SMALL-HOLDER FOOD PRODUCTION: A GEOGRAPHICAL ANALYSIS OF MAIZE PRODUCTION IN RONGO DIVISION, SOUTH-NYANZA DISTRICT.

BY

SAMUEL OCHIEN'G AKECH.

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DECLARATION

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

SAMUEL OCHIEN'G AKECH

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

DR. DUNSTAN A. OBARA
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF NAIROBI

PROFESSOR R.S. ODINGO
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF NAIROBI.

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ABSTRACT

This study is an investigation of small-scale maize production in Rongo Division, South-Nyanza District, Western Kenya. It is an attempt to analyse the factors responsible for spatial variations in maize yield, field sizes, and the adoption of relevant technological innovations. Furthermore, it highlights the problems of maize marketing in the study area. Since its introduction, maize has become an important staple crop in the study area and elsewhere in Kenya. Because of this significance, the National food policy aims at achieving self-sufficiency in maize production.

The analysis is mainly based on primary data collected from a sample of small-scale farmers and traders in the study area. Because of the large number of variables involved in maize production, it was found convenient to use factor analysis, multiple linear regression and logit regression models. The application of these techniques enabled the delineation of different crop combinations in the study area. These crop combinations suggested a negative impact of cash-crops, especially sugar-cane on maize production. Further analysis revealed that the spatial variations in maize yield were associated with variations in soil fertility and agro-ecological zones. These two independent factors also were significantly related to the spatial variations in field sizes of maize.

Low average annual rainfall and inappropriate agronomic practices especially late weeding, intercropping and the planting of second generation hybrid significantly contributed to low maize yields. It was also observed that farms with larger maize and sugar-cane fields had relatively lower maize yields. Finally, it was found that the cultivation of coffee, absentee land ownership, smaller farm sizes, and lack of land preparation implements significantly lowered the area under maize cultivation.

The study revealed that the most widely adopted innovation in the study area was the application of farm manure/fertilizer followed by the planting of hybrid seed. The simultaneous use of the two innovations was recorded in the least number of farms. It was found that the likelihood of adoption of all the three innovations were significantly related to the environmental factors, individual attributes of the farmers, availability of necessary farm assets and the types of crops planted.

Maize farmers in the study area employed multiple marketing strategies as defined by their individual needs and the characteristics of the marketing channels utilised. From the analysis, the informal marketing system emerged as the most important marketing channel on the basis of the number of farmers using it and the volume of produce it handled. Maize prices and the quantities of maize handled by individual traders within the marketing system were found to vary according to the individual attributes of the

traders and the organisational aspects of the informal trade.

Several conclusions have been drawn from the major findings of this study. In the first instance, the production of maize in the study area is certain to decline with increasing cash-crop production. Secondly, inappropriate agronomic practices are the major impediments to increased maize yields in the study area. In addition, the expansion of the cultivated area under maize can only be a short term strategy for increased maize output. Finally, the adoption of innovations is determined mainly by the socio-economic status of farmers, with those in the higher hierarchy being better adopters.

It is strongly recommended that agricultural support services should be intensified within the small-scale farming sector for greater productivity. Furthermore, sugar-cane farmers need to be encouraged to devote an appropriate minimum land for maize. In addition, the informal marketing system should be given greater participation in maize marketing to supplement the services of the existing statutory board.

Further research is required on the effects of pests on maize production and on the suitability of different chemical fertilizers to specific soil types. It is also recommended that suitable biological alternatives to chemical fertilizers in maize production be investigated. Finally, the possible methods of strengthening the informal marketing system with a view to establishing complementary linkages between it and the statutory marketing board require further study.

CHAPTER ONE - INTRODUCTION

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1:0 INTRODUCTION

Since its introduction in Kenya by the beginning of this century, maize has become one of the most important crops in the country's economy. Maize forms the basic staple food in most parts of Kenya and is the most widespread crop in the study area. Kenya's food policy places great emphasis on the achievement of domestic self-sufficiency in maize through agricultural expansion and intensification (Republic of Kenya, 1981; 1986). This study focusses on several facets of maize production in the Rongo Division, South-Nyanza District (Figure 1.1 & 1.2) with special emphasis on yield determinants. Improved maize yields is at the core of the crop's intensification programme. During the colonial era, maize was grown mainly as a cash-crop for the external market. Yields were generally low with little attempt to develop high yielding varieties. This situation has greatly changed following the development of suitable hybrid maize varieties from the 1960s.

Maize has attracted a vast number of studies focussing on diverse aspects of its production and marketing. The geographer's contribution to maize studies in Kenya has been minimal because most of the existing studies have been carried out by agronomists, agriculturalists and economists. Therefore, a spatial analysis of small-holder maize production is clearly justified.

