OPTIMAL FARM PLANS FOR SMALL-HOLDINGS IN KALOLENI, AN IADP LOCATION OF KILIFI DISTRICT, KENYA: A LINEAR PROGRAMMING APPROACH

By

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

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ABSTRACT

This study examines the possibility of increasing farm income and resource use in Kaloleni location of Kilifi district. Many studies reviewed in the literature show that a potential exists for increasing net farm income and farm labour employment in transitional agriculture through reorganisation of existing resources under existing and improved technologies. Specifically the study has the following objectives:

(1) to identify the critical factors constraining production in the farming system practised in the area;

(2) to investigate the present resource allocation between the various farm enterprises (activities);

(3) to find farm systems that make the best use of resources and compare enterprises, and finally;

(4) to examine the impact of the technical package of input recommendations under (IADP) in order to find out to what extent these can improve the use of resources, and hence increase net farm income.

Primary data used for analysis and programming was obtained by a farm survey conducted from November, 1978, inclusive to end of January, 1979. The sample frame was stratified on the basis of the size of small-holdings. The sample size of 30 small-holdings was proportionately distributed among the size groups. Finally the ultimate sampling units were drawn randomly from each size group. The primary data was supplemented with secondary data collected from District Guidelines and the Coast Agricultural Research Station, Mtwapa. All the data collected refer to the 1978 agricultural year, which is the reference year of this study. Gross-margin analysis and linear programming (LP) techniques have been used in the study.

The analysis of the enterprises (activities) on the holdings shows that the present net farm income of the small-holdings is between KShs.2461.40 and KShs.6509.20. The analysis also shows a wide variation of gross-margins among the enterprises (activities). The cashewnut enterprise has the lowest gross-margin of KShs.680.00 per ha while the coconut (whole nuts and toddy) enterprise has the highest gross margin of KShs.1820.20 per ha. The linear programming (LP) results show that there is an increasing net farm income on all sizes of small holding in Kaloleni location through reorganisation of resources under both existing and improved technologies. Introduction of improved technology (IADP) however, shows that net farm income and farm labour employment can even be increased more by this course of action than under existing technology.

The results of the study lead to the conclusion that a potential for increasing farm income and resource use exists in Kaloleni location. However, before planning techniques are applied and improved technologies introduced, some basic technical problems need to be solved, such as improving intercropping systems and determining efficient combinations of tree crops and tolerant crops in the area studied. Crop husbandry techniques need also to be improved through greater use of farm management extension: this is evident because of the low present net farm income situation.

CHAPTER ONE

INTRODUCTION

1.1. Nature of the Study

The role played by agriculture in the development of low-income countries has long been recognised. For this reason high priority is given to agricultural development in Kenya.

The rapid population growth and the expanding demand for agricultural products in Kenya is causing a lot of concern. This, coupled with the scarcity of farm resources and changing techno-economic conditions, requires an examination of the most efficient production alternatives of farm resources that would result in maximisation of farm income. This is in line with past Development Plans, one of the major goals of which is to raise the income of a large proportion of the population which depends primarily on agriculture for their livelihood. The Integrated Agricultural Development Programme (IADP) has been used since 1976 in Kenya as a major vehicle for small scale farmers to increase their participation in the cash economy.

The salient feature of the Integrated Agricultural Development Programme (IADP) is to help the small farmers become economically viable by increasing productivity, employment and income through financial assistance. This programme adopts the whole farm approach, or an integrated approach to a farm, that is, catering for productive activities on the farm simultaneously. The IADP project lays more emphasis on the development of comprehensive farm development systems relating to local conditions by providing the necessary services for such systems and assisting in removing the general constraints to farm development.

The major programme sub-components are: provision of technical packages, financed by credit and supported by training, extension, marketing, input supply, livestock improvement services, soil and water conservation measures. Technical packages under government support are designed for certain hectarages on farms, which in most cases do not concur with the total farm sizes. Technical crop packages are a mixture of food and non-food crops, suitable for a given agro-ecological zone, introducing improved technology and are offered to farmers for adoption. The hectarage of each enterprise included in the technical package is specified, for example (0.8) hectares.

1.2. Statement of the Problem

This study is concerned with some aspects of agricultural development problems facing the low-income countries. Improper and inefficient resource allocation is one of the major problems experienced in transitional agriculture (Yukon, 1971). A sufficient potential may exist for improving agricultural production and augmenting farm returns with proper allocation of existing resources (Desai, 1961). It is, however, argued by some authors that possibilities for increasing farm returns through reorganisation of existing resources are exhausted in traditional agriculture, that is, traditional agriculture is efficient (Hopper, 1965; Chennareddy, 1967; Sahota, 1968; Yotopoulos, 1968 and many others).

In view of this argument, many agricultural development policies emphasize the introduction of certain complementary inputs, of a technical, educational and institutional nature, to farm resources in order to raise the productivity of the existing agricultural economy. Before this expensive policy is adopted, the possibilities of increasing resource productivity and farm incomes through reorganization of existing resources should be explored in all types of farming.

The problems of agriculture are compounded by its diversity in topography, soil types, climate, resource endowment and cultural background, whose ultimate effect is the development of many and varied farming systems. Consequently, the design and implementation of a rational programme of agricultural development is by no means a simple task. Realizing the diversity of agriculture, Dent and Anderson (1971) pointed out that system theory should be employed as a guideline for farm system description and analysis. Elliot, Tapp and Williard (1928) expressed the same views as follows:-

> "In recent years a great deal of attention has been given to development of regional, state and local agricultural programmes - a programme for the so called average farmer is too indefinite. Blanket recommendations are not specific enough and what is needed is a segregation of farmers and in homogeneous type of farming areas so that a correct appraisal can be made of the needs of typical groups."

In all farming systems the critical problem is one of choice between many and varied enterprises. The problem of choice is due to limited resources available.

The farming system considered in this study is in the Agro-Economic Zone IV[1] (Cotton Zone) as defined by the Ministry of Agriculture, Kenya. The National Atlas of Kenya refers to this zone as the Semi-Arid Zone.[2]

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[1] Suitable for cotton, seed beans, katumani maize, cassava, indigenous cattle.

[2] Land of marginal agricultural potential, carrying as natural vegetation dry forms of woodland and "Savanna" (often an Acacia-Themeda association) or derived semi-evergreen or deciduous bushland. This is potentially productive rangeland-usually less than 4 ha per stock unit - limited mainly by the encroachment of woody species. The more open country with a high density of wildlife consistutes a valuable tourist site.

On the other hand, the Kenya Central Bureau of Statistics (Kenya Integrated Rural Survey, 1974-1975) refers to this zone as the Coastal Zone with rain over 40 inches. Inspite of the potential of this zone, the farmers are impoverished in this area. The level of resource productivity is low. The level of total household income in this zone is KShs.4,077 per annum[1] and of this only KShs.1,040 is the farm income. Farm income which constitutes 25.51 per cent of the total household income is the major source of income in this zone. Many reasons can be advanced to explain the low farm income in this zone, but the major problem may be due to mis-allocation of farm resources.

It is therefore useful to know how to improve the use of farm resources that exist in this zone, and also to be able to make farm adjustments (farm plans) as the conditions change. This can be achieved by use of linear programming technique. This technique can establish maximum profit situations on the holdings under given constraints. Since it is expensive to apply linear programming technique on individual small-holdings, it should be applied on representative or average farms.

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[1] Source: Kenya, Central Bureau of Statistics, Integrated Rural Survey 1974-75 Basic Report, page 55.

1.3. Objectives of the Study

This study was undertaken to determine the potential increases in farm income through reorganisation of enterprises and farm resources in Kaloleni location of Kilifi district, Kenya. Optimal reorganisation of farm resources and enterprises has been examined under both existing and improved technology (IADP) at the present level of resource supply. The specific objectives of the study are:

(1) to identify the critical factors constraining production in the farming system practised in the area;

(2) to investigate the present resource allocation between the various farm enterprises (activities);

(3) to find farm systems that make the best use of resources and compare enterprises;

(4) to examine the impact of the technical package of input recommendations under IADP in order to find out to what extent these can improve the use of resources and hence increase net farm income.

Broadly, this study will determine what readjustments (farm plans) should be made for the existing farming system under both existing and improved (IADP) technology. It will also highlight the way the constraints operate on the farming system in assessing the likely impact of new technology (IADP) being introduced in the area.

1.4. Hypotheses

The study seeks to test the general hypothesis that the potential for improvement of the use of resources exists, i.e. that small-holders of Kaloleni location in Kilifi district are inefficient in their farm resource allocation. In other words;

(1) the current level of resource productivity and farm income is below what can be achieved within the present resource constraints, i.e. the resource use is sub-optimal.

(2) given an homogeneous agro-ecological zone, variation in optimal farm plans should be directly related to differences in availability of resources.

(3) the proposed technical package of input recommendations under (IADP) will not improve land and labour utilization and hence increase farm incomes.

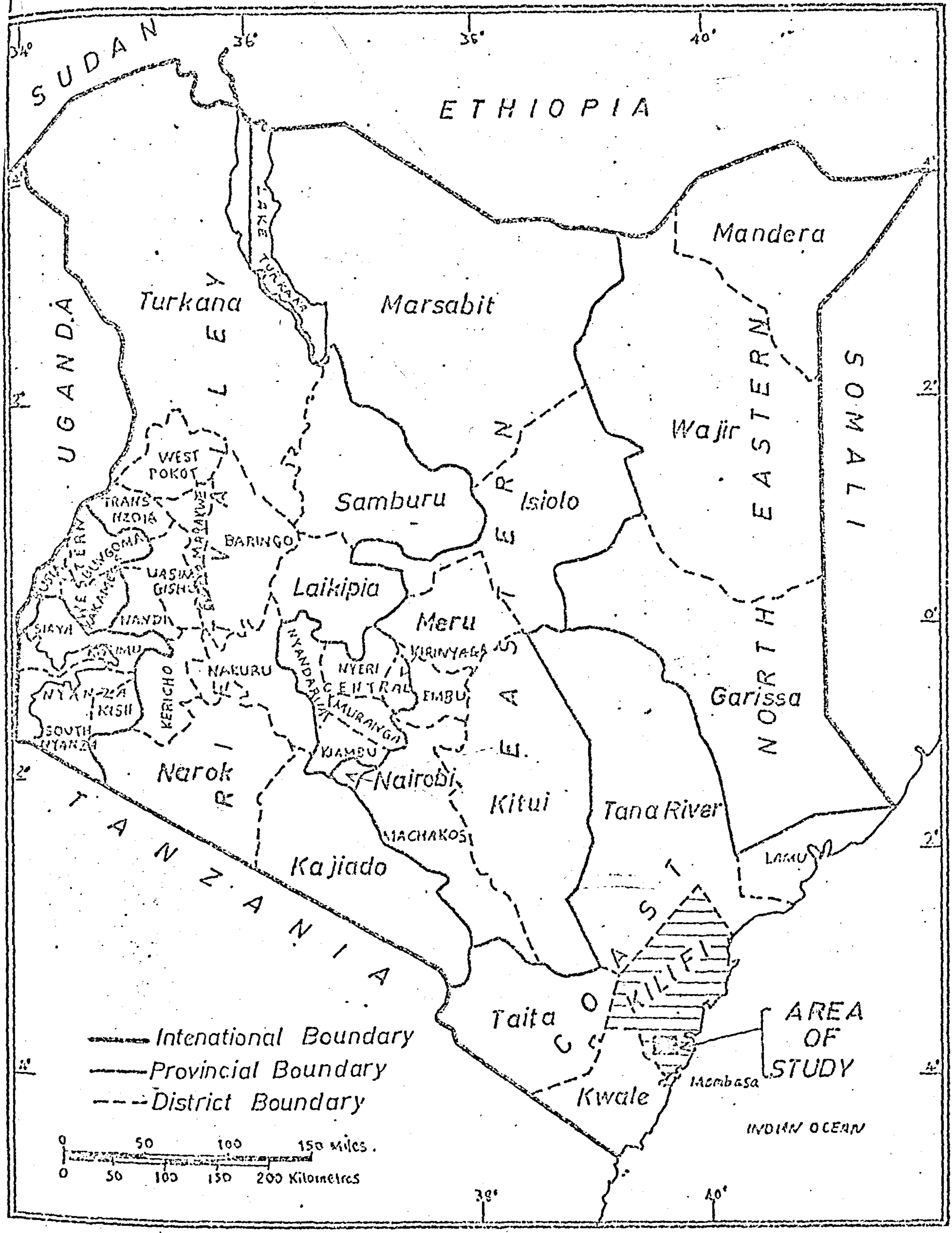
These hypotheses have been tested by use of gross margin analysis and linear programming techniques. The linear programming technique shows a divergence between the actually realized incomes on the farms and those which would have been realized if the given resources were allocated optimally under both existing and improved technology.

1.5. The Area of the Study : Kaloleni Location.

The study took place in Kaloleni location of Southern Division, Kilifi district, Kenya and covers the 1978 growing season. Traditional or semi-subsistence agriculture is practised in this location. Kaloleni location falls within the cotton (Semi-Arid Zone). Kilifi district is in the Coast Province of Kenya and borders to the east the Indian Ocean, to the South Mombasa and Kwale Districts, to the West Taita-Taveta district and Tsavo National Park and to the North, Tana River District, see figure 1.1.

The District is subdivided into four divisions, namely Malindi, Northern, Central and Southern. Each Division is further subdivided into locations. Kilifi District shows two distinct climatic zones; the Semi-Arid and Arid Zones. The Semi-Arid Zone is of marginal agricultural potential. The size of the district is about 800,000 hectares and supports a projected

FIGURE 1·1 MAP OF KENYA



population[1] (1978) of 398,000 persons. Kaloleni location has an estimated population (1978) of over 19,000 persons, and has over 1,600 farm families.[2] All the farms in Kaloleni are adjudicated and about eighty per cent of them are registered.

Kaloleni has an average rainfall of 1000 mm per annum. The long rainy season which starts from late March to end of September is the most reliable. The short rainy season which starts late in October to December is too uncertain. The soils are sandy clay loams, well drained, deep, dark-brown to yellow-brown, firm and of low to moderate fertility. These soils are formed from jurassic rocks.

Farmers use simple traditional tools (Giriama hoe) for most farm operations and most of the farm work is done by women. Mixed cropping is the common practice in the area.

