150	0	40	40	90	60	160
AUGUST LABOUR	180	60	90	0	70	30	70	10	40
SEPTEMBER LABOUR	0	60	90	0	70	30	100	10	40
OCTOBER LABOUR	0	0	0	30	0	100	100	180	100
NOVEMBER LABOUR	0	0	0	30	0	0	100	0	100
DECEMBER LABOUR	0	0	0	30	0	0	240	40	40
OPERATING CAPITAL	3164	1485	960	820	0	1920	1288	0	120

4.5: TECHNICAL COEFFICIENTS FOR THE AGGREGATE RICE FARM MODEL

ENTERPRISE	R1	M1	FM1	CAS1	SORG1	FM/SORG1	COT2	SORG2	M2
GROSS MARGIN	3461	3417	3631	4286	2970	2500	8195	3240	2250
CONSTRAINTS LAND 1	1	1	1	1	1	1	1	0	0
LAND 2	0	0	0	0	0	0	1	1	1
JANUARY LABOUR	160	125	150	90	60	90	70	20	15
FEBRUARY LABOUR	190	120	35	70	10	10	70	20	15
MARCH LABOUR	120	190	180	150	180	130	70	0	0
APRIL LABOUR	0	190	0	180	50	0	0	0	0
MAY LABOUR	180	0	0	0	0	0	0	0	0
JUNE LABOUR	180	0	150	0	40	40	90	0	0
JULY LABOUR	240	60	150	0	40	40	90	60	160
AUGUST LABOUR	180	60	90	0	70	30	70	10	40
SEPTEMBER LABOUR	0	60	90	0	70	30	100	10	40
OCTOBER LABOUR	0	0	0	30	0	100	100	180	100
NOVEMBER LABOUR	0	0	0	30	0	0	100	0	100
DECEMBER LABOUR	0	0	0	30	0	0	240	40	40
OPERATING CAPITAL	2608	1583	1229	1270	0	400	2060	0	1000

4.6: TECHNICAL COEFFICIENTS FOR THE SMALL NON-RICE FARM MODEL

ENTERPRISE	M1	SORG1	FM1	FM/SORG1	CAS1	SORG2	COT2	M2
GROSS MARGIN	3540	1350	2938	1970	4275	810	4298	1962
CONSTRAINTS LAND 1	1	1	1	1	1	0	0	0
LAND 1	0	0	0	0	0	1	1	1
JANUARY LABOUR	125	60	150	90	90	20	70	15
FEBRUARY LABOUR	120	10	35	10	70	20	70	15
MARCH LABOUR	190	180	180	130	150	0	70	0
APRIL LABOUR	190	50	0	0	180	0	0	0
MAY LABOUR	0	0	0	0	0	0	160	0
JUNE LABOUR	0	40	150	40	0	0	90	120
JULY LABOUR	60	40	150	40	0	60	90	160
AUGUST LABOUR	60	70	90	30	0	10	70	40
SEPTEMBER LABOUR	60	70	90	30	0	10	100	40
OCTOBER LABOUR	0	0	0	0	30	180	100	100
NOVEMBER LABOUR	0	0	0	0	30	0	100	100
DECEMBER LABOUR	0	0	0	0	30	40	240	40
OPERATING CAPITAL	960	0	1652	1000	675	0	2000	288