Fig.1.1: THE LOCATION OF THE STUDY AREA IN KENYA

SOURCE: South Nyanza District Development Plan, 1984–88

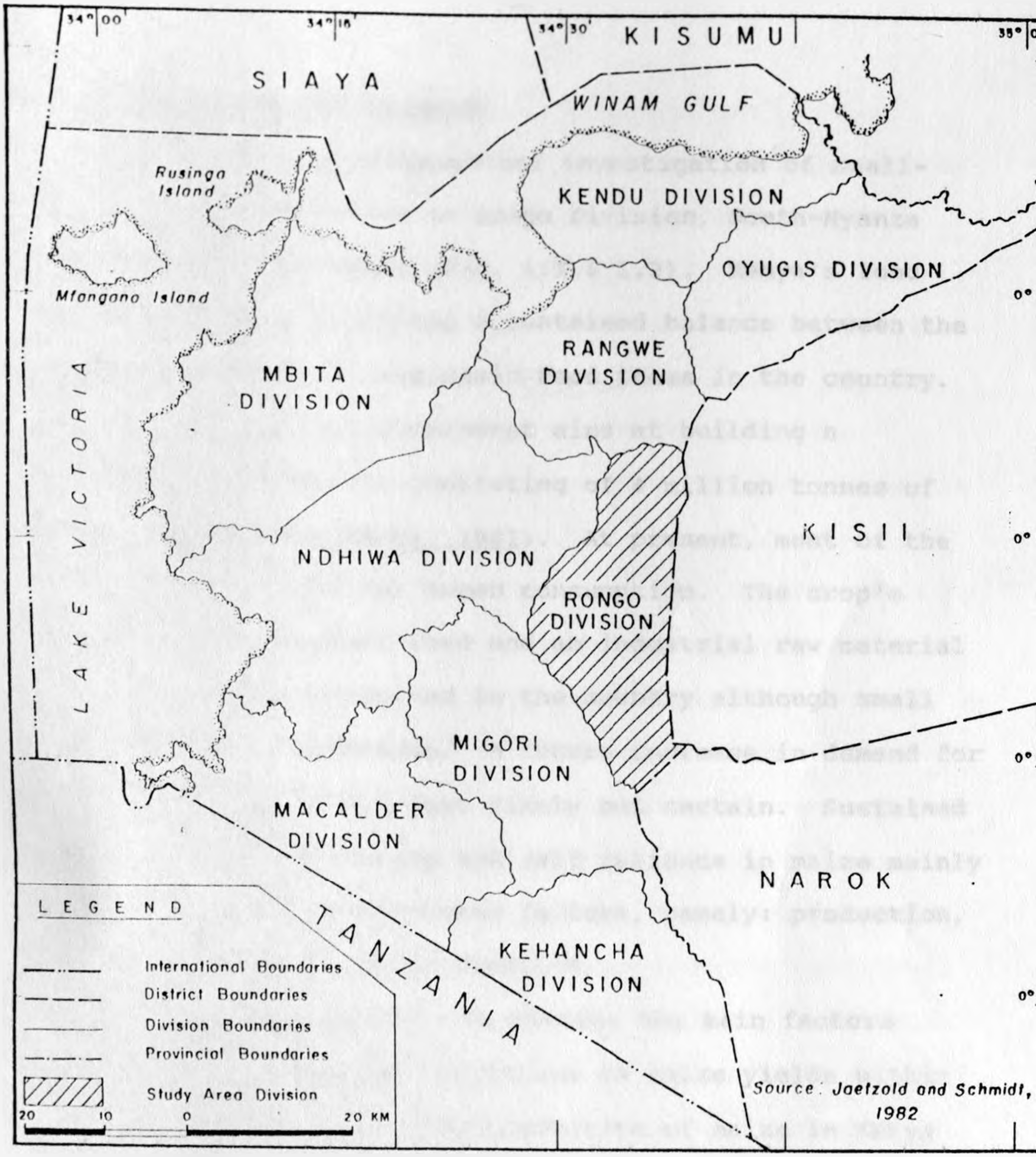

Fig.1.2 POSITION OF STUDY AREA IN SOUTH NYANZA DISTRICT

1.1 STATEMENT OF THE PROBLEM

This study is a geographical investigation of small-holder maize production in Rongo Division, South-Nyanza District, Western Kenya (Fig. 1.1 & 1.2). Kenya's food policy aims at maintaining a sustained balance between the demand and supply of the basic food items in the country. In this respect, the government aims at building a strategic food reserve consisting of 4 million tonnes of maize (Republic of Kenya, 1981). At present, most of the maize grown is used for human consumption. The crop's potential as livestock feed and an industrial raw material is not yet fully exploited in the country although small beginnings have been made. A future increase in demand for maize is therefore not just likely but certain. Sustained domestic self-sufficiency and self reliance in maize mainly depends on three interrelated factors, namely: production, distribution and final consumption.

The present study sets to examine the main factors contributing to spatial variations in maize yields within the small-farm sector. The production of maize in Kenya has been characterised by variations in total output, often leading to food deficits. These are attributable to variations in hectarage planted and yields obtained, the latter mainly due to fluctuations in weather conditions. Hectarage variations is more characteristic of the large-farm sector in which land devoted to maize is largely determined by expected producer prices. Weather conditions are, to a large extent, unpredictable and out of the farmers' control. An effective marketing and distribution system for maize can reduce the adverse effects of uncertain weather conditions. Low yields within the small-scale sector has persisted in Kenya despite great strides already made in agronomic and breeding research. To date, high yielding hybrid maize seed varieties have been developed to suit the varied agro-ecological conditions in the country.

The small-farm sector is the main vehicle for achieving increased food production because of its predominance in the country (Republic of Kenya, 1983). Maize production in Kenya has a dual character in which small-holder farm operators exist side by side with large-scale commercial farmers. Although low maize yields have been typical of the latter, they are becoming increasingly significant in the marketed production of maize. Between 1980 and 1984, small farms surpassed the large scale farms in maize sales to the National Cereals and Produce Board (NCPB), a statutory body with monopoly powers over the marketing of maize in Kenya (Republic of Kenya, 1985). It is in recognition of this that the present study focusses on the major variables limiting maize production amongst small-scale farmers in Rongo Division, South-Nyanza District.

In small-holder agriculture, crops are mostly cultivated in associations. These associations do not occur haphazardly but in distinct crop combinations which if established, may shed light on some underlying structural characteristics of small-holder agriculture. The same can highlight the relative importance of maize in the study area. This study seeks to establish the major crop combinations in the study area and their spatial expression. The possible implications such crop combinations have on maize production in the study area is also explored. This aspect of the study can be useful in identifying specific areas which require special efforts to increase maize production. Rational land-use policies could also emanate from this aspect of study since it is essentially a study of the location of maize production in the study area.

Maize yields are a function of environmental attributes which small-scale farmers can influence only through the adoption of appropriate agronomic practices. These practices vary from one farmer to another depending on ones accessibility to and utilisation of both agricultural information and inputs. The accessibility is dependent primarily on a farmer's ability and motivation as defined by personal characteristics and the socioeconomic environment within which one operates. An efficient system of agricultural services is, therefore, necessary for improved agricultural production. The role of socioeconomic factors in determining yield has largely been ignored in maize research. The main focus of the latter has been mainly the development of high yielding seed varieties. The present study is an attempt to isolate the major environmental, agronomic and socioeconomic factors contributing to maize yield variations in the study area. A knowledge of the interaction between socioeconomic characteristics of small-farm operators and maize yield variation is, particularly necessary for the planning of increased accessibility of farmers to major agricultural inputs and services.

Perhaps the main variable of practical importance to small-scale farmers is the total maize harvested in a particular season. Maize production is, however, dependent on both yield/hectarage levels. An understanding of the /and size structure of maize fields and the influencing factors is of paramount importance, particularly for maize production forecasts and intensified land use.

Due to various constraints, such as population pressure on land and the continuous need to produce cash-crops, it has been realised that hectarage expansion as a strategy for increased maize output is only a short-term solution to food shortages in Kenya. Increased maize output in the long run will be realised only through higher yields within the small-farm sector. Given suitable arable land, the latter requires an increased acceptance of recommended agricultural innovations. The adoption rate of recommended innovations by small-scale farmers has so far been rather minimal contributing to the low yields obtained. In cases where hybrid seed has been planted, yields do not compare favourably with those recorded in experimental stations from identical seeds due to inferior husbandry methods. Much geographical research has invariably been centered on the diffusion of particular innovations on a temporal and spatial context. The present study attempts to identify the main factors influencing the likelihood that a farmer adopts a particular innovation or package of innovations. Particular emphasis has been given to environmental attributes, farmer characteristics and socioeconomic variables determining ones accessibility to agricultural information and services.

Maize harvested by small-scale farmers can be either consumed on the farm or offered for sale. In the latter case, one or both the formal and informal marketing systems can be utilised. The formal marketing system revolves around the National Cereals and Produce Board (NCPB) and its appointed agents. The amount of maize channelled through the NCPB determines the quantity of maize stocks it holds, hence its capability to maintain the strategic reserve Kenya needs and perform its regulatory control on maize prices. However, small-holders will only sell their maize output to the formal marketing system if they consider it efficient in its operations. In particular, farmers are mainly interested in fair producer prices and accessible outlets. The existence of the informal marketing system implies that it satisfies those functions which are not adequately met by the NCPB. Despite its long history, relatively little is known about the informal marketing system. This study examines the structural characteristics of the existing marketing system with particular emphasis on the informal sector. Findings from this study could therefore be useful both in the reorganisation of the maize marketing system and forecasts of maize sales to the formal marketing system.

1.2 OPERATIONAL DEFINITIONS:

The following are the major operational definitions of terms and concepts employed in the present study:

(a) MAIZE PRODUCTION:

This encompasses all the field operations involved in maize cultivation as well as the final disposal of the resultant maize 'output', the latter referring to the total harvested grain excluding pre-harvest loses and usages and is expressed in bags per hectare (unshelled maize). Maize production is understood in this/ as a function of the total [study hectarage under maize and yield per unit area of land.

(b) SMALL-HOLDER:

This refers to a farmer operating farms of less than twelve hectares with limited mechanization and investment in other agricultural inputs. "Small-holder" and "small-scale" are used interchangeably in the present study. In Kenya, the statistical definition of a small-holding is a piece of arable land ranging in size from 0.2 to 12 hectares. Enyi and Kuyembeh (1980) defined a small-holder farm as a small-farm unit which cannot afford to invest in the elements of modern production technology under prevailing agro-ecological conditions.