The common crops grown in the location are maize, cassava, coconut, cashewnut and citrus (oranges). Occasionally, farmers grow simsim, cowpeas, green gram, groundnut and cotton. Some livestock graze under the coconut-cashewnut complex.

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[1] Population profiles for the districts of Kenya prepared by the Population Studies and Research Institute, Universit of Nairobi, 1978.

[2] Compiled by the Author from the Kilifi Land Register, Ministry of Lands and Settlement, Kenya.

CHAPTER TWO

REVIEW OF LITERATURE

The view that traditional agriculture is efficient was originally propounded by Schultz, 1964, when he formulated the following hypothesis:

> "There are comparatively few significant inefficiencies in allocation of factors of production in traditional agriculture."

Schultz's policy conclusion is that no appreciable increase in agricultural production is to be had by reallocating the factors at the disposal of farmers who are bound by traditional agriculture and maximizing-utility under perfect competition. This conclusion also implies that underdeveloped agricultural communities, as well as individual farmers, are "efficient" even though they are poor. The community and farmers are poor because the resources on which the economy depends are not capable of producing more under existing circumstances. Although Schultz, explicitly mentions only allocative (economic) efficiency, he also stresses technical efficiency in the use of resources and technology.

This view has repeatedly been put to the test by many economists in their studies in India and other countries. Some of the studies support the view, others do not. Schultz's view has been supported by the empirical work of Hopper, 1965; Chennareddy, 1967; Sahota, 1968; Saini, 1969; Welsch, 1965; Yotopoulos, 1968; Wolgin, 1973, and many others.

The empirical work of testing Schultz's hypothesis is mainly based on the estimation of Cobb-Douglas production functions and derivation of marginal value products. The marginal value products (MVP) are compared with marginal factor costs (MFC).

The following illustrates some of the conclusions drawn by those researchers who supported the allocative efficiency formulated by Schultz:

> "There is no evidence that an improvement in economic output could be obtained by altering the present allocations as long as the village (Senapur in India) relies on traditional resources and technology" (Hopper, 1965, p.620).

> "With the exception of seed, reallocating the present factors of production in the rice and yam enterprises in the area does not appear to be a fruitful means of increasing productivity. The present factors are allocated about as efficiently as they can be (in Eastern Nigeria)" (Welsch, 1965, p.907).

> "My investigations support the opinion of Schultz and the empirical evidence of both Hopper and Welsch that in a traditional and technologically stagnant agriculture (in South India) farmers are aware of efficient use of traditional inputs" (Chennareddy, 1967, pp.819-820).

> "Other than the relatively few exceptions the bulk of evidence provided by this study (of Indian farming) appears to support the hypothesis that resources available to farmers in India have, by and large, been efficiently allocated" (Sahota, 1968, p.604).

However, Shapiro (1977) re-examined the empirical work of supporters of Schultz's hypothesis and showed that on average, the marginal value product of inputs differ by more than 40 per cent from the marginal factor costs to which they should be equated under allocative efficiency. Consequently, he came to the following conclusions:

> "The data presented and reviewed do not provide support for the hypothesis that peasant agriculture is highly efficient (allocatively and technically) and that, hence, important gains in production must rely solely on the infusion of new inputs and technologies. On the contrary, the data reveal sizeable deviations from optimal resource allocations and from the highest output/input ratios possible, given the available inputs and technologies. Thus our major conclusion is that decision makers might fruitfully increase efforts such as extension and education, which are aimed at improving the allocation and use of available resources, so that more farmers come to operate closer to the efficiency ideals now achieved by only a few. This conclusion is not intended to down-play the overwhelming importance of new inputs and technologies for developing agriculture especially in the longer runs; rather, the intention is to point out that there are observable efficiency differentials in peasant agriculture which may imply the potential for relatively inexpensive, shorter run gains in output that do not depend on major new investments or research programmes".

There is also enough empirical evidence that farm income and resource utilization can be improved through modernization of agriculture by introducing the right technology (Ruttan, 1977; Yudelman, 1971; Staub, 1973; and Sepulveda, 1979). While the importance of a new technology cannot be overemphasized, it should not be taken for granted that farmers will effectively use the technology. Many and varied constraints determine the adoption and effective use of new and improved technology by farmers in developing countries (Schultzer and Vandervan 1977).

However, little research on the economic constraints on adoption of agricultural technology has been done in developing countries. Cleave (1974) and Hellier (1975) showed the importance of seasonal labour supply/ peak labour demand constraints in African Agriculture. Therefore use of labour in peak seasons should be a key consideration in designing a technological package for small farmers (Spencer, 1976; Singh and Day, 1975).

The bulk of evidence presented here shows the possibilities of increasing net farm income through reorganisation of resources and modernization by introducing the right technology. Nevertheless, very few studies have been done in this direction in tropical and sub-tropical agriculture.

McFarquhar and Evans (1957) applied linear programming (LP) to a number of problems of varying complexity in Tropical Agriculture. The purpose was to illustrate the ramifications of the linear programming methods. They found that maximum returns were obtained by different enterprise combinations.

Desai (1961) applied linear programming techniques on Indian farming and found significant improvement in the optimal farm incomes over the actual farm incomes.

Kapur and Kahlon (1968) applied linear programming in an IADP District of India, and were able to conclude that the net returns on fixed farm resources and net farm earnings could be increased by rationalizing the farm resources use and by adopting improved production techniques in all the different-sized synthetic farm situations.

Olayide and Oluwude (1972) showed that arable farming with livestock could be as profitable, if not more profitable, than tree-crop farming in the Western state of Nigeria. They stressed that in tree-crop farming there is a need to work out a profitable combination of enterprises.

Norman (1973) used LP technique to evaluate the profitability of agricultural production and labour utilization among the Hausa of Northern Nigeria. The adjustments included reallocation of existing resources, increased products, increased labour inputs and use of new technologies, all of which tended to increase net farm income.

Dahrya (1976) examined the impact of agricultural land allocation patterns on farm incomes in the State of Haryana. He found a divergence between the actual realized incomes on the farms and those which would have been realized had the given resources been allocated optimally.

Archanga (1977) examined the impact of the Integrated Area Development (IAD) Scheme in Tasgaon Taluka Block of Sangh district. He found that the annual gross farm returns of the participants increased more than those of the non-participants by 25 per cent during the study period.

Singh (1977) examined the impact of varying levels of dairy enterprise with crop farming in the context of augmenting income and employment potential of small farmers in Patiala district (Punjab). The optimization of resources under different farm situations resulted in an increase in farm income over the existing plans.

Karam Singh (1978) examined the optimum land use pattern in the Punjab and showed that in addition to optimum resource use resulting in an increase in farm incomes, it also gave a more labour intensive operational plan.

The pioneer study in Kenya applying linear programming (LP) technique was done by Clayton (1960, 1961, 1963) in Nyeri and showed the critical importance of labour when planning for farm improvements. He concluded that when family labour is employed, labour and not land is the limiting factor of production. The family is under-employed in varying degrees, nevertheless labour is limiting from a seasonal point of view. The maximum profit situations for the family farms computed showed maximum potential, in terms of productivity and income, with particular endowment of resources. The addition of hired labour to the family farms showed an increase in net farm income. McArthur (1963) criticised the work done by Clayton as having been based on too much imagination and not enough attention to the realities of the situation.

Odero-Ogwel and Clayton (1963) used an aggregate (LP) model for Nyeri district and showed that there are distinct possibilities for increasing productivity through reorganisation of existing resources. An important finding of this study is the relatively unprofitable nature of arable crop production. The optimal plans provide a small marketable surplus of potatoes, but maize and beans remain generally at subsistence levels of production. It was concluded that it would appear that no marketable surpluses can be expected from arable food crops unless major technological innovations can be introduced.

Also the analysis of labour use in Nyeri showed that there are possibilities for increasing employment of rural labour. However, Lewis (1966) cautions about the dangers of an aggregate, quantitative approach to planning in developing countries as follows:

> "The principal danger of a macro-economic exercise has in it propensity to dazzle. The more figures there are in a plan produced by an army of professionals who have laboured mightily to make them consistent, the more persuasive the plan becomes. Attention shifts from policy to arithmetic. Consistency can be mistaken for truth. Revision is resisted. Yet the plan is not necessarily right merely because its figures are mutually consistent."

Heyer (1971) in her study of the small scale farms in Masii Location of Machakos district pointed out that labour and land are not the only critical resources likely to influence the solutions that are optimal. However, she concluded that the constraints that play a central role are labour and land. Capital is relatively unimportant in Masii farming. Heyer's work was of particular importance in demonstrating the likely patterns of crop production in changing land/labour conditions. Heyer compared three alternative production systems: a traditional system, a system with quick maturing maize, and a system with cotton. The analytical results showed that the cotton system had some improvement over traditional crops at low land/labour ratios. At high land/labour ratios quick-maturing maize represented a more significant improvement. However, the improvements in net farm income in all cases were not substantial. Heyer's study was highly commended by Belshaw and Hall (1970) for its emphasis on the fundamental error of the technical approach which stresses the maximum returns to land irrespective of the resource situation.

Nelson (1974) used linear programming to analyse all typical farm types in the main smallholder areas of Eastern Province of Kenya. He concluded that there is a need for a farm system research unit to be set up in the Ministry of Agriculture to develop a "bank" of LP farm models covering all farm types in the country.

Ateng' (1977) in his study in Makueni Location of Machakos district showed that although in many respects labour is relatively abundant there are critical tasks for which there is scarcity of planting, weeding and harvesting labour, which constitute the critical factors constraining production in most cases. Land also becomes a critical bottleneck in some cases. Availability of cash limits the number of tractor-hours or ox days a farmer can hire when he does not own tractor or oxen. Family labour supplemented with hired labour increases the expected net returns substantially.

Mukhebi (1977) while planning a cooperative farm in Nakuru district, showed that land, and labour in April and September were the tight constraints. These constraints limited the production of dairy, maize and wheat activities respectively. The study was also able to show an increase in net farm income through reallocation of resources.

Ruigu (1978) used static linear programming to analyse the economic organisation of small holder farms in Central Province of Kenya in order to determine the potential effects of resources reorganisation and increased supply of operating capital on farm income and milk supply. The LP results revealed that optimal reallocation of resources under existing technologies and prices would result in substantial increases in farm income. The increases were 17.3 per cent, 14.5 per cent, 7.2 per cent for coffee, tea and high altitude zones respectively over the initial incomes.

The reviewed literature conclusions indicate the existance of potential of increasing farm incomes through the reallocation of resources and modernization of agriculture. These conclusions form the basis of this study. The present study is unique in that it examines allocative efficiency of resources under existing and improved technologies simultaneously. So far studies done in Kenya have paid very little attention to the possibility of adjusting resources in line with opportunities arising from changes in technology.

CHAPTER THREE

METHODOLOGY

3.1. Sample and Sampling Technique

The sample frame consisting of all small-holdings[1] and their sizes in Kaloleni location was drawn from the office of the Land Registrar, Kilifi. The sample frame was stratified on the basis of size of the holdings, viz 0.2 to 4.0 hectares (small), 4.01 to 8.0 hectares (medium), and large, over 8.0 hectares. The overall total sample size taken is 30 small-holdings. The number sampled in each size group is based on the proportion of the population of holdings in each size group.

The ultimate sampling units were drawn randomly from each size group. In this way, the holdings selected were 18, 8 and 4 in small, medium and large size holdings respectively as shown in Table 3.1. The sample was stratified in order to bring holdings with almost the same resource endowment together.

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[1] In this study small holdings are defined as ones whose size falls between 0.2 to 20 hectares. Holding in this study refers to land, single parcel or several parcels associated with a household being used wholly or partially for agricultural purposes and being managed as a single economic unit under the overall control and direction of a holder.

Table 3.1. Size Groups of Small-holdings in Kaloleni Location, Kilifi District

Size-groups of small-holdings in hectares	Number	Per cent	Number sampled in each size group.
0.2-4.0	1,000	61	18
4.01-8.0	415	25	8
Over 8.0	227	14	4
Overall total	1,642	100	30

Source: Author's farm survey 1978/79.

3.2. Data Collection

The field survey was conducted from November 1978 to January 1979 immediately after the end of the long rains. Data collected refer to the 1978 season, which is the reference year of the study.

The data was collected by the single interview method. The person in charge of the holding was interviewed using a questionnaire (Appendix 1) in order to obtain the relevant data. Since the respondents in this area do not keep farm records, the answers were based on the individual's memory. In brief, the primary data obtained by the survey method include output of products, their value and the input of resources and other expense items. The author was assisted by two local agricultural extension agents (Agricultural Assistants) from the District Agricultural Office while carrying out the farm survey.

Secondary data was also collected to supplement the primary data. This was collected from the district agricultural office (District Guidelines) and Coast Agricultural Research Station , Mtwapa.

3.3. Data Collection Problems

The problems experienced in collecting farm management data are many and varied, (Norman, 1973 and

Collinson, (1972). In this study the major problems were in determining labour input and in output data collection. Difficulties arose since the respondents in most cases were the husbands, who actually are not involved with farm work, but only give directives. In such cases husbands were interviewed in the presence of their wife or wives.

Input-output data were collected by plot to estimate inputs and outputs of different enterprises (activities). The plots were identified on the basis of crop remains, since most of the annual crops had been harvested. Yields of cassava were arrived at through the estimation of the yield per cassava plant since the crop is not harvested completely.

Another problem encountered is in measuring the crop areas in the case of mixed cropping-particularly tree crops. This was solved by deriving estimates of area equivalent under different crops. Where the crop boundaries were well defined the areas were obtained without problems.

3.4. Linear Programming Model:

The profit maximization model of linear programming technique is used to find out the optimal farm plans[1] (normative solutions). The linear programming model has three components; the objective function, resource constraints and activities. According to Heady and Candler (1958) the mathematical formulation in matrix form is given as follows:-

$$\text{Maximize} \quad Z_o = \sum_{i=1}^{n} P_i X_i$$

$$\text{Subject to} \quad R_j \geq \sum_{i=1}^{n} a_{ij} X_i$$

$$x_i \geq 0$$

Where

Z_o	=	Net returns (returns to fixed farm resources)
P_i	=	Net returns from the ith activity
X_i	=	The level of the ith activity
R_j	=	Quantity available of the ith resource
a_{ij}	=	Quantity of R_j input required per unit of ith activity.

[1] An optimal farm plan has been defined as one, which under given physical, technical and resource conditions, shows what enterprises (activities) to undertake and how much land to allocate to each activity so that net farm returns (farm incomes) are maximized in an annual cycle.