(c) ENVIRONMENT

This term is used in reference to the external physical and biological conditions which influence the growth and development of crops in a particular farm. The concept of environment is often used in a more general context to define the totality of immediate external conditions which impinge on the life and development of an organism, a community or an object (Obara, 1988).

(d) MAIZE YIELD

This term is used in this study in reference to the economic yield of maize, that is, the amount of grain harvested per hectare of land. It should be differentiated from the biological yield which refers to the total dry matter production. Maize yields in this study are expressed in 90 Kilogramme bags of unshelled maize per hectare.

(e) AGRONOMY

This is a branch of science concerned with theory and practice of field production of crops and soil science. Agronomic practices are therefore all the operations involved in the field production of crops including field preparation, fertilizer/manure application, planting, weeding and harvesting.

(f) FOOD-CROPS:

These are crops which are grown primarily to meet the food needs of the farmers' households although a small proportion may be offered for sale. Such crops normally require minimal processing before they are consumed.

(g) CASH-CROPS:

These are crops grown mainly for sale and normally constitute a very limited part, if any,of the farmers' diet.

(h) INFORMAL MARKETING SYSTEM:

This phrase has been used in reference to that part of the maize marketing system which exists outside the National Cereals and Produce Board and its appointed agents. The system consists of private traders.

1.3 LITERATURE REVIEW

This section provides a review of selected literature considered relevant to the study of small-scale maize production and marketing. Because of its significance in the Kenya's economy, no other food crop has attracted as much attention from scholars and researchers as maize. The literature on maize production in Kenya and elsewhere is consequently vast and only a selective review is attempted here. A review of such literature is not without value in the present study. It is on the basis of the review that major gaps with regard to the problem investigated in this study were identified. The review was also invaluable in the selection of relevant variables subjected to quantitative analyses in the core chapters of this study.

The available literature on maize consists of both empirical and non-empirical accounts focussing mainly on the crops origin, introduction and spread in Kenya, its role in the economy, agronomic and breeding aspects, field operations and marketing.

Maize is not an indigenous cereal in Kenya but rose to become an important staple food in the country following its introduction by the early Portuguese explorers and Arab slave traders in the Kenyan coast in the 16th century (Harrisson, 1970; Acland, 1971; Allan, 1971). In these days, maize in Kenya was of the Caribbean Flint type which had low yields. This was later intercrossed with other varieties from South-Africa in the beginning of this century to produce the Kenya Flat White maize. This proved to be a better variety which led to increased spread of maize which by 1903 occupied only 20% of the total food crop acreage in Kenya (Harrisson, 1970). Other important food crops introduced into the country during this period included rice, wheat and beans. Acland (1971) gave a detailed but general account of the ecological requirements for the growth of maize, the major pests and diseases, field operations and production constraints in East Africa. He also gave the reasons for its early spread in the region especially the advantages it had over traditional cereals like sorghum which dominated at the time. These advantages included higher yield potential, less vulnerability to pests and diseases, less labour requirements, easier storage and better palatability.

In the Old Nyanza Province, maize served mainly as a cash-crop due to the restrictive colonial agricultural policies predating the Swynnerton Plan (Swynnerton, 1954). It was only in the 1950s that maize was accepted in most of the peoples diet (Fearn, 1964; Ogutu, 1973). Although maize has become a major food item in the diets of the majority of Kenyans, there is a renewed interest in the promotion of alternative food items such as livestock products, horticultural crops, cassava, beans, groundnuts, and traditional cereals such as sorghum and millet to achieve self-sufficiency in food (Republic of Kenya, 1981).

Acland's (1971) account stated that maize can be grown under diverse rainfall regimes and its production is limited only beyond an altitude of 2400 metres in East Africa. However, it requires fertile and well drained soils. He pointed out that maize has strict water requirements during its growth and is particularly sensitive to waterlogging during the early stages. Late planting is consequently an important factor inhibiting maize yields. Acland (1971) estimated that maize yields ranged between 110 and 1350 kilogrammes in Kenya and attributed low maize yields in the country to poor husbandry methods especially insufficient weeding and low plant populations. He asserted that fertilizer use in maize cultivation could only be beneficial if accompanied by good husbandry methods. Although Acland's work is useful, it is not directly applicable at the micro-level where more detailed analysis leading to area specific recommendations are required. This study is therefore an attempt to alleviate this shortcoming with respect to maize production in the study area.

The introduction and the subsequent rise of maize to significance in Kenya in addition to the evolution of the present maize varieties is well documented by Harrisson (1970). He observed that the present maize varieties in the country are mainly the result of maize breeding and agronomic research programmes which began intermittently in the 1930s. The major breakthrough in these programmes was the production of hybrid seed varieties in the 1960s. By 1967, these varieties had been completely adopted within the large scale farming sector. The main reasons behind variations in the adoption of hybrid seed and associated innovations therefore form a major focus of the present study.

Several other accounts exist addressed specifically to the ecological requirements of maize, its production and uses (Fearn, 1964; Miracle, 1966; Ogutu, 1973; Shah, Fisher, Kromer and Parikh, 1984). The emerging importance of maize as a food crop and the numerous uses it is put to in different parts of the Africa were examined by Miracle (1966). He observed that the importance of maize as food crop in Africa was likely to increase in the short-run but would be overshadowed in the long run by non-traditional cereals such as wheat and rice. In an analysis of the demand and supply of the major cereals in Africa, Shah, Fisher, Kromer and Parikh (1984) noted that there was a growing demand of non-traditional cereals like wheat and rice in the African continent. This shift was attributed to food aid, increasing populations, and changing dietary patterns associated with rapid urbanization and rising incomes in the continent.

Following the tradition of maize agronomy and breeding research in Kenya, many researchers have empirically investigated the influence of environmental parameters and agronomic practices on maize production. Findings from such studies have often been translated into packages of innovations disseminated to farmers through extension services. Allan (1971) investigated the influence of agronomic factors on maize yields in Western Kenya. These included time of planting, genotype, plant population, weeding and fertilizer application. He singled out time of planting as the most critical factor influencing maize yields. The desire to spread the planting operation coupled with technological constraints were found to be the main causes of late planting. In addition, poor husbandry methods were found to reduce maize yields considerably. However, fertilizer application was not a limiting factor in maize production. Allan (1971) therefore concluded that the application of fertilizer could not be profitable unless it is accompanied by adequate husbandry practices. He cited ignorance, carelessness, inefficiency, inadequate supervision, labour shortage and excessive rainfall as the major reasons for poor weeding and low maize plant populations. He subsequently suggested that clean weeding, the adoption of hybrid maize seeds, and high plant populations could considerably increase maize yields. Although these findings are useful, it is important to note that the study was based on controlled field experiments mainly in Kitale area of Kenya which could not reflect the actual conditions in small-scale maize fields. This therefore marks a major point of departure in this study which utilised data collected from actual small-scale maize farms.

The influence of both rainfall and solar radiation on maize yields in Kenya has been investigated by Simango (1976). Through the application of the multiple regression model, he established a significant relationship between rainfall and maize yields especially between the periods of sowing and flowering. The relationship was least significant during the flowering to maturing stages of growth. These findings concurred with an earlier observation that maize is extremely sensitive to excessive rainfall in the early stages of growth and to soil moisture deficit during the tasselling stage (Acland, 1971). Simango's (1976) study further established that variations in maize yields in Kenya could not be ascribed to solar radiation differences which were found to be uniform in the country. Besides, he found that radiation income and temperatures were equally fairly uniform in the country. Minimum and maximum temperatures of 18 and 30 degrees centigrade respectively are considered optimal for maize cultivation (F.A.O., 1980). Consequently, neither radiation income nor temperature were considered critical in the present study.

Poor farm management practices prevail in South-Nyanza District where the study area is located. These practices especially late planting have been found to be responsible for low crop yields in the District. The most affected crops in this respect are maize and subsistence food crops like sorghum, beans, cassava and finger millet (Republic of Kenya, 1984a). This is even true with regard to some of the cash-crops in the area especially cotton (Akech, 1985). The influence of previous crop on maize yields has been done by Jones (1975) in Nigeria. He observed that maize fields previously planted with cotton and sorghum had lower yields than those previously planted with groundnuts. He explained this finding to be the possible result of the nitrogen fixing capacity of groundnuts.

While suitable environmental attributes and agronomic practices are needed for improved maize yields, socio-economic factors have a bearing on the actual management of maize farms. These factors include individual attributes of farmers, the availability of and accessibility to required farm inputs and supportive services. In an analysis of maize yields in Vihiga District, Moock (1973) established a positive and significant relationship between maize yields and residual soil fertility. Furthermore, he found that farms managed by women had lower maize yields. Farmers who belonged to the Friends African Mission, a church denomination, were also found to be more competent maize farmers. Formal education was also significantly and positively related to the overall managerial ability of the farmers. Moock (1973) mentioned that small-scale maize farmers tended to use too much labour and too little fertilizer. He therefore concluded that maize output could be improved through an efficient allocation of available farm resources.

Matovu (1979) applied the Cobb-Douglas production function to investigate the efficiency of resource utilization in small-scale farming of maize and cotton in Machakos and Meru Districts of Kenya. He found that marginal value productivities of resources did not differ significantly from marginal factor costs. He therefore concluded that small-scale farmers were relatively efficient in the utilization and allocation of resources between maize and cotton enterprises. Consequently, the re-allocation of resources between maize and cotton enterprises offered little scope for increased crop output. He therefore suggested that expanded adoption of already existing technological innovations such as use of hybrid seed varieties, pesticides and tractors could lead to increased crop output. However, this would depend upon increased economic incentives to farmers.

In South-Nyanza District, extension training of farmers was found to be an important factor influencing the level of farm output (Mugerwa, 1983). In a quantitative analysis of factors affecting cotton yields, Mugerwa (1983) established a positive and significant regression coefficient between yields and farmers' age, sex and size of family labour. Farmers who had attended agricultural courses organized at the local Farmers' Training Centre (FTC) had considerably higher maize yields. Although the study was carried out in the same District as the present one, it was not specifically addressed to small-scale maize farming.

Although much effort has been put in agronomic and breeding research in maize, comparatively less has been put on the adoption of innovations recommended from these investigations. The introduction of hybrid maize in South-Nyanza District was empirically investigated by Johnson (1970). While observing that maize was the dominant crop in the area, he found that very few adopters of hybrid seed were able to sustain its use. Many farmers reverted to the planting of local seed varieties or second generation hybrid seed after initial adoption of hybrid seed. The main reasons for this phenomenon included lack of land, money and farm machinery coupled with farmers' desire to experiment with second generation hybrid. Furthermore, some farmers claimed that hybrid seed produced lower yields compared to local seed varieties. However, Johnson (1970) stressed that the poor husbandry practices prevalent in the area contributed to low maize yields hence the subsequent rejection of hybrid seeds. He further established that the control of productive capital was significantly related to both the adoption of hybrid seed and its sustained use. The size of land owned and the availability of labour were also found to be significantly related to hybrid seed adoption. Johnson's study was however restricted to only one sub-location which is outside the present study area. It was also conducted at a time when hybrid maize seeds were in their initial period of introduction to the farmers.

Gerhart (1974) used probit analysis to investigate the diffusion of hybrid seed in Western Kenya. He noted that the crop accounted for 80% of the starchy staple calories in urban areas and even more in the rural areas of Kenya. From his study, he found the income accruing from cash-crops and farm size to be both positively related to earliness of adoption. The most important explanatory variable in the adoption of hybrid seed was found to be agro-ecological zone. In connection with this, the location of a farm in high altitude and high rainfall areas in Western Kenya increased the likelihood of adoption. The presence of drought resistant crops and off-farm work experience were, however, found to be negatively related to hybrid maize adoption. Other factors considerably related to hybrid maize adoption included formal education, extension visits, knowledge of existing credit facilities and attendance of courses at the local F.T.Cs.[1] He therefore called for improved agricultural services including input supply and extension services to farmers.

Rundquist (1984) investigated the temporal and spatial diffusion patterns of hybrid maize in South-Nyanza District and Central Province Of Kenya. The main finding of his study was that the adoption of innovation packages was closely associated with the existing socio-economic stratification of the rural areas. The farmers in the higher hierarchy were found to be better adopters of innovations and tended to adopt more complex innovation packages. He called for a "welfare approach" to the dissemination of innovations whose main components included an increased access of farmers to the major factors of production, seed distribution points, credit and extension services. Without these measures, he arrived at the conclusion that further dissemination of innovations would magnify the already existing socio-economic stratification. It should be noted that Rundquist's study and the present study differ markedly with respect to the specific areas covered and the analytical techniques employed.

The marketing of maize has important implications for its production and consumption, both of which must be

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1. Farmers Training Centre

equated to avoid maize shortages in Kenya. The country's maize marketing system has attracted numerous studies in which some of its shortfalls have been identified and recommendations put forward to redress them (Massell, 1965; Republic of Kenya, 1966, 1973, 1986; Kariungi, 1976; Gsaenger & Schmidt, 1977; Schmidt, 1979).

The bulk of these studies have tended to concentrate on the formal marketing system with little work done on the informal sector (Schmidt, 1979, p.3). The Kenya maize industry has been afflicted by numerous marketing crises, attracting eight government inquiries between 1922 and 1965 alone (Harrisson, 1970). However, there has been an apparent reluctance to implement recommendations that have been put forward to reorganise the maize marketing system (Schmidt, 1979).

Most criticisms have been levelled against the National Cereals and Produce Board (NCPB), a statutory board with monopoly powers on cereals marketing in Kenya. The frequent maize shortages that have been experienced in the country have been largely blamed on the Board's failure to provide adequate outlets for maize surpluses from farmers and its inability to maintain adequate reserves (Massell, 1965; Kenya, 1973, 1981; Gsaenger & Schmidt, 1977). Massell (1965) described the formal marketing system as too rigid and lending itself to opportunities for graft and corruption thereby encouraging the emergence of a black-market for maize. Kariungi (1976) noted that the then

Maize and Produce Board (now NCPB) had a minimal share in the supply of maize in Kitui District, the bulk of the supply being handled by illicit informal traders.

The maize pricing policy of the NCPB has also attracted criticisms. Producer prices of maize in Kenya have been found to lack appropriate regional differentiation which could eliminate inefficient maize producers in marginal areas, thereby encouraging high production costs of maize (Republic of Kenya, 1973; Gsaenger & Schmidt, 1977). Temporal maize producer prices have been such that they do not act as an incentive to farmers and private traders to utilise their own storage facilities. This could lessen the pressure on the storage facilities run by the NCPB (Schmidt, 1979).