The final optimal plans were given by the solution of the linear programming problem through the simplex method.

Although the objective function is very difficult to determine in a traditional or transitional agriculture, the argument is that farmers should maximize farm income if they are not to remain poor. Johnson (1969) pointed out that there is no objective proof that the subsistence sector prefers to grow its own food supplies before all other considerations. In this study, both of the objectives have been considered since farmers are aware of the market opportunities of their products existing in the nearby markets.

3.5. Constraints or Restrictions

Constraints may be classified as resource or input constraints, external constraints and subjective constraints. Mainly, resources on a farm consist of land, labour, cash or working capital required to buy inputs. The availability or otherwise of these resources act as constraints within which the feasible planning needs to be maximized. In this study land, labour, family and household food requirements constraints were incorporated in the model.

The household food requirement was calculated on the basis of calorie requirement. Requirement per average person per day was taken as 2709 calories and

68.098 grams of protein (Bohdal, 1964-1968). The total requirement per average person per year would be 988,785 calories and 24,856 grams protein. 75 per cent of the calorie requirement is supplied by cereals, tubers and roots.[1] Maize and cassava in this study were found to be the major source of calorie requirement. The major source of protein in this area is fish. On the basis that maize supplies two third and cassava one third of calorie requirements, the quantities required for different family sizes of the different size groups were calculated using Tables by Platt, 1962.

3.6. Activities in the Model

The activities in the model include crop producing and selling activities and labour hiring activity. The following are the activities which have been included in the LP Model.

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[1] Survey-Report-Kenya, Nutritional, Food Habits and Marketing Investigations with the view of determining protein in food formulations which are acceptable, marketable and economically feasible, contract AID/AFR June 1969.

Activities	Unit of Activity
Producing Copra[1]	1 ha
Producing Whole Nuts[2]	1 ha
Producing Copra & Palm-wine (toddy)[3]	1 ha
Producing Whole Nuts & Palm-wine (toddy)[4]	1 ha
Producing Cashewnuts	1 ha
Producing Citrus (oranges)	1 ha
Producing local maize	1 ha
Producing local maize and cassava	1 ha
Producing local maize/cotton	1 ha
Selling copra	1 kg
Selling Whole Nuts	1 nut
Selling Palm-wine (toddy)	1 litre
Selling Cashewnuts	1 bag
Selling Citrus (oranges)	1 pakacha[5]
Selling local maize	1 bag
Selling Cassava	1 bag
Selling Cotton	1 kg

Under improved technology (IADP) the following additional activities are incorporated in the LP model.

Producing coast composite maize/simsim	1 ha
Producing cotton	1 ha
Selling coast composite maize	1 bag
Selling simsim	1 bag
Selling programme cotton	1 kg
Hiring April labour	1 Man-hour
Hiring May labour	1 Mhr.

1,2,3 & 4 - All these activities arise from coconut crop.
5-A pakacha is a basket which is normally used for putting mangoes or citrus (oranges) in for sale. One pakacha contains about 100 oranges.

The activities incorporated in the models are the most important alternatives available to Kaloleni farmers. Livestock activities were not considered because livestock is still relatively unimportant in Kaloleni.

3.7 Farm Models

The models are developed from the synthetic holdings shown in Table 3.2. The synthetic holdings were developed by pooling and averaging all resource constraints and input-output data of the selected holdings in each size group.

Table 3.2. Synthetic holdings

Sizes of holding	Cultivable land[1] (Hectares)	Labour available for farm work (Mhrs) per year
Small	2.82 (2.8)	4233
Medium	5.95 (6.0)	5880
Large	9.88 (10.0)	6299
Aggregate	4.6	4944

Source: Author's farm survey 1978/79.

[1] Figures in brackets are approximate figures and they are the figures used in the analysis.

In order to arrive at the amount of labour available for farm work a five-hour working day and two hundred and ten farm-working days[1] in a year were used in this study. For school children and students who work only during the holiday months, April, August and December, a total of fifty farm working days was used. Farm labour from different age groups was weighted in Table 3.3. shows the different sources of farm labour. It is evident from the Table that the family household supplies nearly all the farm labour requirements.

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1 Source: Author's farm survey 1978/79.

Table 3.3. Labour: Average Number of Persons Available for Farm Work[1]

Size of Holdings	Family Labour					Permanent Labour	Casual Labour	Total Labour Available for Farm Work	Man Equivalents	Total Labour Available for Farm Work (Mhrs)
	Farmer	Wife	Adult Male	Adult Female	Children	Adult Male	Adult Female			
Small	0.2	1.7	0.66	0.94	2.4	0.1	0	6.0	5.0	4233
Medium	0.25	8.0	0.25	1.0	3.0	0.4	0	7.87	6.4	5880
Large	0.25	4.5	0.5	0	3.0	0	0	8.25	6.75	6288
Aggregate	0.2	2.43	0.53	0.83	2.6	0.17	0	6.83	5.58	4944

Source: Author's Farm Survey 1978/79

[1]Weights adopted for a small child, less than 7 years; a big child 7 - 14 years; male and female adults (15-60) years; and male and female adults 61 or more years are 0, 0.5, 1.0 and 0 man-equivalents respectively.

The input coefficients and gross margins[1] used in each LP model are identical regardless of the size of the synthetic holdings, but each has its own constraint column. The gross-margin for each enterprise (activity) is calculated by deducting variable and allocatable costs from the gross-income. The average farm gate prices are used for output and actual market prices at the place and time of application are used for inputs. In this study, the main input is family labour as Hunt (1969) found and was treated as fixed input. The gross margins for individual enterprises (activities) are shown in Table 3.4. The details of gross-margin calculations are shown in Appendix 2.

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[1]All gross margins shown in Table 3.4 and Appendix 2 were calculated as averages of individual sample farm per hectare activity data. The same gross margins for activities were applied to all groups of holdings in the analysis.

Table 3.4. Calculated Average Gross-Margins for the Various Enterprises (Activities) in Kaloleni Location

Enterprise (Activity)	Gross Margin/ Hectare (KShs)
Copra	918.60
Whole Nuts	1400.00
Copra/Palm-wine (toddy)	1400.40
Whole Nut/Palm-wine (toddy)	1821.20
Cashewnuts	680.00
Citrus (Oranges)	1650.00
Local Maize	1145.00
Maize/Cassava	1547.00
Maize/Cotton	1384.50
Coast Composite Maize/Simsim (IADP)	2995.00
Cotton (IADP)	1205.00

Source: Compiled by the author.

The labour input coeffients used in the LP models are shown in Appendix 3.

3.8 Type of farm models

The farm models considered are those which were run through the computer in order to find optimal farm plans. These models were formulated on the basis of technology and with or without household food constraints for the various synthetic holdings.

1. Under Existing Technology

1.1 Small size holding

1.1.1. Without household food constraint

1.1.2. With household food constraint

1.2. Medium size holding without or with household food constraint.

1.3. Large size holding without or with household food constraint

1.4. Aggregate holding without or with household food constraint

2. Under Improved Technology (IADP)

2.1. Small size holding

2.1.1. Without household food constraint

2.1.2. With household food constraint

2.2 Medium size holding without or with household food constraint.

2.3 Large size holding without or with household food constraint.

2.4 Aggregate holding without or with household food constraint.

3. Under Improved Technology and with relaxed constraints

3.1.1. Small size holding

3.1.2. Medium size holding

3.1.3. Large size holding

3.1.4. Aggregate holding.

3.8.1. Specific farm models under existing technology

The specific farm models under the existing technology show the present level of farm resources in the area. Land, labour and household constraints are treated as the major constraints. Land and labour constraints show the upper constraint levels, while the household food constraint showsthe lower constraint level. The specific models and their details are listed as follows:-

Model 1.1.1.	- Constraint Levels
Land available -	- 2.8 Hectares
Labour Available[1] per month	
(i) Holiday months	
April, August and December	- 427 Mhrs
(ii) other months	- 328 Mhrs.

Model 1.1.2.	
Land available	- 2.8 Hectares
Labour available per month	
(i) Holiday months	
April, August and December	- 427 Mhrs
(ii) Other months	- 328 Mhrs.
Household food requirement	
(i) Maize	- 9 bags
(ii) Cassava	- 10.8 bags.

[1] Labour available per month unless noted otherwise is farm family labour.

Model 1.2.1.

Land available - 6.0 Hectares

Labour available per month

(i) Holiday months

April, August and December - 565 Mhrs .

(ii) Other months - 465 Mhrs.

Model 1.2.2.

Land available - 6.0 Hectares

Labour available per month

(i) Holiday months

April, August and December - 565 Mhrs.

(ii) Other months - 465 Mhrs.

Household food requirement

(i) Maize - 12.4 bags

(ii) Cassava - 14.4 bags.

Model 1.3.1.

Land available - 10.0 Hectares

Labour available per month

(i) Holiday months

April, August and December - 599 Mhrs.

(ii) Other months - 499 Mhrs.

Model 1.3.2.

Land available - 10.0 Hectares

Labour available per month

(i) Holiday months

April, August and December - 599 Mhrs

(ii) Other months - 499 Mhrs.

Household food requirement

(i) Maize - 14 bags

(ii) Cassava - 16 bags

Model 1.4.1.

Land available - 4.6 Hectares

Labour available per month

(i) Holiday months

April, August and December - 487 Mhrs

(ii) Other months - 387 Mhrs

Model 1.4.2

Land available - 4.6 Hectares

Labour available per month

(i) Holiday months

April, August and December - 487 Mhrs

(ii) Other months - 387 Mhrs

Household food requirement

(i) Maize - 10.85 bags

(ii) Cassava - 12.60 bags.

3.8.2. Specific Farm Models under improved technology (IADP)

The specific farm models under improved technology (IADP) are formulated as in the case under existing technology. The same constraints - land, labour and household food constrains - are included with a few more constraints as specified in the IADP project. Under IADP models, production of cotton and coast composite maize relayed with simsim is constrained to 0.8 hectares for each activity. Hiring of labour for weeding during some months is also limited by the capital (credit) given. The specific farm models under improved technology (IADP) are listed as follows:

Model 2.1.1.	Constraint levels
Land available	- 2.8 Hectares
(i) Land required for cotton production	- 0.8 Hectares
(ii) Land required for maize/ simsim production	- 0.8 Hectares.
Labour available per month	
(i) Holiday months April, August and December	- 427 Mhrs.
(ii) Other months	- 328 Mhrs.
(iii) Hiring April labour	- 160 Mhrs.
(iv) Hiring May labour	- 160 Mhrs.

Model 2.1.2.

Land available	- 2.8 Hectares
(i) Land required for cotton production	- 0.8 Hectares
(ii) Land required for maize/ simsim production	- 0.8 Hectares.

Labour available per month

(i) Holiday months	
April, August and December	- 427 Mhrs.
(ii) Other months	- 328 Mhrs.
(iii) Hiring April labour	- 160 Mhrs.
(iv) Hiring May labour	- 160 Mhrs.

Household food requirement

(i) Maize	- 9 bags
(ii) Cassava	- 10.8 bags.

Model 2.2.1

Land available	- 6.0 Hectares
(i) Land required for cotton production	- 0.8 Hectares
(ii) Land required for maize/ simsim production	- 0.8 Hectares.

Labour available per month

(i) Holiday months	
April, August and December	- 565 Mhrs.
(ii) Other months	- 465 Mhrs.
(iii) Hiring April labour	- 160 Mhrs.
(iv) Hiring May labour	- 160 Mhrs.

Model 2.2.2.

Land available	- 6.0 Hectares
(i) Land required for cotton production	- 0.8 Hectares
(ii) Land required for maize/simsim production	- 0.8 Hectares
Labour available per month	
(i) Holiday months	
April, August and December	- 565 Mhrs.
(ii) Other months	- 465 Mhrs.
(iii) Hiring April labour	- 160 Mhrs.
(iv) Hiring May labour	- 160 Mhrs.
Household food requirement	
(i) Maize	- 12.4 bags
(ii) Cassava	- 10.8 bags.

Model 2.3.1.

Land available	- 10.0 Hectares
(i) Land required for cotton production	- 0.8 Hectares
(ii) Land required for maize/simsim production	- 0.8 Hectares.
Labour available per month	
(i) Holiday months	
April, August and December	- 599 Mhrs.
(ii) Other months	- 499 Mhrs.
(iii) Hiring April labour	- 160 Mhrs.
(iv) Hiring May labour	- 160 Mhrs.

Model 2.3.2.

Land available	- 10.0 Hectares
(i) Land required for cotton production	- 0.8 Hectares
(ii) Land required for maize/ simsim production	- 0.8 Hectares
Labour available per month	
(i) Holiday months	
April, August and December	- 599 Mhrs.
(ii) Other months	- 499 Mhrs.
(iii) Hiring April labour	- 160 Mhrs.
(iv) Hiring May labour	- 160 Mhrs.
Household food requirement	
(i) Maize	- 14 bags.
(ii) Cassava	- 14.4 bags.

Model 2.4.1

Land available	- 4.6 Hectares
(i) Land required for cotton production	- 0.8 Hectares
(ii) Land required for maize/ simsim production	- 0.8 Hectares
Labour available per month	
(i) Holiday months	
April, August and December	- 487 Mhrs.
(ii) Other months	- 387 Mhrs.
(iii) Hiring April labour	- 160 Mhrs.
(iv) Hiring May labour	- 160 Mhrs.

Model 2.4.2.

Land available	- 4.6 Hectares
(i) Land required for cotton production	- 0.8 Hectares
(ii) Land required for maize/ simsim production	- 0.8 Hectares.
Labour available per month	
(i) Holiday months	
April, August and December	- 487 Mhrs.
(ii) Other months	- 387 Mhrs.
(iii) Hiring April labour	- 160 Mhrs.
(iv) Hiring May labour	- 160 Mhrs.
Household food requirement	
(i) Maize	- 10.85 bags
(ii) Cassava	- 12.60 bags

3.8.3. Specific farm models under improved technology (IADP) and with relaxed constraints

The farm models specified in this category assume that the constraints associated with IADP are relaxed. Production of cotton and coast composite maize relayed with simsim is not constrained to 0.8 hectares for each activity. Capital is assumed to be unlimited. This means farmers can hire any amount of labour and technical crop packages can enter the optimal plans at any level determined by other constraints. The farm models are also without household food constraints. The following is a list of the specific farm models:

Model 3.1.1.