Amongst the recommendations that have been put forward to streamline Kenya's maize marketing system is the elimination of some existing controls on maize trade. The role of the of the NCPB also needs to be newly defined. The elimination of artificial barriers to inter-district movements of maize and greater participation of the private sector in grain marketing have been recommended to improve maize marketing in the country (Massell, 1965; Republic of Kenya, 1981, 1983; Schmidt, 1974). Already steps are being taken to gradually decontrol the maize marketing system such that the private sector gains a greater participation in the maize trade. The NCPB's role has been newly defined to include the maintenance of a national grain reserve consisting of four million tonnes of maize besides acting as a buyer of last resort (Republic of Kenya, 1981). In order to perform the former function, the Board's internal management will need to be improved (Republic of Kenya, 1986). Miracle (1966, p.226) recommended that maize marketing should be left exclusively to the private sector. However, it has been noted that this may not be possible in the Kenyan context because of the special significance of maize in the economy (Massell, 1965; Gsaenger & Schmidt, 1977). It is apparent that maize marketing in Kenya should be organised to allow a harmonious participation of botn the private sector and the statutory board.

Schmidt (1979) examined the probable effects of a relaxed maize marketing system in Kenya. He observed that the existing controls largely prohibit the free exchange of maize between surplus and deficit areas and have not achieved the objectives they were designed for. He therefore called for a relaxation of the controls and an increased participation of the informal sector, the major channel for small-holder maize producers and rural consumers (Schmidt, 1979, p.121).

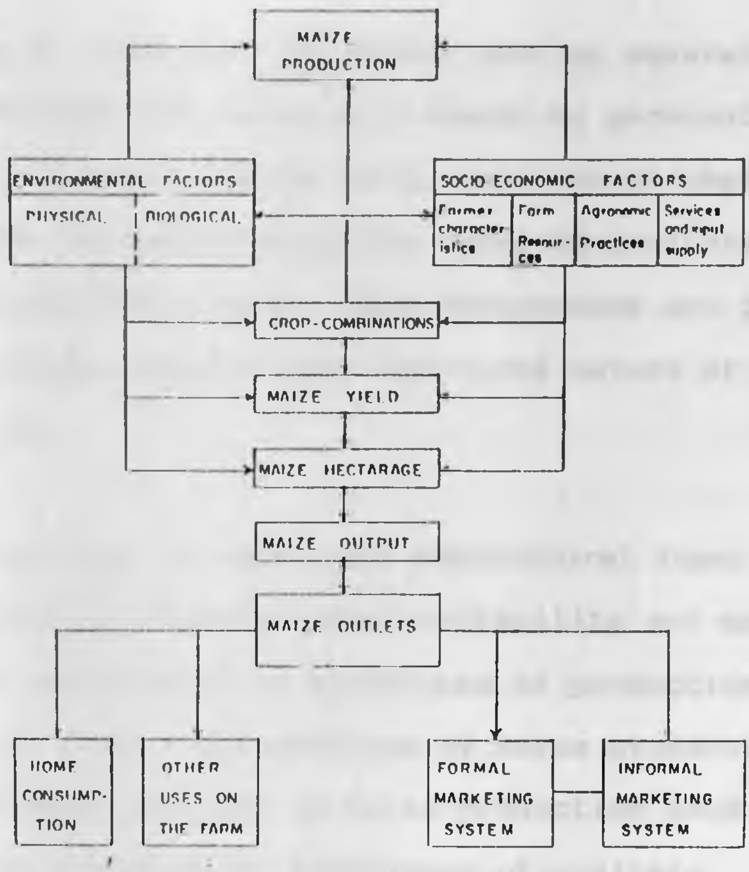
With regard to general maize policy in Kenya, the official food policy contained in the Sessional Paper No.4 of 1981 (Republic of Kenya, 1981) contains useful guidelines for action. The paper observed that the food shortages witnessed in Kenya in 1980 (which led to the importation of 350,000 tonnes of maize) was the result of population increase, the failure of the National Cereals and Produce Board (NCPB) to purchase all the maize from farmers, and adverse weather conditions. According to the Paper, the demand for maize in Kenya increases by 1 million bags per annum. The paper indicated that the country would require 9,400 additional hectares of maize to achieve domestic self-sufficiency in 1989. It noted that much of the anticipated increase in maize output would come from improved crop yields through intensified production. It emphasized heightened maize research focussing particularly on improved yields through genetic improvements. Other measures outlined included adequate supplies of seed by the Kenya Seed Company, availability of land preparation services, increased fertilizer and credit use, better handling and storage of crops by small-scale farmers. It estimated that approximately 16% of small-holder maize production is lost during the post-harvest period as a result of inadequate storage facilities. These recommendations were later echoed in the Sessional Paper no.1 of 1986 (Republic of Kenya, 1986) which emphasized increased economic growth through the utilization of available domestic resources.

It is apparent from the literature review that several aspects of maize production and marketing in Kenya have been considered by a wide range of researchers and scholars. In general, most of the non-empirical accounts are valuable but cannot offer recommendations applicable specifically at the micro-level. Furthermore, some of the empirical studies have been based on data generated under controlled experimental conditions which might not reflect what actually goes on in the field. These two aspects offer a reasonable ground for the justification of the present study. It is also apparent from the literature review that the role of physical parameters and agronomic variables have tended to be emphasised to the neglect of socio-economic variables which form an important ingredient of the farm environment especially with respect to the adoption of innovations. This study is an attempt to bridge this gap through a multivariate treatment of the various variables influencing maize production. Finally, studies explicitly addressed to maize hectarage variations within the small-scale farming sector are particularly lacking in addition to those concerned with informal maize marketing. These two important aspects have been given prominence in this study.

1:4 CONCEPTUAL FRAMEWORK:

Fig. 1.3 below is a conceptual representation of the major features dealt with in the present study. Real world variables and their interaction are infinitely complex and a reasonable simplification is necessary to capture the major features of their complexity.

FIG 1.3 A CONCEPTUAL FRAMEWORK FOR A GEOGRAPHICAL ANALYSIS OF SMALL-HOLDER MAIZE PRODUCTION



A complete variable list in any research is "infinitely large.....and the job of the social scientist is to simplify it by selecting a finite number of variables on the basis of existing theory and research" (Moock, 1973, p.73). The conceptualisation of a problem can also be based on ones personal experience.

Agricultural production is one of the most prominent human activities in terms of use of space. The major aspects of maize production therefore have distinct spatial dimensions in so far as each can be traced to an individual location at the farm level. The location of maize production and the resultant spatial patterns is the aggregate of individual decisions made by several farmers. These decisions are invariably shaped by personal characteristic of farmers, farm resources at their disposal in addition to competition from other agricultural and non-agricultural enterprises. Such enterprises are defined by the individual needs of the farmer and nature of the environment.

The provision of essential agricultural input and services partly influence the availability and use of farm resources and associated techniques of production hence influencing locational patterns of maize production. The spatial characteristics of maize production lend themselves readily to geographical techniques of analysis.

The crop-mix in a particular farm reflects both the capacity of the environment to support diverse crops and the farmers' attempts to meet their multiple needs. Taken in aggregate, crop combinations in every farm can reveal distinct and broader crop-combination regions. These can help in understanding the apparent chaotic crop diversity within the small-scale farming sector. In addition, such regionalisation can indicate the relative position of maize in the overall agricultural economy of the study area. Since such information identifies the crops mostly associated with maize, the long term prospects of maize production in a particular area can be estimated on the basis of competing crops likely to override its production.

Crop associations in individual farms and the resultant crop combination regions are theorised to be the result of farmers' decisions, as shaped by prevailing environmental, agronomic and socioeconomic attributes.

Maize yields and hectarages are functions of prevailing physical, biological and socioeconomic attributes within and without the farm, all interlinked in a complex manner. Variations in any of the attributes lead to changes in both variables. However, it is expected that socioeconomic characteristics should exert a greater influence on maize production since they largely define the farmer's capability to make and implement sound farming decisions. The implication here is that low maize yields is more of a socioeconomic rather than an environmental or technical problem. Because of diversity in farmers' characteristics and the variables influencing them, regional differences in maize yield and hectarages can be detected even within a small study area. It is important to note the close relationship between maize yield and hectarage. A farmer obtaining high maize yields can reduce the amount of land devoted to the crop without necessarily reducing the gross harvest. On the other hand, a farmer having a large land area under maize cultivation can record comparable harvest as a consequence of low yield levels.

The achievement of high maize yields presupposes the complete adoption of relevant innovations suitable to prevailing environmental conditions. The decision to adopt a particular innovation is, however, personal and rests on the individual farmer. On the assumption that a farmer has adequate information about a particular innovation, the decision to adopt is influenced mainly by the perceived superiority of the new innovation to the already existing practices. In addition, the farmer has to decide whether the innovation is actually necessary, for example, whether there is need to improve yields beyond their prevailing levels. In this instance, aspects of the farmers' motivation become important. The socioeconomic circumstance of the farmer also influences the decision to adopt an innovation especially if such involves an additional expenditure of time, energy and money. The adoption of recommended innovations in maize production is therefore expected to depend on prevailing agronomic practices, individual characteristics of farmers, environmental attributes and other socioeconomic circumstances facing the potential adopter.

The maize marketing system has the dual function of not only offering an outlet for the farmers' surplus maize but also acting as a source whereby the farmer can procure maize to stem deficits at the farm. The marketing system therefore brings together both the farming and non-farming community. The reliance on the maize marketing system for either the disposal or procurement of maize depends largely on the existence of either a surplus or deficit as defined by the total maize output realized. The structure of the maize marketing system, and the efficiency with which it operates is therefore linked to all the variables influencing agricultural production at the farm level. The same is equally related to the food and cash needs of both the agricultural and non-agricultural population.

The conceptualisation of the problem of small-scale maize production stresses the complex interlinkages between variables and the reflection of such linkages in space. The problem at hand therefore makes the application of geographical and multivariate methods of data analysis and presentation necessary.

1:5 JUSTIFICATION OF THE STUDY.

This study is of both practical and academic significance. It is broadly concerned with agriculture which is the most important activity in Kenya's economy and specifically with maize, the most important staple food crop in the country today. To sustain domestic self-sufficiency in maize through intensified production, there is a constant need to investigate the problems inhibiting maize production within the small-scale farming areas of Kenya.

Maize yields in the study area are not only low but also declining. An examination of the possible reasons for this trend need to be investigated if they are to be consciously reversed for the better. No empirical investigation on maize production of the nature attempted in this study has been done in the study area. Diverse variables giving character to agricultural activities dictate that they should be so treated in any meaningful investigation. Crop combination analysis of the kind attempted in this study forms an important aspect of methodological approaches in Agricultural Geography which has not yet been attempted in the country although significant developments have occurred elsewhere.

The adoption of innovations is an important aspect of agricultural development anywhere, given the twin problems of diminishing arable land and an increasing population whose food needs must be adequately met. Research leading to improvements in agricultural techniques are not very important until the innovations are ultimately adopted at the farm-level.

The choice of Rongo Division in South-Nyanza District as the area of study has been influenced by a number oi reasons, namely:

1. The area has a higher potential for agricultural production compared to other parts of South-Nyanza District. This potential has not yet been fully exploited. While it is the most important maize growing area in South-Nyanza District, maize yields still fall below the expected standards and contrasts markedly with the neighbouring Kisii district.
2. Small-scale farming is dominant in the study area

with a marked population pressure on available land. It therefore presents a reasonable scenario in which problems of small-scale maize production can be investigated.

3. The area is undergoing a period of rapid transition towards small scale commercial farming following the recent introduction of lucrative cash-crops such as sugar-cane, coffee and tea. The effect of cash-crops on food production within the small-scale farming sector can therefore be investigated.

Although the study area is limited in areal extent, findings from this study are applicable in broad policy designs aimed at intensified maize production. This is true not only in the study area but also other small-scale farming areas having similar characteristics. Further more, agricultural research based on small areas is invaluable due to its specificity (Kenya, 1983). Recommendations are more valuable when they can be readily applied to specific agricultural enterprises, agro-ecological zones or groups of farmers.

1:6 OBJECTIVES OF THE STUDY:

The main objectives of the present study are itemised into three broad areas namely:

1. To analyse the influence of the bio-physical environment, agronomic and socioeconomic factors

on spatial variations in small-scale maize production.

2. To examine the major variables influencing the adoption of relevant innovations in maize production.
3. To describe and evaluate the maize marketing system in the study area.

1:6:1 <u>DETAILED BREAKDOWN OF OBJECTIVES.</u>

1. To analyse the influence of environmental, agronomic and socioeconomic factors on spatial variations in small-scale maize production:
   - (a) To identify the major crop combinations in the study area and discuss the implications they have on maize production.
   - (b) To analyse factors influencing spatial variations in maize yield:
     - i. To analyse the influence of environmental factors on maize yield namely: agro-ecological zones, rainfall and soil conditions.
     - ii. To examine the influence of agronomic practices on maize yield namely: date of planting, application of fertilizer, intercropping, use of hybrid seed, land preparation date, first weeding date and crop rotation.

iii. To examine the influence of individual attributes of farmers on maize yield namely: sex, age, educational level, occupation, religion, receipt of remittances and absence of farm owner from farm.

iv. To examine the influence of socioeconomic factors on maize yield namely: physical farm resources (total land, total area devoted to maize, number of maize fields planted, total land devoted to coffee and sugar-cane, ownership of ox-plough team/tractor, mode of land acquisition, possession of land title, accessibility to credit and extension services) and human resources (total farm population, size of family labour, use of casual and communal labour).

(c) To analyse the major factors contributing to maize hectarage variations namely: environmental factors, agronomic practices and socioeconomic characteristics within and without the farm environment.

2. To examine and account for the nature and extent of the adoption of innovations relevant to maize production namely, the use of hybrid seed varieties, the application of commercial fertilizer and/or farm manure.

(a) To examine the prevailing adoption patterns in the study area.

(b) To examine selected environmental and socioeconomic factors influencing the adoption of innovations in maize production.

3. To describe and evaluate the maize marketing system in the study area:

(a) to identify and describe existing maize marketing structures in the study area.

(b) To describe and account for the utilisation of identified marketing structures in the study area.

(c) To account for variations in quantities of maize sold by small-holders.

(d) To evaluate the performance of the informal marketing system on the basis of:

i. characteristics of markets and traders

ii. the organization of the informal trade

iii. amounts of maize handled by traders

iv. price variations of maize

1:7 NULL HYPOTHESES:

This study tested the following null hypotheses:

1. Environmental, agronomic and socioeconomic factors do not significantly influence spatial variations in maize yield.

2. Selected environmental, agronomic and socioeconomic factors do not significantly explain spatial variations in maize hectarage.
3. Variations in the level of adoption of innovations are not attributed to variations in environmental, agronomic and socio-economic factors.
4. Socio-economic factors do not significantly explain variations in the amounts of maize handled and maize prices within the informal marketing system.

1:8 SCOPE AND LIMITS OF THE STUDY.

This study investigates selected variables affecting several aspects of maize production including crop combinations, yield and hectarage variations; the adoption of innovations, and the marketing of maize. It should be realised that a complete variable list is often impossible in any research in the social sciences. The variables dealt with in the present study have been carefully selected on the basis of existing research and personal experience. Any variable left out is in no way irrelevant but has not been included only to keep the analysis within manageable limits. Since the bulk of information utilised in the present study is mainly derived from primary sources, many potentially relevant factors have been left out so as to cut down on interview time.