Land available	- 2.8 Hectares
Labour available per month	
(i) Holiday months	
April, August and December	- 427 Mhrs.
(ii) Other months	- 328 Mhrs.
(iii) Hiring April labour	- Unlimited Mhrs.
(iv) Hiring May labour	- Unlimited Mhrs.

Model 3.1.2.

Land available	- 6.0 Hectares
Labour available per month	
(i) Holiday months	
April, August and December	- 565 Mhrs.
(ii) Other months	- 465 Mhrs.
(iii) Hiring April labour	- Unlimited Mhrs.
(iv) Hiring May labour	- Unlimited Mhrs.

Model 3.1.3.

Land available	- 10.0 Hectares
Labour availabour per month	
(i) Holiday months	
April, August and December	- 599 Mhrs.
(ii) Other months	- 499 Mhrs.

(iii) Hiring April labour - Unlimited Mhrs.

(iv) Hiring May labour - Unlimited Mhrs.

Model 3.1.4.

Land available - 4.6 hectares.

Labour available per month

(i) Holiday months

April, August and December - 487 Mhrs.

(ii) Other months - 387 Mhrs.

(iii) Hiring April labour - Unlimited Mhrs.

(iv) Hiring May labour - Unlimited Mhrs.

3.9. Linear Programming Problem Matrix

The problem matrices were constructed for both models, under existing and improved technology. In the matrices the constraints are listed down the left hand side to form rows, and their appropriate levels are listed on the right hand side. The levels on the right hand side have the appropriate type of constraint relationship. The producing, selling and hiring of labour[1] activities form the columns of the matrices.

The information contained in the problem matrices was coded for inputs into the International Computer Limited (ICL 2950) linear programming mark 3 (LP 3) system at the Institute of Computer Science, Chiromo, University of Nairobi. The coded data were punched on computer input cards and then run through

[1]As explained under specific farm models, only IADP technology models allow for hired labour. These models are constrained in such a way that family labour would be used up before any labour is hired in the specified months.

the computer. The solutions of the programmes XDLA 21 showing optimal cropping patterns, net farm incomes and amounts of unutilized labour by activities entering the optimal plans, are given in the tables in the following Chapter.

In using LP models to obtain a determinate solution, several assumptions are made:

(a) additivity and linearity of activities;

(b) divisibility of activities and resources;

(c) fineness of alternative activities and resource restrictions and;

(d) single value expectations; that is resource supplies, input coefficients and prices are assumed to be known with certainty.

Undoubtedly LP is a very useful tool for farm planning and can answer many questions, such as what are the major constraints on the farm system; how do these constraints influence the farm systems; and what would be the result of reducing or removing some of these critical constraints. In addition, the model provides the following useful information to the extension worker and to farmers.

(1) An understanding of the enterprise relationships within a particular system of farming.

(2) Worked-out "maximum profit" situations (farm plans). These maximum profit situations show the maximum potential of a given agricultural economy.

(3) Marginal value product (shadow prices) for the limiting resources. MVPs are useful to know in the sense that they indicate the prices of limiting resources that it would be profitable to pay for extra units.

Inspite of its potential for answering many questions, the use of LP in farm planning has the following limitations:

(1) LP cannot help the farmer or manager in the difficult task of formulating price expectations. The process can only indicate the best way to use resources once a judgement has been made as to what the future prices are.

(2) LP is of little help in estimating the input-output relationships themselves.

(3) LP does not easily take into account the principle of diminishing returns although it can give it recognition by using many variations of data for a given type of activity.

(4) Activities that involve decreasing costs cannot be treated adequately with the use of simple LP.

(5) Another weakness of simple linear programming analysis lies in the rigidity of solutions. Only the pattern of producing that gives maximum returns within the specified model is emphasized. Alternatively, sub-optimal plans probably exist that may be acceptable to farmers under defined conditions.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

The results of the present study showing the existing and optimal cropping patterns, the net farm incomes, the marginal productivities of resources and the patterns of resource utilization are presented in this Chapter. The discussions are based on the different sizes of holdings operating under different technologies and constraints. This makes it possible to compare results in the existing and programmed cropping patterns.

4.1. Existing and Optimal Cropping Patterns

An important feature in most size-groups of holdings is the dominance of coconut production activity in all cropping patterns, as shown in Tables 4.1, 4.2, 4.3 and 4.4. However, the proportion of land under different enterprises (activities) varies from one size group holding to another.

In the existing cropping patterns, the propotion of land under fallow varies from 24.33 to 41.40 per cent, while the cultivated land varies from 55.19 to 69.66 per cent. The largest proportion, 23.00 to 27.92 per cent of cultivated land, is taken up by coconut, while maize and cassava mixture occupies 18.70 to 24.66 per cent.

Some other crops, although having very low gross margins per hectare, such as cashewnuts and producing coconuts and selling copra, occupy comparatively large areas. This is due to the low labour requirements of these crops but this is not consistent with profit maximization principles.

The high dominance of the proportion of land under fallow and tree crops means that restricting resources such as farm family labour are under-utilized during most months. This labour can be utilized by working out a better cropping pattern.

The programmed optimal cropping patterns for the synthetic holdings indicate that producing and selling whole nuts and limited palm-wine (toddy) activities dominate in nearly all optimal cropping patterns. This is due to the present high gross margins and low labour requirements of these activities compared to the others.

4.1.1. Small Size Holdings (2.8 hectares)

Table 4.1. shows the existing and optimal cropping patterns in the small size holdings. In the optimal plans under existing technology without and with food constraints, the whole nuts/palm-wine (toddy) producing activity increases to 2.8 and 1.6 hectares respectively.

Table 4.1. Existing and Optimal Cropping Patterns in the Small Size Holding.(2.8 ha).

Crops Enterprises (Activities)	Existing Cropping Pattern (ha)	Optimal Cropping Pattern (ha)				
		Under Existing Technology		Under Improved Technology (IADP)		
		Food without constraint Model 1.1.1.	With food constraint Model 1.1.2.	Without food constraint Model 2.1.1.	With food constraint Model 2.1.2	Relaxed Constraints and Without food constraint. Model 3.1.1.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Fallow Land	0.73	-	-	-	-	-
Coconut (Copra)	0.32	-	-	-	-	-
Coconut (Whole Nut)	0.08	-	-	-	-	-
Coconut Copra/Palm wine (toddy)	0.06	-	-	-	-	-
Coconut Whole Nut/ Palm wine (toddy)	0.11	2.8	1.6	1.2	-	1.63
Cashewnut	0.34	-	-	-	-	-
Citrus (oranges)	0.07	-	-	-	-	-
Local Maize	0.22	-	-	-	-	-

Table Cont./d.

Table 4.1 - Cont./d

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Local Maize and Cassava	0.74	-	1.2	-	1.2	-
Local maize and cotton	0.06	-	-	-	-	-
Coast composite maize and simsim	-	-	-	0.8	0.8	1.17
Cotton	-	-	-	0.8	0.8	-

Source: Author's farm survey and XDLA 21 computer printout.

With the introduction of improved technology (IADP), coast composite maize relayed with simsim and cotton producing activities enter the optimal cropping pattern each at 0.8 hectares. As a result the area under whole nuts/palm-wine producing activity increases to 1.2 hectares under improved technology and without food constraints. However, whole nuts/ palm-wine (toddy) activity does not enter the optimal plans in the case of the with-food-constraint model. This indicates that the introduction of the IADP package will conflict with the production of coconuts. Under both technologies and with food constraints, 1.2 hectares of maize/cassava activity is retained in the optimal cropping pattern for the farmer's home consumption.

The results under improved technology but without any imposed restriction, model 3.1.1., are of much interest. The results show that only whole-nuts/ palm-wine (toddy) and coast composite maize relayed with simsim producing activities enter the optimal cropping pattern. This indicates that farmers in this area, given adequate working capital and operating under the prevailing resource levels, should choose the cropping pattern shown in model 3.1.1.

4.1.2. Medium Size Holding (6.0 hectares).

Table 4.2 shows the existing and optimal cropping patterns in the medium size holdings. The area under whole nuts/palm-wine (toddy) producing activity increases to 6.0 and 4.35 hectares in the optimal plans, without and with food constraints, respectively, under existing technology.

With the introduction of improved technology (IADP), coast composite maize relayed with simsim and cotton producing activities enter the optimal cropping pattern at 0.8 hectares respectively. As a result the area under whole nuts/palm-wine (toddy) producing activity increases to 4.4. and 2.75 hectares under improved technology, without and with food constraints respectively.

Under improved technology but with no restrictions imposed, only whole-nuts/palm-wine (toddy) and coast composite maize relayed with simsim producing activities enter the optimal cropping pattern at 4.48 and 1.52 hectares respectively. When food constraint is incorporated, 1.65 hectares of maize/cassava producing activity is retained in the optimal cropping pattern for the farmer's home consumption under both technologies.

Table 4.2: Existing and optimal cropping patterns in the Medium Size Holding (6.0 ha).

Crop Enterprises (Activities)	Existing Cropping Pattern (ha)	Optimal cropping pattern (ha)				
		Under existing Technology		Under improved Technology (IADP)		
		Without food constraint Model 1.2.1	With food constraint Model 1.2.2	Without food constraint Model 2.2.1	With food constraint Model 2.2.2	Relaxed Constraints and without food constraint Model 3.1.2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Fallow land	2.55	-	-	-	-	-
Coconut (copra)	0.54	-	-	-	-	-
Coconut (whole nut)	0.75	-	-	-	-	-
Coconut copra/palm-wine (toddy)	-	-	-	-	-	-
Coconut whole nut/palm-wine (toddy)	-	6.0	4.35	4.4	2.75	4.48
Cashewnut	0.04	-	-	-	-	-
Citrus (oranges)	0.11	-	-	-	-	-
Local maize	0.15	-	-	-	-	-
Local maize and cassava	1.30	-	1.65	-	1.65	-
Local maize and cotton	0.08	-	-	-	-	-
Coast composite maize and simsim	-	-	-	0.8	0.8	1.52
Cotton	-	-	-	0.8	0.8	-

Source: Author's farm survey and XDLA 21 computer printout.

4.1.3. Large Size Holding (10.0 hectares)

The existing and optimal cropping patterns in the large size holdings are depicted in Table 4.3. The area under whole nuts/palm-wine (toddy) producing activity increases to 10.0 and 8.13 hectares in the optimal plans under existing technology, without and with food constrains, respectively.

With the introduction of improved technology (IADP), without and with food constraints considered, whole nuts and palm-wine (toddy) producing activity increases to 8.4 and 6.53 hectares respectively in the optimal plans. Under the same technology and without restrictions imposed, whole-nuts/palm wine (toddy) and coast composite maize relayed with simsim producing activities enter the optimal cropping pattern at 8.44 and 1.56 hectares respectively. When food constraints are considered in both technologies, 1.87 hectares of maize/cassava activity is retained in the optimal cropping for the farmer's consumption.

Table 4.3: Existing and Optimal Cropping Patterns in the Large Size Holdings (10.0 ha).

Crop Enterprise (activities)	Existing cropping pattern (ha)	Optimal Cropping Pattern (ha)				
		Under Existing Technology		Under Improved Technology (IADP)		
		Without food constraint Model 1.3.1	With food constraint Model 1.3.2.	Without food constraint Model 2.3.1	With food constraint Model 2.3.2.	Relaxed constraints and without food constraint Model 3.1.3
Fallow Land	4.08	-	-	-	-	-
Coconut (copra)	1.70	-	-	-	-	-
Coconut (whole nut)	0.73	-	-	-	-	-
Coconut copra/palm-wine (toddy)	-	10.00	8.13	8.4	6.53	8.44
Coconut whole nut/palm-wine (toddy)	1.45	-	-	-	-	-
Cashewnut	-	-	-	-	-	-
Citrus (oranges)	-	-	-	-	-	-
Local maize	1.9	-	1.87	-	1.87	-
Local maize and Cassava	-	-	-	-	-	-
Local maize & cotton	-	-	-	0.8	0.8	1.56
Coast composite maize and simsim	-	-	-	0.8	0.8	-
Cotton	-	-	-	-	-	-

Source: Author's farm survey and XDLA 21 computer printout.

4.1.4. Aggregate Holding (4.6 hectares)

Table 4.4. shows the existing and optimal cropping patterns in an aggregate holding. This holding, being an aggregate one, reflects the overall cropping pattern behaviour. The area under whole nuts/palm-wine (toddy) producing activity increases to 4.6 and 3.15 hectares in the optimal plans under existing technology, without and with food constraint, respectively.

With the introduction of improved technology (IADP), without and with food constraints, whole nuts/palm-wine (toddy) producing activity increases to 3.0 and 1.55 hectares respectively in the optimal plans. Under the same technology and without restrictions imposed, whole-nuts/palm-wine (toddy) and coast composite maize relayed with simsim producing activities enter the optimal cropping pattern at 3.28 and 1.32 hectares respectively. When food constraint is considered in both technologies, 1.45 hectares of maize/cassava producing activity is retained in the optimal cropping patterns.

Table 4.4. Existing and Optimal Cropping Patterns in the Aggregate Holding (4.6 ha).

Crop Enterprises (Activities)	Existing Cropping Pattern (ha)	Optimal Cropping Pattern (ha)				
		Under existing technology		Under imrpoved technology IADP		
		Without food constraint Model 1.4.1	With food constraint Model 1.4.2	Without food constraint Model 2.4.1	With food constraint Model 2.4.2	Without food constraint and government restrictions Model 3.1.4
Fallow Land	1.67	-	-	-	-	-
Coconut (copra)	0.56	-	-	-	-	-
Coconut (whole nut)	0.25	-	-	-	-	-
Coconut copra/palm-wine (toddy)	0.14	-	-	-	-	-
Coconut whole nut/palm wine (toddy)	0.07	4.6	3.15	3.0	1.55	3.28
Cashewnut	0.41	-	-	-	-	-
Citrus (oranges)	0.07	-	-	-	-	-
Local maize	0.07	-	-	-	-	-
Local Maize and cassava	1.05	-	1.45	-	1.45	-
Local maize and cotton	0.03	-	-	-	-	-
Coast composite maize and simsim	-	-	-	0.8	0.8	1.32
Cotton	-	-	-	0.8	0.8	-

Source: Author's farm survey and XDLA 21 computer printout.