In investigating the yield determinants, potentially useful variables have been excluded. These include diseases and pests. The rainfall and soil variables have also been measured in general terms. However, these are considered matters of detail outside the scope of this study. This study is time specific such that temporal variations in crop combinations, maize yields, hectarages, and adoption patterns have not been specifically dealt with. Although such would have been more useful,they were excluded to keep the study within manageable limits. The study is also limited to only one administrative division in South-Nyanza District. However, this need not restrict the usefulness of the research finding to other areas with similar characteristics.

1.9 SUMMARY OF CHAPTERS.

This study is organised into three main parts. The first three chapters form the first part and have dealt with the study problem, study area and research methodology.

Part two consists of chapters four, five and six in which data analysis and results are presented. The analysis of crop combinations, maize yield and hectarage variations are presented in chapter four. The adoption of relevant innovations in maize production is dealt with in chapter five. Chapter six deals mainly with maize marketing in the study area.

A summary of the major findings, conclusions and recommendations are contained in chapter seven, the only chapter in section three.

CHAPTER TWO - BACKGROUND TO THE STUDY AREA

CHAPTER TWO - BACKGROUND TO THE STUDY AREA

This chapter gives an overview of the main physical and socio-economic characteristics of the study area. Environmental attributes provide a broad framework within which human efforts are employed to support diverse agricultural enterprises. On the other hand, these human efforts are partly determined by the socio-economic factors within and without the farm environment. This background therefore provides a useful basis for the selection of variables considered critical in maize production for statistical analyses in the ensuing chapters. The background is also invaluable in the interpretation of relationships established between variables established in later chapters.

2:1 LOCATION AND SIZE

This study was undertaken in Rongo Division, one of the nine administrative units of South Nyanza District, Western Kenya (Fig. 1.1 & 1.2). Rongo Division is roughly bound by longitudes 34 degrees 40'E and 34 degrees 30'E in the east and west respectively; and latitudes 0 degrees 40'S and 1 degrees 00'S in the north and south. It occupies the extreme western side of South-Nyanza District. It derives much of its climatic aspects from the Lake Victoria in the west and the Kisii Highlands in the East.

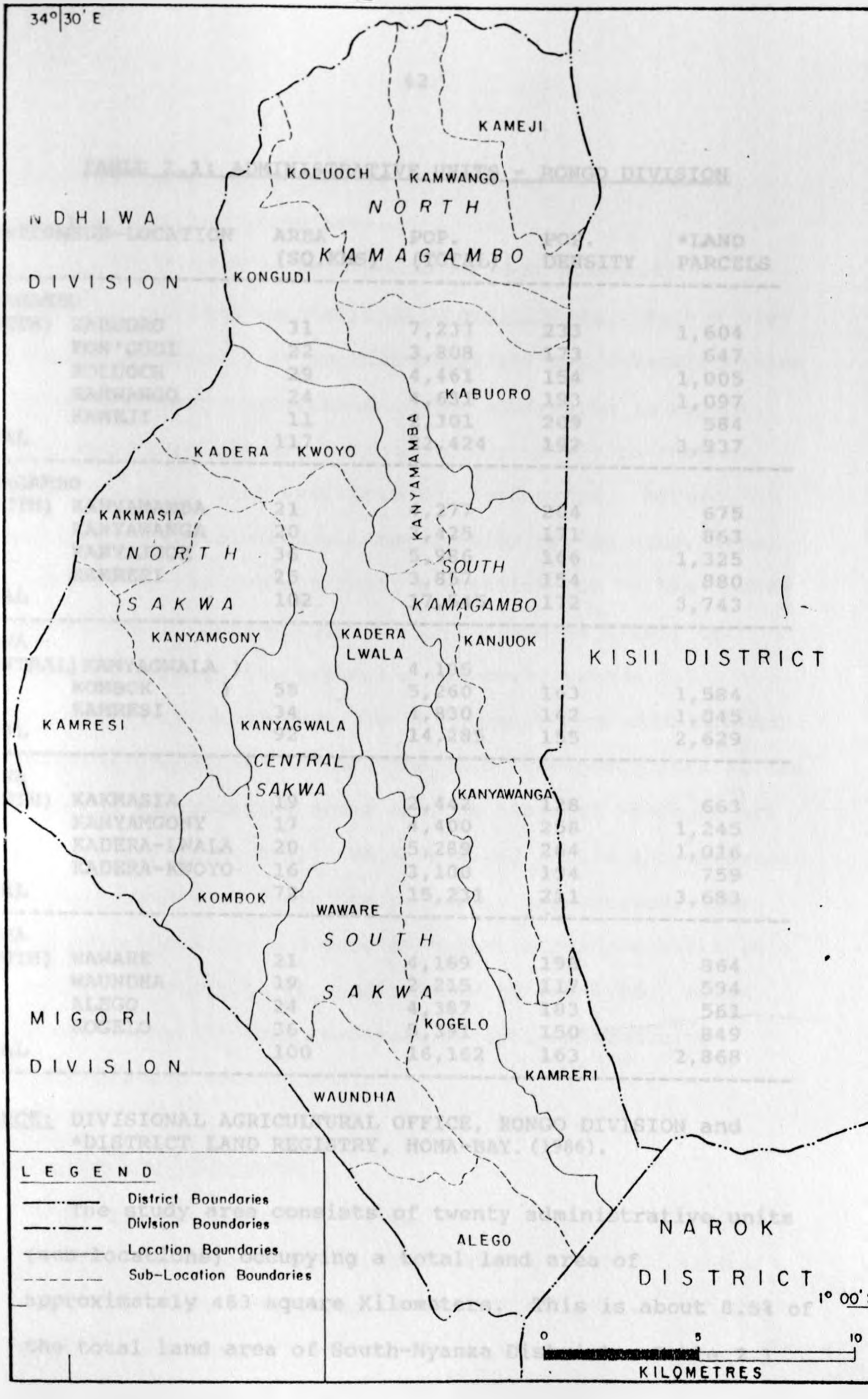


Fig. 2.1 RONGO DIVISION : ADMINISTRATIVE UNITS

TABLE 2.1: ADMINISTRATIVE UNITS - RONGO DIVISION

LOCATION/SUB-LOCATION		AREA (SQ.KMS)	POP. (TOTAL)	POP. DENSITY	*LAND PARCELS
KAMAGAMBO (NORTH)	KABUORO	31	7,233	233	1,604
	KON'GUDI	22	3,808	173	647
	KOLUOCH	29	4,461	154	1,005
	KAMWANGO	24	4,631	193	1,097
	KAMEJI	11	2,301	209	584
TOTAL		117	22,424	192	3,937
KAMAGAMBO (SOUTH)	KANYAMAMBA	21	4,277	204	675
	KANYAWANGA	20	3,425	171	863
	KANYAJUOK	36	5,986	166	1,325
	KAMRERI	25	3,857	154	880
TOTAL		102	17,545	172	3,743
SAKWA (CENTRAL)	KANYAGWALA)		4,195		
	KOMBOK)	58	5,260	163	1,584
	KAMRESI	34	4,830	142	1,045
TOTAL		92	14,285	155	2,629
SAKWA (NORTH)	KAKMASIA	19	2,442	128	663
	KANYAMGONY	17	4,400	258	1,245
	KADERA-LWALA	20	5,289	264	1,016
	KADERA-KWOYO	16	3,100	194	759
TOTAL		72	15,231	211	3,683
SAKWA (SOUTH)	WAWARE	21	4,169	198	864
	WAUNDHA	19	2,215	117	594
	ALEGO	24	4,387	183	561
	KOGELO	36	5,391	150	849
TOTAL		100	16,162	163	2,868

SOURCE: DIVISIONAL AGRICULTURAL OFFICE, RONGO DIVISION and *DISTRICT LAND REGISTRY, HOMA-BAY. (1986).