4.2. Stability Limits for the Optimal Plans

Linear programming technique (LP) in addition to showing optimal plans can also show the right hand-side and objective ranging for the optimal plans. Objective-ranging defines the limits for individual activity price and cost coefficients under 'ceteris paribus' conditions, within which activity and slack resource variables and their values appearing in the optimal basis all remain the same. This implies that when activity price and cost coefficient limits are exceeded, activity and resource variables and values already in the optimal basis can change. The lower and upper limits of the objective value represent the range beyond which the optimal basis can change. When the basis changes the shadow prices of resources can change.

Objective-ranging, defining the stability limits for the aggregate optimal plans is the only case discussed because of space limitation. Right-hand-side ranging of resources which also defines the conditions for stability of the optimal basis can also be shown. The abbreviations used in Tables 4.5, 4.6, 4.7, 4.8 and 4.9 are given in full in Appendix 4.

Tables 4.5 and 4.6 illustrate the stability limits for the models 1.4.1 and 1.4.2. optimal bases under the existing technology. Considering whole-nuts/ palm-wine (toddy) producing activity in the model 1.4.1 optimal basis (Table 4.5), after the negative gross margin (variable costs)[1] at the lower limit increases from KShs.100.00 to KShs.271.20, the citrus (orange) producing activity would come into the optimal plan. At the upper limit, if the negative gross margins for the whole nuts/palm-wine (toddy) producing activity changes to plus infinity, there would be no change in the optimal plan. This indicates that whole nuts/palm-wine (toddy) production in the optimal plan is very stable. In model 1.4.2. optimal basis (Table 4.6), producing whole nuts/palm-wine (toddy) activity changes as explained in Table 4.5. Considering maize/cassava producing activity, the base plan remains unchanged from minus infinity to plus infinity variable costs, because certain minimum household food requirement must be produced. Similar interpretations can be made with respect to the results for other variables.

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[1]Negative gross margins for production activities are simply the assessed variable cost totals. Ranging of coefficients in the objective function involves negative gross margins for production and buying activities and positive gross margins for selling activities.

Table 4.5: Stability Limits for the Model 1.4.1. Optimal Basis

Activity	Objective Value	Lower limit of Objective Value	Incoming at Lower Limit	Upper Limit of Objective Value	Incoming at Upper Limit
PRODND	-100.00	-271.0	PRODCR	+ infinity	
HVSLWN	0.40	0.35	PRODCR	+ infinity	
TPSLTD	0.35	0.25	PRODCR	+ infinity	

Source: XDLA 21 computer printout.

Table 4.6: Stability Limits for the Model 1.4.2. Optimal Basis

Activity	Objective Value	Lower Limit of Objective Value	Incoming at Lower Limit	Upper Limit of Objective Value	Incoming at Upper Limit
PRODND	-100.00	-271.20	PRODCR	+ infinity	
PRODMC	-163.00	-Infinity		+ infinity	
HVSLWN	0.40	0.35	PRODCR	+ infinity	
TPSLTD	0.35	0.25	PRODCR	+ infinity	
SELLCV	24.00	0	PRODMC	+ infinity	

Source: XDLA 21 computer printout.

Tables 4.7 and 4.8 illustrate the stability limits for the models 2.4.1 and 1.4.2 optimal bases under improved technology (IADP). Considering whole-nuts/palm-wine (toddy) producing activity in the model 2.4.1 optimal basis (Table 4.7) at the lower limit, after an increase in variable costs from KShs.100.00 to KShs.271.20, the citrus (orange) producing activity would come into the optimal plan. At the upper limit, if the negative gross margin for the whole nuts/palm-wine (toddy) producing activity changes to plus infinity, there would be no change in the optimal plan. Considering cotton and composite maize relayed with simsim producing activities, the base plan remains unchanged from minus infinity to plus infinity variable costs. This is because certain amounts of cotton, maize and simsim must be produced as specified in the IADP. In Table 4.8 the model 1.4.2 optimal basis indicates the changes in the base plan which occur. Similar interpretations can be made for the activities in this base plan as for the base plan in Table 4.7.

Table 4.7: Stability Limits for the Model 2.4.1. Optimal Basis

Activity	Objective Value	Lower limit of Objective Value	Incoming at Lower Limit	Upper Limit of Objective Value	Incoming at Upper Limit
PRODND	-100.00	-271.20	PRODCR	+ infinity	
PRODCT	-1275.00	-infinity		+ infinity	
PRODMS	-1475.00	-infinity		+ infinity	
HVSLWN	0.40	0.35	PRODCR	+ infinity	
TPSLTD	0.35	0.25	PRODCR	+ infinity	
SELLPT	3.10	0	PTPRD	+ infinity	
SELLCM	85.00	0	CMPRD	+ infinity	
SELLSM	240.00	0	SMPRD	+ infinity	

Source: XDLA 21 computer printout.

Table 4.8 : Stability Limits for the Model 2.4.2 Optimal Basis

Activity	Objective Value	Lower Limit of Objective Value	Incoming at Lower Limit	Upper Limit of Objective Value	Incoming at Upper Limit
PRODND	-100.00	-271.20	PRODCR	+ infinity	
PRODMC	-163.00	-infinity		+ infinity	
PRODCT	-1275.00	-infinity		+ infinity	
HVSLWN	0.40	0.35	PRODCR	+ infinity	
TPSLTD	0.35	0.25	PRODCR	+ infinity	
SELLCV	24.00	23.74		+ infinity	
SELLPT	3.10	0	PTPRD	+ infinity	
SELLCM	85.00	0	CMPRD	+ infinity	

Source: XDLA 21 computer printout

Table 4.9 illustrates the stability limits for model 2.1.4 optimal basis under improved technology but with relaxed constraints. Considering whole nuts/ palm-wine toddy producing activity, after an increase in variable costs at the lower limit from KShs.100.00 to 271.20, the citrus (oranges) producing activity would come into the optimal plan. At the upper limit, after the negative gross margin for the whole nuts/palm-wine (toddy) producing activity changes from KShs.100.00 to KShs.1073.80, more August labour would be utilised for producing whole nuts and palm-wine (toddy). At the lower limit, considering composite maize relayed with simsim producing activity, after an increase in variable costs from KShs.1475.00 to KShs.2648.80 August labour would be released from composite maize relayed with simsim producing activity for some other uses. Similar interpretations can be made with respect to the results for other variables in the base plan.

Table 4.9: Stability Limits for the Model 2.1.4. Optimal Basis

Activity	Objective Value	Lower Limit of Objective Value	Incoming at Lower Limit	Upper Limit of Objective Value	Incoming at Upper Limit
PRODND	-100.00	-271.20	PRODCR	1073.80	AUGL
PRODMS	-1475.00	-2648.80	AUGL	40731.68	PRODCT
HPSLCP	1.90	0	CPPRD	2.80	PRODCD
HVSLWN	0.40	0.35	PRODCR	0.76	AUGL
TPSLTD	0.35	0.25	PRODCR	1.02	AUGL
HVSLCS	130.00	0	CSPRD	320.20	PRODCS
HVSLCR	6.00	0	CSPRD	6.57	PRODCR
SELLCV	24.00	0	CVPRD	38.77	PRODMC
SELLMZ	100.00	0	MZPRD	178.80	PRODMC
SELLCT	1.93	0	CTPRD	5.94	PRODCT
SELLPT	3.10	0	PTPRD	3.85	PRODCT
SELLCM	85.00	45.87	AUGL	1491.89	PRODCT
SELLSM	240.00	93.28	AUGL	5515.84	PRODCT

Source: XDLA 21 computer printout.

4.3. Comparative Net Farm Incomes

4.3.1. Small Size Holding (2.8 hectares)

Table 4.10 presents net farm income yielded by the optimal allocation of existing scarce farm resources in small size holdings under different technologies and constraints.

In all models, there is an increase in net farm income over the existing plan, resulting from optimal re-organization of existing farm resources under both technologies. Under the existing technology, net farm income increased by 107 and 46 per cent without and with food constraints respectively. Under improved technology (IADP) net farm income increased by 125 and 61 per cent without and with food constraint respectively. The highest increase of 163 per cent in net farm income is observed in model 3.1.1. Although the introduction of Integrated Agricultural Development Programme (IADP) resulted in a further increase in net farm income, the increase over optimal plans under existing technology without and with food constraint is only by 9 and 10 per cent respectively.

Table 4.10: Net Farm Incomes on the Small Size Holding

Particulars	Existing Plan	Optimal Plans Under				
		Existing Technology		Improved Technology		(IADP)
		Model 1.1.1.	Model 1.1.2.	Model 2.1.1.	Model 2.1.2.	Model 3.1.1
1. Net farm income[1] KShs.	2461	5099	3611	5545	3972	6477
2. Additional net farm incomes over existing plans KShs.	-	2638	1150	3084	1511	4016
3. Percentage increase in net farm income	-	107	46	125	61	163
4. Additional net farm income over optimal plans under existing technology and same constraints KShs.	-	-	-	446	361	-
5. Percentage increase in net farm income	-	-	-	9	10	-

Source: Author's calculations and XDLA 21 computer printout.

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[1]Net farm income is being used as total gross margin (Net family Farm Income) since it is not easy to cost the family labour which is the main fixed input.

4.3.2. Medium Size holding (6.0 hectares)

As a result of re-organization of existing farm resources under both technologies an increase in net farm income occurs. The net farm income in medium size holdings increased by 170 and 120 per cent under existing technology without and with food constraints respectively, (Table 4.11). Under improved technology (IADP) the increase is by 181 and 144 per cent without and with food constraint respectively. The highest increase of 214 per cent in net farm income is observed in Model 3.1.2. The introduction of the Integrated Agricultural Development Programme (IADP) made an increase in net farm income over optimal plans under existing technology, without and with food constraints, of 4 and 11 per cent respectively.

4.3.3. Large Size Holding (10.0 hectares)

The results of the various plans presented in Table 4.12 indicate substantial increases in net farm incomes as a result of optimal allocation of farm resources.

Table 4.11: Net Farm Incomes on the Medium Size Holdings

Particulars	Existing Plan	Optimal Plans Under				
		Existing Technology		Improved Technology		(IADP)
		Model 1.2.1	Model 1.2.2	Model 2.2.1	Model 2.2.2	Model 3.1.2
1. Net Farm Income KShs.	4048	10927	8888	11373	9885	12711
2. Additional net farm incomes over existing plan KShs.	-	6879	4840	7325	5837	8663
3. Percentage increase in net farm incomes	-	170	120	181	144	214
4. Additional net farm income over optimal plans under existing technology and same constraints KShs.	-	-	-	446	997	-
5. Percentage increase in net farm income KShs.	-	-	-	4	11	-

Source: Author's calculations and XDLA 21 Computer Printout.

Table 4.12: Net Farm Incomes on the Large Size Holding

Particulars	Existing Plan	Optimal Plans Under: Existing Technology		Improved Technology		(IADP)
		Model 1.3.1	Model 1.3.2	Model 2.3.1	Model 2.3.2	Model 3.1.3
1. Net Farm Income KShs	6509	18212	15916	18658	16325	20043
2. Additional net farm income over existing plan KShs.	-	11703	9407	12149	9815	13534
3. Percentage increase in net farm income KShs.	-	180	145	187	151	208
4. Additional net farm income over optimal plans under existing technology and same constraints KShs.	-	-	-	446	408	-
5. Percentage increase in net farm income KShs.	-	-	-	2	3	-

Source: Author's calculations and XDLA 21 computer printout.

The net farm income increased by 180 and 145 per cent, without and with food constraints respectively, under programmed existing technology over the existing plan. Under improved technology (IADP), the increases are by 187 and 151 per cent without and with food constraints respectively. However, the increases in net farm income of optimal plans under improved technology over optimal plans under existing technology are only by 2 and 3 per cent, without and with food constraint respectively. As in the other optimal plans, Model 3.1.3 shows the highest increase in net farm income of 208 per cent.

4.3.4. Aggregate holding (4.6 hectares)

Table 4.13, shows the results on an aggregate holding. There is a similar trend in increase in net farm incomes on the optimal plans over existing plans as in other size group of holdings. Net farm incomes on the optimal plans under existing technology increase by 143 and 92 per cent without and with food constraint respectively over the existing plan. The increase under improved technology is by 156 and 103 per cent without and with food constraint respectively, while in Model 3.1.4, the increase is 188 per cent. The optimal plans under improved technology and without and with food constraints result in 5 and 6 per cent increases in net farm income over optimal plans under existing technology respectively.

Table 4.13: Net Farm Incomes on the Aggregate Holdings

Particulars	Existing Plan	Optimal Plans Under				
		Existing Technology		Improved Technology		(IADP)
		Model 1.4.1	Model 1.4.2	Model 2.4.1	Model 2.4.2	Model 3.1.4
1. Net farm Income KShs.	3443	8378	6593	8824	6979	9925
2. Additional net farm income over existing plan KShs.	-	4935	3151	5381	3536	6482
3. Percentage increase in farm income KShs.	-	143	92	156	103	188
4. Additional net farm incomes over optimal plans under existing technology and same constraints	-	-	-	446	386	-
5. Percentage increase in net farm income	-	-	-	5	6	-

Source: Author's calculations and XDLA 21 computer printout.

In conclusion, the net farm incomes presented and discussed for all size-groups of holdings under different technologies and constraints indicate a substantial increase in the optimal plans over existing plans. The highest potential increase in farm income exists in the large size-group of holdings. However, the highest potential exists, under improved technology and with no restrictions imposed in all size-groups of holdings. The results therefore support the hypothesis formulated, that the current level of resource productivity and farm income in Kaloleni location is below what can be achieved within the present resource constraints that is the resource use is sub-optimal. The proposed technical crop package of input recommendations under IADP will also increase farm income.

4.4. Costs of Forcing Non-Optimal Activities into the Optimal Plans (Aggregate Holding 4.6 hectares)

Table 4.14 shows, for each activity not selected for inclusion in the optimal plan, how much the total gross-margin of the optimal plan would be reduced by forcing in one unit of an activity. The higher the cost the lower the competitive position of the activity. The LP results, Table 4.14, show that the cost of forcing cashewnuts into all optimal plans with the exception of the optimal plan of model 2.4.1 would reduce total gross margins by KShs.1141.20. In the optimal plan of model 2.4.1, forcing copra production has the highest cost and reduces the total gross margin by KShs.902.80.

Table 4.14: Costs of Forcing Non-Optimal Activities into the Optimal Plans (Aggregate Holding 4.6)

Column information (activities)	Costs (KShs) Under				
	Existing Technology		Improved Technology		(IADP)
	Model 1.4.1	Model 1.4.2	Model 2.4.1	Model 2.4.2	Model 3.1.4
Producing copra	-902.80	-902.80	-902.80	-902.80	-902.80
Producing whole nuts	-421.20	-421.20	-421.20	-421.20	-421.20
Producing copra and palm-wine (toddy)	-420.70	-420.70	-420.70	-420.70	-420.70
Producing whole nuts & palm-wine (toddy)	0	0	0	0	0
Producing cashewnut	-1141.20	-1141.20	-11	-1141.20	-1141.20
Producing citrus (oranges)	0	-171.20	-171.20	-171.20	-171.20
Producing local maize	-237.48	-237.48	-676.20	-16.48	-992.99
Producing local maize and cassava	0	0	-274.20	0	-590.99
Producing cotton under the programme	-162.50	-162.50	-436.70	-158.50	-753.49
Producing coast composite maize & simsim	-	-	0	0	0
Harvesting, processing & selling copra	0	0	0	0	0
Harvesting and selling toddy	0	0	0	0	0
Tapping and selling palm-wine (toddy)	0	0	0	0	0
Harvesting and selling cashewnuts	0	0	-190.20	0	0
Harvesting and selling citrus (oranges)	-0.57	0	0	0	0
Selling local maize	-36.56	-36.56	0	-77.89	0
Selling cassava	0	0	0	0	0
Selling cotton under the programme	-	-	-	-	-
Selling coast composite maize	-	-	0	0	0
Selling simsim	-	-	-1.00	0	-1.00
Labour, April hiring	-	-	0	0	-1.00
Labour, May hiring	-	-	0	0	-1.00

For the other optimal plans based on small, medium and large size holdings, reduced costs are not tabulated because of space limitation. However, it suffices to discuss the results. Under existing technology and without and with food constraints, the LP results show that the cost of forcing cashewnuts into the optimal plans based on small and medium size holding is also KShs.1141.20. For the optimal plans based on large size holding copra production has the highest cost and reduces the gross margin by KShs.902.80. Under improved technology (IADP) and with food constraint, forcing cashewnuts into the optimal plans under discussion has also the highest cost of KShs.1141.20. On the other hand, for the optimal plans without household food requirement forcing copra production has the highest cost of KShs.902.80. Under improved technology but without imposed restrictions (constraints), forcing cashewnut production into optimal plans based on small size-holding shows the highest cost. Copra production has the highest cost in optimal plans based on medium and large size holdings.

The indicated costs are very important because the gross margins for cashewnuts and copra producing and selling activities must be increased by KShs. 1141.20 and 902.80 respectively in order for them to become profitable (competitive) enough to be indluded in the optimal plans. In other words, farmers in Kaloleni location lose KShs.1141.20 or 902.80 per hectare by growing and selling cashewnuts or coconut (copra).

4.5. Marginal Value Productivities of Resources

The marginal value products (MVPs) or shadow prices indicate the productivity of resources at the margin on the farm. They show the amounts of increase or reduction in the total gross margins that would occur if one unit more or one unit less of a resource were used, all other constraints and activities in the optimal plans remaining constant. In linear programming, only limiting resources in the optimal plan take positive MVPs. Resources that are non-limiting (slack) in the optimal plans take on zero MVPs.

The marginal value product (Table 4.15) of a hectare of land in all the optimal plans under existing technology models remained constant at KShs.1821.20, while the marginal value product (MVP) of labour on the same optimal plans remained zero. This indicates that land and not labour is the most limiting constraint in increasing farm incomes in all size-groups of holdings.

Under improved technology (IADP), the marginal value product of a hectare of land for nearly all optimal plans also remained at KShs.1821.20. The

Table 4.15: Marginal Value Products (MVPs) for all Optimal Plans Under Both Technologies and Various Constraints

Row Information (Constraints)	SMALL					MEDIUM					LARGE					AGGREGATE				
	Under Existing Technology		Under Improved Technology			Under Existing Technology		Under Improved Technology			Under Existing Technology		Under Improved Technology			Under Existing Technology		Under Improved Technology		
	Model 1.1.1	Model 1.1.2.	Model 2.1.1.	Model 2.1.2	Model 3.1.1.	Model 1. 2.1	Model 1.2.2	Model 2.2.1	Model 2.2.2	Model 3.2.1	Model 1.3.1	Model 1.3.2	Model 2.3.1	Model 2.3.2	Model 3.3.1	Model 1.4.1	Model 1.4.2	Model 2.4.1	Model 2.4.2	Model 3.4.1
Land	1821.20	1821.20	1821.20	1811.20	1804.53	1821.20	1821.20	1821.20	182120	180453	1821.20	1821.20	1821.20	181620	180453	182.20	1821.20	1821.20	1811.20	180453
January Labour	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February "	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
March "	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
April "	0	0	0	1.00	0	0	0	0	0	0	0	0	0	1.00	0	0	0	0	1.00	0
May "	0	0	0	1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00	0
June "	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July "	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August "	0	0	0	0	3.33	0	0	0	0	3.33	0	0	0	0	3.33	0	0	0	0	3.33
September "	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October "	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov. "	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec. "	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hiring " April	-	-	0	0	0	-	-	0	0	0	-	-	0	0	0	-	-	0	0	0
Hiring Labour. May	-	-	0	0	0	-	-	0	0	0	-	-	0	0	0	-	-	0	0	0

Source: XDLA 21 Computer Printout.

exceptions are models 2.1.2, 2.4.2 and 2.3.2. optimal plans, where it dropped to KShs.1811.20 and KShs. 1816.20 respectively. As regards the marginal value product of labour, it remained zero except in the Models 2.1.2, 2.4.2 and 2.3.2 optimal plans, where it is hired at KSh. 1.00 per man-hour in the months of April and May. This indicates that besides land, April and May family labour will be constraining in the models. Finally the marginal value product on a hectare of land for optimal plans of models 3.1.1, 3.2.1, 3.3.1, and 3.4.1 remained KShs.1804.53, while for labour it is zero for all other months, except in August, where it is KShs.3.33 per man-hour. This means that August labour is limiting and must be hired.

Since the marginal value products or shadow prices indicate the productivities of resources, they should be compared with the marginal costs of the resources. Although renting or buying of land is uncommon in Kaloleni location, the high marginal value product of about KShs.1800.00 would represent a substantial return by a farmer renting or buying an additional unit of land.

4.6 Pattern of Resource Utilization

4.6.1. Small Size Holding (2.8 hectares)

Table 4.16 explains that 0.73 hectares of land remained unutilized in the existing plan, while for all optimal plans land was utilized completely.

Table 4.16 Distribution of Unutilized Resources in the Small Size Holding (2.8 hectares)

Resources	Existing Plan	Optimal Plans Plans				
		Existing Technology		Improved Technology		(IADP)
		Model 1.1.1	Model 1.1.2	Model 2.1.1	Model 2.1.2	Model 3.1.1
Land (ha)	0.73	0	0	0	0	0
January Labour (Mhrs)	293	314	320	322	328	320
February Labour "	213	314	190	322	198	320
March Labour "	127	314	124	238	49	253
April Labour "	234	413	185	181	0	184
May Labour "	192	314	170	106	0	132
June Labour "	291	314	320	158	164	179
July Labour "	323	314	320	274	280	320
August Labour "	320	413	299	132	21	0
September Labour "	240	314	260	242	188	203
October Labour "	323	314	320	322	328	320
November Labour "	287	314	320	26	32	203
December Labour "	341	413	419	133	139	313
Total unutilized "	3184 (75.22)	4065 (96.03)	3247 (76.71)	2456 (58.02)	1727 (40.80)	2747 (64.89)
Hired April Labour (Mhrs)				160	133	160
Hired May Labour "				160	122	160

Figures in parentheses are percentages.

Source: Authors farm survey and XDLA 21 printout.

Farm labour is completely utilized only during the months of April, May and August in the optimal plans under improved technology with food constraint and without imposed restrictions respectively. The optimal plans with food constraint provide better opportunity for labour utilization in most of the periods. Some hired labour is also utilized.

The total unutilized labour decreased from 75.22 per cent in the existing plan to 40.80 per cent in the optimal plan under improved technology and with food constraint. The optimal plans under existing technology do not improve labour utilization over the existing plans.

4.6.2. Medium Size Holding (6.0 hectares)

Table 4.17 indicates that 2.55 hectares of land remained unutilized in the existing plan, but completely utilized in the optimal plans. Farm labour is completely utilized only during August under the improved technology and without imposed restrictions. The optimal plan under improved technology and with food constraint provides better oppotunity for labour utilization. The lowest total percentage of 52.67 of unutilized farm labour appears in the optimal plan under improved technology and with food constraint.

Table 4.17: Distribution of Unutilized Resources in the Medium Size Holding (6.0 hectare)

Resources	Existing Plan	Optimal Plans Under				
		Existing Technology		Improved Technology		(IADP)
		Model 1.2.1	Model 1.2.2	Model 2.2.1	Model 2.2.2	Model 3.1.2
Land (ha)	2.55	0	0	0	0	0
January Labour (Mhrs)	454	435	443	449	449	443
February Labour	293	435	265	443	319	443
March Labour	157	435	173	360	170	356
April Labour	268	535	221	303	75	239
May Labour	263	435	237	227	83	199
June Labour	404	435	443	279	285	260
July Labour	458	435	443	395	401	443
August Labour	405	535	378	257	143	0
September Labour	327	435	361	363	309	391
October Labour	458	435	443	443	449	443
November Labour	446	435	443	146	153	291
December Labour	491	543	543	355	261	406
Total unutilized Labour	4424 (75.24)	5528 (94.01)	4393 (74.71)	3914 (66.56)	3097 (52.67)	3814 (64.86)
Hire April Labour				160	160	160
Hire May Labour				160	160	160

Figures in parentheses are percentages.

Source: Author's farm survey and XDLA 21 computer printout.

4.6.3: Large Size Holding (10.0 hectares)

Table 4.18 shows that 4.08 hectares of land remained unutilized in the existing plan in the large size holding. All land is completely utilized in the optimal plans. Farm labour is completely utilized in April and August in the optimal plans with food constraint and without imposed restrictions respectively. Some hired labour is utilized in April under improved technology and with food constraint.

The total unutilized labour decreased from 56.30 per cent in the existing plan to 45.29 per cent in the optimal plan under improved technology and with food constraint. The optimal plans under existing technology do not provide better opportunity for labour utilization over the existing plan.

4.6.4. Aggregate Holding (4.6 hectares)

The results of aggregate holding repeat the same pattern of results as explained in the previous holdings (Table 4.19). Unutilized land is 1.67 hectares in the existing plans. The total lowest unutilized labour of 43.22 per cent is in the optimal plan under improved technology and with food constraint.

Table 4.18: Distribution of Unutilized Resources in the Large Size Holding (10.0 hectares)

Resource	Existing Plan	Optimal Plans Under				
		Existing Technology		Improved Technology (IADP)		
		Model 1.3.1	Model 1.3.2	Model 2.3.1	Model 2.3.2	Model 2.1.3
Land (ha)	4.08	0	0	0	0	0
January Labour (Mhrs)	356	449	458	457	466	457
February Labour "	274	449	257	457	265	457
March Labour "	0	449	154	374	79	368
April Labour "	209	549	194	317	0	245
May Labour	242	449	225	241	17	207
June Labour "	210	449	458	293	302	207
July Labour "	480	449	458	409	418	457
August Labout "	390	549	372	271	94	0
September Labour "	215	449	365	377	293	301
October Labour "	480	449	456	457	466	457
November Labour "	356	449	458	161	466	461
December Labour "	228	549	458	269	278	416
Total Unutilized (Mhrs)	3540 (56.30)	5688 (90.46)	4315 (68.10)	4083 (64.93)	2848 (45.29)	3936 (62.60)
Hire April Labour (Mhrs)				160	160	160
Hire May Labour "				160	122	160

Figures in parenthese's are percentages

Source: Author's farm survey and XDLA 21 computer printout.

Table 4.19: Distribution of Unutilized Resources in the Aggregate Holding (4.6 hectares)

Resource	Existing Plans	Optimal Plans Under: Existing Technology Model 1.4.1	Existing Technology Model 1.4.2	Improved Technology Model 2.4.1	Improved Technology Model 2.4.2	(IADP) Model 3.1.4
Land (ha)	1.67	0	0	0	0	0
January Labour (Mhrs)	344	364	371	372	379	371
February Labour "	244	364	215	372	223	371
March " "	121	264	135	289	360	295
April " "	243	464	189	232	0	207
May " "	222	364	190	156	0	160
June " "	323	364	371	208	215	212
July " "	379	364	371	324	331	371
August " "	354	464	327	186	49	0
September " "	260	364	299	292	227	239
October " "	379	364	371	372	379	371
November " "	341	364	371	76	83	239
December " "	368	464	471	184	191	352
Total unutilized Labour	3580 (72.41)	4668 (94.41)	3682 (74.47)	3063 (61.95)	2137 (43.22)	3188 (64.48
Hired April Labour (Mhrs)				160	160	160
Hired May Labour "				160	142	160

Figures in parentheses are percentages

Source: Author's farm survey and XDLA 21 printout.

In conclusion, the pattern of resources utilization on all size groups of holdings indicates that land utilization in the optimal plans under both technologies and constraints improves over the existing plans. As regards labour utilization, only optimal plans under improved technology result in improvement in farm labour utilization over the existing farm plans. Optimal plans under existing technology and constraints do not improve farm labour utilization. This is because of the dominance of whole-nuts/palm-wine (toddy) producing activity in the optimal plans, whose labour requirement is small. The improvement in farm labour utilization in the optimal plans under improved technology is highest in small and aggregate size holdings (Tables 4.16 and 4.19). This shows that farm labour utilization can be improved by introducing improved technology (IADP) in Kaloleni location particularly on small-size holdings.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

5.1. Summary and Conclusions

The problem of increasing agricultural productivity and farm income needs to be tackled in many ways. This study has shown some of the means in which agricultural productivity can be increased particularly in Kaloleni location of Kilifi district. Two major means have been demonstrated. Firstly, by re-organisation of existing resources so as to achieve a better use of the resources available to the farmer, and secondly, by introducing new farming practices through the Integrated Agricultural Development Programme (IADP). The static linear programming technique has been used in both cases on synthetic holdings. Although the present farming system in the area is homogeneous, differences within the system are noticeable. These include the individual farmer's choice of products, the proportion in which the resources are combined and the productivity of the resources.

The data used for analysis and programming was obtained by a farm survey conducted from November, 1978 through to the end of January, 1979. The sample frame was stratified on the basis of the size of holdings, viz 0.2 to 4.0 hectares (small), 4.01 to 8.0 hectares (medium), and large, over 8.0 hectares. A sample size of 30 holdings was on a proportional basis, distributed among the size groups. Finally, the ultimate sampling units were drawn randomly from each size group. The primary data was supplemented by secondary data collected from District Guidelines and the Coast Agricultural Research Station, Mtwapa. Data collected cover the 1978 agricultural year. Therefore, the subsequent analysis and results reflect 1978 agricultural year.

The method used for the analysis of data collected involves enterprise analysis to show the gross margins for the various enterprises, and farm analysis in order to show the present net farm income. Finally LP as a planning technique is used to determine optimal farm plans which would result in maximization of net farm income and greater farm labour employment generation.

The analysis of this study shows interesting results which can lead to various conclusions and policy implications. The analysis of the present resource use shows that the proportion of cultivated land varies from 24.33 to 41.40 per cent. From these results it can be concluded that the degree of intensification is low. Coconut production and maize-cassava mixture take the largest proportions, 23 to 27.92 per cent, 18.7 to 24.66 per cent respectively, of the cultivated land.

Coconunt, therefore, is the major source of income for all farmers, while maize and cassava provide subsistence requirement. As regards labour, an average of 4944 manhours per year are available for farm work and an average of 27.59 per cent of the available farm labour is used under the existing farm plans and technology.

The present resource productivity is very low as indicated by the present net farm income in the range of KShs.2461.40 and KShs.6509.20. The low gross margins of the various enterprises is due to poor husbandry techniques being practised and lack of application of modern farming techniques.

The linear programming (LP) results show that under existing cropping patterns, farm resources are not utilized optimally on small holdings of all sizes in Kaloleni. This indicates that there is a substantial potential for increasing farm income within the existing resource supplies and the present technical knowledge of the farmers. This supports the contention that there is sub-optimal use of resources in Kaloleni location. However, the potential for increasing farm incomes varied from one size-group of holding to another under different constraints. The highest potential for increasing farm income occurs in the large size holdings in comparison to other size of holdings. On the other hand, there is no improvement in farm labour utilization in the optimal plans under existing technology over existing plans.

The results of the linear programming (LP) also indicate that the introduction of the Integrated Agricultural Development Programme (IADP) can increase farm income and employment on the small-holdings. In the aggregate holding, programmed labour utilization is 38.05 and 56.18 per cent without and with food constraint respectively. This is a greater improvement in labour utilization over the existing plan. The results also show that producing coconut and selling whole nuts and palm-wine (toddy) activities entered all the optimal plans except in the case of small sized holdings under improved technology (IADP) and without food constraints.

The LP results therefore indicate that those farmers who produce coconut and sell copra would do better by selling whole nuts and a limited amount of palm-wine (toddy). Although palm-wine (toddy) is very profitable, the market is limited and it is highly perishable.

5.2. Policy Implications

Many policy implications can be made on the basis of the results or conclusions reached in this study. Nevertheless, one needs to be cautious when making policy recommendations given the period and the coverage of the study. However, the data was used to stimulate a farm operation unit that is representative of the area and a group of holdings. Several clear implications and recommendations that can be made out of the results of the study are as follows:

1. The high proportion of fallow land in the existing farming system indicates that agricultural productivity can be increased by putting more land under cultivation.

2. The high percentages of unutilized labour under existing farm plans can be reduced substantially by introducing labour intensive enterprises, as opposed to the tree-crop enterprises which dominate the cropping pattern and are not labour intensive.

3. Since the existing land-use pattern was found to be sub-optimal, it would follow that there is scope for farm management extension in this area, through re-organization of resources coupled with simultaneous improvements in crop husbandry techniques.

4. Since the results of the optimal plans show an increase in farm incomes and farm labour employment, particularly under (IADP), development efforts in the direction of farm planning or adjustments in the cropping pattern should be taken up in all farming systems.

5. The dominance of coconunt activities in most optimal plans and the existence of surplus farm labour in most of the periods both without or with food constraints, indicate the need for encouraging other enterprises such as dairying and poultry. This would also bring about diversification of agriculture since the optimal plans show a trend towards specialization.

6. In order for cashewnut enterprise to become profitable (competitive) enough to be included in the optimal plans, its gross margin must be raised by KShs.1141.20. This is important if the cashewnut factory in Kilifi is to be assured of continuous and steady supply of cashewnuts.

7. Since the optimal plans under improved technology (IADP) show a further increase in net farm income and farm labour employment over the existing level of technology, steps should be taken to enable smallholders in all farming systems to get the required inputs, including credit facilities. However, before such technologies are introduced,

the possibilities of increasing farm income and employment through reorganisation of existing resources should be fully exploited in all farming systems.

8. Finally before such improved technologies under IADP are introduced, technical answers to problems of crop and animal development which are lacking at the Coast should be known. The attractiveness of intercropping, as evident in the existing farm plans, calls for the need of research into ways of improving production within intercropping systems. Most of the research in the past has concerned pure stands. More research information is also required on determining efficient combinations of coconut palms with shade tolerant crops, either with other tree crops or annual crops. This would improve farm income as the present results show that coconut production is most profitable.

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APPENDIX 1

QUESTIONNAIRE FOR THE SMALL-HOLDINGS IN KALOLENI LOCATION OF KILIFI DISTRICT (1978 SEASON)

I - Identification

Farmer's Name ---------------------------

District ---------------------------

Location ---------------------------

Sub-location ---------------------------

Date of Interview ---------------------------

Enumerator ---------------------------

II - Background Information

(a) Are you the owner of this farm?

Yes ----------- No ------------

(b) Are you Single/Married/Divorced/Widowed?

(Tick the correct group you belong to).

(c) If you are married, how many wives do you have -------------------------------------

(d) How many children do you have -----------

(e)

Family members	Age Yrs	Level of education	Whether living on the farm or not
Husband			
Wife or wives 1. 2. 3. 4.			
Children 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.			
Other relatives living on the farm 1. 2. 3. 4.			

(f) What is your main occupation?

1. Farmer
2. Small trader in vegetables
3. Small trader in other items (specifiy --------)

(4) Business - shop operator etc.

(5) Other (specify)

(g) Do you have any subsidiary occupation or sources of income besides this one?

Yes---------------- No ------------------

If Yes, state the occupation -----------------

III. Farm Structure and organization

(a) What is the total size of this farm

Acres ----------------- Hectares -------------

(b) Areas of the major uses of the farm land

Annual Crops	Owned		Rented	
	Acres	Hectares	Acres	Hectares
Pasture				
Tree Crops (Orchard)[a]				
Land in farmstead houses, barn, yard etc.				
Fallow				
Other land: land in roads, paths, ditches, wells, etc.				
Total land in farm				

[a]If fruit or other productive trees are few to record in terms of area occupied, give kind and number of trees.

(c) What area is used for cultivation at present

Acres -------------------- Hectares -------------

(d) What crops and crop mixtures did you have on your farm during the last season?

Crop or Crop Mixture	No. of plots	Area Acres/Hect.	Yield Harvested unit (bags or kg)	Sold or to be sold bag or Kg.		Quantity Retained as seeds and for home consumption
			Quantity	Quan.	Val. Ksh.	
1. Maize						
2. Maize-simsim						
3. Maize-cowpeas						
4. Cassava						
5. Maize						
6. Cassava						
7. Simsim						
8. Cowpeas						
9. Sweet potatoes						
10. Green gram						
11. Sunflower						
12. Beans						
13. Coconut						
14. Cashewnut						
15. Coconut-Cashewnut						
16.						
17.						
18.						
19.						
Total						

Give reasons for high or low yields compared to normal years

(e) What inputs did you use during the last growing season? Do not include anything previously stated as sold or to be sold or used by household.

Kind	Quantity used (indicate unit)	Value or cost
1. Seeds (type) (a) (b) (c) (d) (e) etc		
2. Tubers or cuttings (Type) (a) (b)		
3. Fertilizers (Type)/ Crop (a) (b) (c)		
4. Manure/crop		
5. Lime/Crop		
6. Insecticide (type)/ Crop (a) (b)		
7. Herbicides etc/Crop		

(f) What crops and crop mixtures do you have on your farm during the short rains?

Crop or Crop Mixture	No. of plots	Area		Yield harvested unit (bags or Kg.)	Sold or to be sold (bag or Kg.)		Quantity retained as seed and for home consumption
		Acres	Hect.	Quantity	Quan.	Value KShs.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Maize							
2. Maize / Simsim							
3. Maize / Cowpeas							
4. Cassava							
5. Maize							
6. Groundnut							
7. Simsim							
8. Cowpeas							
9. Sweet potatoes							
10. Green gram							
11. Sunflower							
12. Beans							

Cont.'d.

(f) Cont'.d

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
13. Coconut							
14. Cashewnut							
15. Coconut-Cashewnut							
16.							
17.							
18.							
19. Total							

(g) What inputs did you use during the short rains?

Do not include anything previously stated as sold or to be sold or used by households.

Kind	Quantity used indicate units	Value or cost
1. Seeds (Type) (a) (b) (c) (d) (e)		
2. Tubers or cuttings (Type) (a) (b) 3. Fertilizers (Type)/ Crop (a) (b) (c)		
4. Manure/Crop		
5. Lime/Crop		
6. Insecticide type/ Crop (a) (b)		
7. Herbicides etc/ Crop		

IV: Animal Enterprise

(a) Class	Grade Cattle		Local Cattle		Total
	Number	Total Milk production kg or Litres	Number	Total Milk Production Kg or Litres	Kg or Litres
Cows (total)					
Cows in milk					
Heifers over 2 years					
Heifers 1 - 2 years					
Female calves less than 1 year.					
Male calves less than 1 year.					
Young bulls over 1 year					
Mature bulls					
Oxen					
Total					

(b) What other livestock do you have?

Livestock	Number
1. Goat	------------------
2. Sheep	------------------
3. Donkeys	------------------
4. Poultry (kind)	------------------
(a) Layers	------------------
(b) Broilers	-------------------
(c) --------	-------------------
(d) ---------	---------------------
(e) ---------	---------------------

(c) What feeds do you give your livestock

1. ------------------------------------

2. ------------------------------------

3. ------------------------------------

4. -------------------------------------

d) What is the amount and cost (value) of each of the feeds

1. ---------------------------------------

2. ---------------------------------------

3. ---------------------------------------

4. ---------------------------------------

(e) What are your livestock products?

Kind of Product	Production		Sold or to be sold			Household use	
	Unit	Quantity	Quan.	Price	Value	Quan.	Value
Milk							
Eggs							

V- Land and Related Investment

Give the estimated value of each type of investment, excluding land and buildings rented to others

Kind of Investment	Value
1. Land	
2. Buildings	
3. Drainage works	
4. Irrigation works	
5. Fences, hedges etc.	
6. Fruit trees etc.	
7. Crops in fields	
8. Other	
Total	

Vi - Farm Machinery, Equipment, Tools

Give value of all implements, tools, machinery etc. having useful live longer than a year

Kind	Number	Date of purchase	Purchase price	Present value
1. Tractors				
2. Vehicles				
3. Tools and Implements (a) (b) (c) (d) (e) (f) (g) (h)				
4.				

Vii - Labour

(a) How many family members are available for farm work?

Family Member	Number	Number of hours worked per day	No. of days available for farm work per week and month	Kind of farm-work performed
Husband				------------ ------------ ------------
Wife (wives)				------------ ------------ ------------
Boys over 15 years				------------ ------------ ------------
Girls over 15 years				------------ ------------ ------------
Relative over 15 years and below 60 years				------------ ------------ ------------
Total				

(b) Do you have any permanent labourer? Yes/No.

(c) How many? --

(d) Are they assigned any specific tasks?

e.g. weeding ------------------------

household work etc. -------------------------

(e) How much do you pay him/her per month? --------------

(f) Do you employ casual labourers? Yes/No.

If yes, then

Month	No. of Labourers	Rate of payment per day	Total Amount paid/day	Total Amount paid/month	Type of work employed for	Remarks
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						

Viii - Cultivation Methods

Crop or Crop Mixture and Activity (1)	Month (2)	Family Labour Hand (Mhrs) (3)	Employed Labour Hand (Mhrs) (4)	2-ox team owned (Mhr) (5)	2-ox team hired (Mhr) (6)	Tractor owned (Mhrs) (7)	Tractor hired (Thr) (8)
1. Maize (a) Land prep. (b) Planting (c) Weeding (d) Harvesting (picking) (e) Transport etc.							
2. Maize-simsim (a) Land prep. (b) Planting (c) Weeding (d) Harvesting (picking) (e) Transport (f) Other (specify)							
3. ------------ (a) Land prep. (b) Planting (c) Weeding (d) Harvesting (Picking) (e) Transport (f) Other (specify)							
4. -------------- (a) Land prep. (b) Planting (c) Weeding (d) Harvesting (picking) (e) Transport (f) Other (specify)							
5. ------------ (a) Land prep. (b) Planting (c) Weeding (d) Harvesting (e) Transport (f) Other specify							

Cont.'d

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
6. (a) Land preparation (b) Planting (c) Weeding (d) Harvesting (e) Transport (f) Other specify							
7. ---------------- (a) Land prep. (b) Planting (c) Weeding (d) Harvesting (e) Transport (f) Other specify							
8. ---------------- (a) Land prep. (b) Planting (c) Weeding (d) Harvesting (e) Transport (f) Other specify							

Ix. - Marketing of Farm Products

Kind of product	Marketing period during the year		Type of buyer[a] or outlet	Name of place where sold	Distance from farm to market	Method of Transport	Cost of transport
	from the month of	to the month of					
e.g. cotton							

[a]indicate whether the buyer is an individual dealer or a co-operative etc.

(b) Are you satisfied with the present marketing facilities available to you?

(1) Yes ------------------ (2) No ----------------

If No. Why not?

(a) Lack of buyers

(b) Markets too far from home

(c) Poor communications.

(d) Too much control on marketing

(e) Transportation cost too high

(f) Others specify.

X <u>Credit</u>

(a) Did you borrow anything for your farm needs last season? Yes ----------------- No --------------

and if Yes from (a) Friends ---------------

(b) Relatives -------------

(c) Financial institutions

(b) How much was the value of your borrowing? -------

(c) For what purpose did you borrow -----------------

(d) Are you satisfied with the present arrangement of supplying credit? -------------------------------

(1) Yes ------------------ (2) No --------------

If No, why not?

1. Approval takes too long

2. It requires too much security

3. Delays in payments

4. Deductions are too high

5. Can not get the loan wanted

6. Others (specify) ----------------------------

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

Yes ---------------- No --------------------

If Yes state purpose and amount

Purpose ----------------- Amount --------------

If no, why not?

(a) Has enough cash

(b) Present debts too high

(c) It is too risky

(d) Others (specify) ------------------------

(f) What is your most important problem facing you in farming?

1. Inadequate rain ----------------------------

2. Lack of operating capital ------------------

3. Inputs are very essential but expensive -------

4. Lack of extension advice ---------------------

5. Lack of proper tools -------------------------

6. Others (specify) -------------------------------

Xi - Eating Habits

What are your major subsistence crops and livestock products.

Type of food (dish)	Subsistence crops or livestock products	Requirement per day (kg)	Periods (months) the dishes are eaten	Quantity of subsistence crops/Livestock products per year
1. Irio				
2. Githeri				
3. Muthokoi				
4. Ugali				
5. Milk etc.				
6.				

APPENDIX 2

GROSS-MARGINS PER HECTARE FOR 1978 GROWING SEASON FOR SELECTED ENTERPRISES (ACTIVITIES) IN KALOLENI LOCATION.

1. Coconut (Copra)

Item	Value(KShs.)
Output	
1. Yield, 536kg of copra	
2. Total Gross output 536kg @ KShs.2.60	1393.60
Variable Costs	
3. Opportunity cost before maturity	100.00
4. Fertilizer	-
5. Dust and sprays	-
6. Other costs e.g. harvesting, processing and transport	
Harvesting by private dealers[1]	375.00
7. Hired labour for,	
(a) Weeding	-
(b) Fertilizing	-
(c) Dusting and spraying	-
(d) Prunning etc.	-
Total variable costs	475.00
Gross Margin	918.60

[1]Private dealers paid in kind (nuts), value as shown.

2. Coconut (Whole Nuts)

Item	Value (KShs)
Output	
1. Yield, number of whole nuts 3750	
2. Total Gross output 3750 @ KShs.0.50	1850.00
Variable Costs	
3. Opportunity cost before maturity	100.00
4. Fertilizer	-
5. Dust and sprays	-
6. Other costs e.g. harvesting, and transport	
Harvesting by private dealers[1]	375.00
7. Hired labour for	
(a) Weeding	-
(b) Fertilizing	-
(c) Dusting and spraying	-
(d) Prunning etc.	-
Total variable costs	475.00
Gross margin	1400.00

[1] Private dealers paid in kind (nuts) value as shown

3. Coconut Copra/Palm-wine (toddy)

Item	Value (KShs.)
<u>Output</u>	
1. Yield, (a) 467 kg of copra	
(b) 1752 litres of palm-wine (toddy)	
2. Gross output	
(a) 467 kg @ KShs.2.60	1214.20
(b) 1752Lt @ KShs.0.70	1226.40
3. Total Gross output	2440.60
<u>Variable costs</u>	
4. Opportunity cost before maturity	100.00
5. Fertilizer	-
6. Dust and sprays	-
7. Other costs e.g. harvesting, tapping and transport.	
Harvesting by private dealers[1]. Tapping[2] by private dealers.	327.00
0.5 x 1752Lt @ KShs.0.70	613.20
8. Hired labour for	
(a) Weeding	
(b) Fertilizing	
(c) Dusting and spraying	
(d) Prunning etc.	
Total variable costs	1040.20
Gross margin	1400.40

[1]Private dealers paid in kind (nut) value as shown.

[2]The total output of palm-wine is shared equally between the farmer and the tapper .

4. Coconut whole nut/palm-wine (toddy)

Item	Value (KShs.)
1. Yield (a) 3270 Number of whole nut	
(b) 1752 litres of palm-wine (toddy)	
2. Gross output	
(a) 3270 @ KShs. 0.50	1635.00
(b) 1752 @ KShs. 0.70	1226.40
3. Total gross output	2861.40
Variable costs	
4. Opportunity costs before maturity	100.00
5. Fertilizer	-
6. Dust and sprays	-
7. Other costs e.g. harvesting and tapping Harvesting private dealers[1] Tapping[2] by private dealers.	327.00
0.5 x 1732Lt @ KShs. 0.70	613.20
8. Hired labour for	
(a) Weeding	
(b) Fertilizing	
(c) Dusting and spraying	
(d) Prunning etc.	
Total variable costs	1040.20
Gross margin	1821.20

[1]Private dealers paid in kind, value as shown.

[2]The total output of toddy is shared equally between the farmer and the tapper.

5. Cashewnut

Item	Value KShs.
Output	
1. Yield, 6 bags of cashewnut	
2. Total gross output, 6 bags @ average price of both grades KShs.130.00	780.00
Variable costs	
3. Opportunity costs before maturity	100.00
4. Fertilizer	
5. Other costs, e.g. harvesting, processing	
6. Dust and sprays	
Harvesting, processing and transport	
7. Hired labour for,	
(a) Weeding	
(b) Fertilizing	
(c) Dusting and spraying	
(d) Prunning etc.	
Total variable costs	100.00
Gross margin	680.00

6. Citrus (oranges)

Item	Value KShs.
Output	
1. Yield, 300 pakacha of oranges	
2. Total Gross output, 300 pakacha @ KShs.6.00	1800.00
Variable costs	
3. Opportunity cost before maturity	150.00
4. Fertilizer	-
5. Dust and sprays	-
6. Other costs, e.g. harvesting, transport etc.	-
7. Hired labour for,	
(a) Weeding	-
(b) Fertilizing	-
(c) Dusting and spraying	-
(d) Prunning etc.	-
Total variable costs	150.00
Gross margin	1650.00

7. Local Maize

Item	Value KShs.
Output	
1. Yield in 90 kg bags, 12 bags	
2. Total Gross output 12 bags @ KShs.100.00	1200.00
Variable costs	
3. Land preparation (excluding hired Labour)	-
4. Seeds (own) 25 kg @ KShs.0.75	19.00
5. Fertilizer	-
6. Dust and sprays	-
7. Other costs e.g. transport and gunnies (gunnies 12 second hand bags @ KShs.3.00	36.00
8. Hired labour for,	
(a) Land preparation	-
(b) Planting	-
(c) Weeding	-
(d) Harvesting etc.	-
Total variable costs	55.00
Gross margin	1145.00

8. Local maize/Cassava

Item	Value KShs.
Output	
1. Yield (a) Local maize in 90 kg bag, 7.5 bags	
(b) Cassava in 100 kg bag, 40 bags	
2. Gross output	
(a) Maize 7.5 bags @ KShs.100.00	750.00
(b) Cassava 40 bags @ KShs.24.00	960.00
3. Total Gross output	1710.00
Variable costs	
4. Land preparation (excluding hired labour)	-
5. Seeds/cuttings	
Seeds (own), 22.0 kg. @ KShs.0.75	16.50
Cutting number, 6250 @ KShs.0.01	62.50
6. Fertilizer	-
7. Dust and sprays	-
8. Other costs e.g. transport and gunnies,	
Second hand bags @ KShs.3.00	24.00
Gunnies, 20 second hand bags @ KShs.3.00	60.00
9. Hired labour for:	
(a) Land preparation	-
(b) Planting	-
(c) Weeding	-
(d) Harvesting etc.	-
Total variable costs	163.00
Gross Margin	1547.00

9. Local Maize/cotton

Item	Value KShs.
Output	
1. Yield (a) Local maize in 90 kg. bag, 7.5 bags	
(b) Cotton in Kg. (i) 70% AR., 175 kg (ii) 30% BR, 75 kg.	
2. Gross output	
(a) Maize 7.5 bags @ KShs.100.00	750.00
(b) Cotton 175 kg AR @ KShs.3.65	604.00
75 kg BR @ KShs.1.70	127.50
3. Total Gross output	1481.50
Variable costs	
4. Land preparation (excluding hired labour)	
5. Seeds,	
Local maize 16 kg. @ KShs.0.75	12.00
Cotton 15 kg	-
6. Fertilizer	-
7. Dust and sprays	-
8. Other costs e.g. transport and gunnies	
Transport 8 bags cotton @ KShs.5.00	40.00
Gunnies 7 bags, @ KShs.3.00	21.00
Gunnies 7 bags, @ KShs. 3.00	24.00
9. Hired labour for: (a) Land preparation (b) Planting (c) Weeding (d) Harvesting etc.	
Total variable cots	97.00
Gross margin	1384.50

10. Cotton[1]

Item	Value KShs.
Output	
1. Yield (a) 80% AR, 640 kg	
(b) 20% BR, 160 kg	
2. Gross output	
(a) 640 kg @ KShs.3.45	2208.00
(b) 160 kg @ KShs.1.70	272.00
3. Total gross output, 800 kg	2480.00
Variable costs	
4. Land preparation, (excluding hired labour)	
1 x ploughing	300.00
1 x harrowing	200.00
5. Seeds, 22.5 kg	-
6. Fertilizer	-
7. Dusts and sprays	
2.5 cartons DDT/Sevin @ KShs.150.00	375.00
8. Other costs transport, 30 bags @ KShs. 5.00	150.00
Gunnies, 30 bags @ KShs.3.00	90.00
9. Hired labour for:	
(a) Land preparation	-
(b) Planting	-
(c) Weeding, 20 MD @ KShs.8.00	160.00
(d) Harvesting	-
Total variable costs	1275.00
Gross margin	1205.00

[1] Integrated Agricultural Development Programme Crop Package.

11. Maize/simsim[1]

Item	Value KShs.
Output	
1. Yield, 90 kg bag maize (a) 30 bags 80 bags simsim, (b) 8 bags	
2. Gross output (a) 30 bags @ KShs.85.00 (b) 8 bags @ KShs.240.00	2550.00 1920.00
3. Total gross output	4470.00
Variable costs	
4. Land preparation (excluding hired labour) 1 x ploughing 1 x harrowing	 300.00 200.00
5. Seeds, coast composite, 125 kg @ KShs.3.20 Simsim, 15 kg @ KShs.3.00	93.00 45.00
6. Fertilizer, SSP 125 kg @ KShs.1.26 SA 125 kg @ KShs.1.49	158.00 186.00
7. Dust and sprays 12.5 kg DDT 5% Dust @ KShs.2.30	 29.00
8. Other costs, transport 38 bags @ KShs.5.00 Gunnies 38 bags @ KShs.3.00	190.00 114.00
9. Hired labour for: (a) Land preparation (b) Planting (c) Weeding, 20 MD @ KShs.8.00 (d) Harvesting	 - - 160.00 -
Total variable costs	1475.00
Gross margin	2995.00

[1]Integrated Agricultural Development Programme Crop package

APPENDIX 3

MONTHLY LABOUR INPUT-COEFFICIENT (MANHOURS) PER HECTARE

1. Under existing technology

Months (Mhrs)	Coconut[1] (Copra)	Coconut (Whole)	Coconut Copra/ toddy)	Coconut Whole nut Toddy	Cashew-nut[1]	Citrus[1] (Orange)	Local Maize	Local maize/ Cassava	Local Maize/ Cotton
January	5	5	5	5	90	5			
February	5	5	5	5	5	5	108	108	108
March	105	5	5	5	5	5	148	163	163
April	5	5	5	5	5	5	160	195	148
May	5	5	5	5	5	5	125	125	168
June	105	5	5	5	5	5			
July	5	5	5	5	5	5			
August	5	5	5	5	5	5	100	100	100
September	105	5	5	5	5	5	50	50	50
October	5	5	5	5	5	5			
November	5	5	5	5	90	5			100
December	105	5	5	5	130	5			100

[1]Weeding labour for tree crops is irregular, so the labour input coefficient is distributed throughout the year.

2. Under Improved Technology (IADP)

Months	Coconut[1] (Copra)	Coconut (Whole-nut)	Coconut Copra/ Toddy	Coconut Whole nut/Toddy	Cashew nut[1]	Citrus[1] (Orange)	Local Maize	Local maize /Cassava	Local maize/ cotton	Cotton	Composite Maize/simsim
January	5	5	5	5	90	5					
February	5	5	5	5	5	5	108	108	100		
March	105	5	5	5	5	5	148	163	163	47	57
April	5	5	5	5	5	5	160	195	148	100	200
May	5	5	5	5	5	5	125	125	168	110	160
June	105	5	5	5	5	5				85	120
July	5	5	5	5	5	5				60	
August	5	5	5	5	5	5	100	100	100		357
September	105	5	5	5	5	5	50	50	50		100
October	5	5	5	5	90	5					
November	5	5	5	5	5	5				270	100
December	105	5	5	5	130	5			100	270	90

[1]Weeding labour for tree crops is irregular, so the labour input-coefficient is distributed throughout the year.

APPENDIX 4

EXPLANATIONS OF ABBREVIATIONS USED IN TABLES 4.5, 4.6, 4.7, 4.8 AND 4.9.

Abbreviations	In Full
PRODND	Produce whole nuts and palm-wine (toddy)
PRODCS	Produce Cashewnut
PRODCD	Produce Copra and palm-wine (toddy)
PRODCR	Produce Citrus (orange)
PRODMC	Produce maize and cassava
PRODMT	Produce maize and cotton
PRODCT	Produce cotton
PRODMS	Produce maize and simsim
HVSLWN	Harvest and sell whole nuts
TPSLCD	Tap and sell palm wine (toddy)
HPSLCP	Harvest process and sell copra
HVSLCS	Harvest and sell cashewnut
HVSLCR	Harvest and sell citrus (oranges)
SELLCV	Sell cassava
SELLMZ	Sell maize
SELLCT	Sell cotton
SELLPT	Sell programme cotton
SELLCM	Sell composite maize
SELLSM	Sell simsim
CPPRD	Copra production
CSPRD	Cashewnut production
MZPRD	Maize production
CVPRD	Cassava production
CTPRD	Cotton production
CMPRD	Composite maize production
SMPRD	Simsim production
PTPRD	Programme cotton production
AUGL	August Labour.