The study area consists of twenty administrative units (sub-locations) occupying a total land area of approximately 483 square Kilometers. This is about 8.5% of the total land area of South-Nyanza District. Table 2.1

shows the size variations of all the sub-locations constituting the study area.

The whole area is designated as high potential agricultural land (Republic of Kenya, 1984a). With a high population density of approximately 177/km, intensification of agricultural production in the study area is urgent. The cash-crops already introduced are likely to further diminish total land available for food crops. Already sugar-cane has claimed a large portion of the study area, occupied by the nucleus sugar plantation run by the South-Nyanza Sugar Company (SONY). This trend is likely to continue through the expanding outgrower scheme.

Locational advantages the Division enjoys with respect to maize production include the good transport links it has with the neighbouring areas and the District headquarters in Homa-Bay (Fig. 2.2). Both required inputs and marketed maize produce can therefore be easily transported. Its strategic position and good transport links places it in a favourable position to supply maize to low-lying, maize deficit areas in South-Nyanza District, neighbouring districts and even Tanzania.

2:2 PHYSICAL BACKGROUND

2:2:1 PHYSIOGRAPHY AND SOILS.

Lying between an altitudinal range of 4300 to 5300 feet, the study area occupies the eastern plateau of the Lake Victoria Basin. The northern and eastern portions of the area consist of a rugged landscape of valleys and hills reflecting the beginning of the Kisii Highlands. The central and southern parts are dominated by a rather flat landscape which must have influenced the location of the nucleus sugar plantation found there. There is a general rise in elevation eastward towards the Kisii Highlands. The drainage pattern is dominated by Sare and Kuja rivers together with their tributaries (Fig. 2.3). Both rivers rise from the Kisii Highlands, flowing eastward towards the Lake Victoria.

Maize cultivation is only limited at altitudes beyond 2400 metres above sea level. On account of altitude alone, the area is apparently suitable for maize production. The topography can have an influence on maize production through indirect effects on soil characteristics. Waterlogging in the flat areas of the central and southern parts is detrimental to maize growth especially in its early stages. The workability of soils in such areas is also made difficult. However, waterlogging is a highly localised phenomenon in the study area.

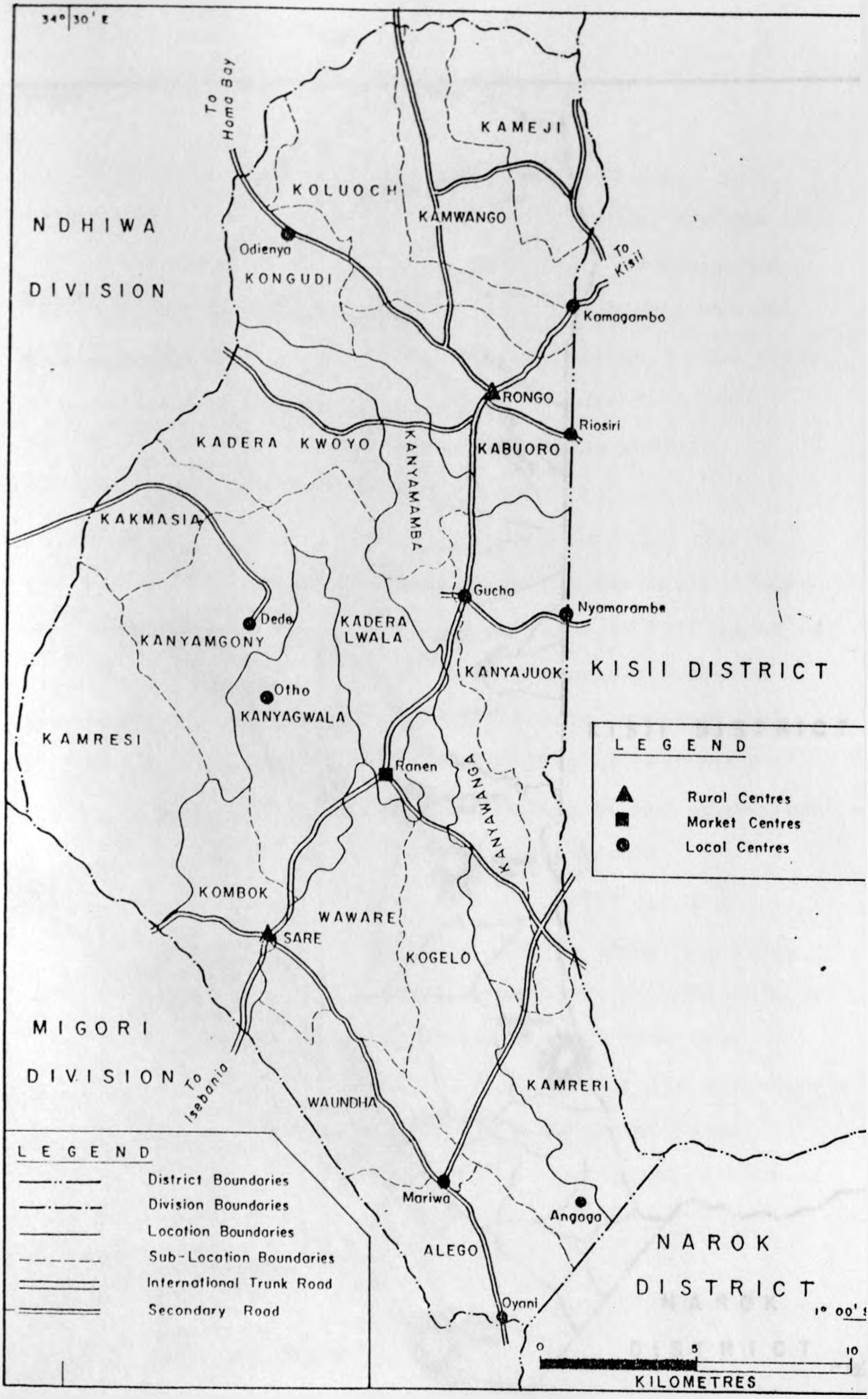


Fig.2.2 RONGO DIVISION : COMMUNICATION NETWORK AND MARKET CENTRES

Fig. 2.3 RONGO DIVISION : PHYSICAL FEATURES

Soils in Rongo Division are predominantly clays with highly localised variations attributable to differences in topography and underlying parent material. Jaetzold and Schmidt (1982, pp.143-46) have given a reasonable account of major soil types and their fertility status in the study area. Well-drained soils ranging in texture from sandy clay, clay loam to clay predominate. These include cambisols, phaezoms and luvisols.

Maize requires well-drained and fertile soils and is particularly sensitive to waterlogging in the early stages of growth (Acland, 1971). Since variation in soil types is not marked in the study area, it is reasonably expected that soil fertility status can have a more important bearing on maize yields. The suitability of particular soils to a given crop is dependent mainly on the prevailing nutrient status of the soil and the nutritional requirements of the crop in question. Maize has a particularly high requirement of nitrogen (Miracle, 1966, P.11). Figure 2.4 shows marked regional variations in soil fertility status in the study area, ranging from low, moderate to highly fertile soils. Highly fertile soils are restricted to the south-eastern parts while the least fertile soils are found exclusively in localised patches in the south.

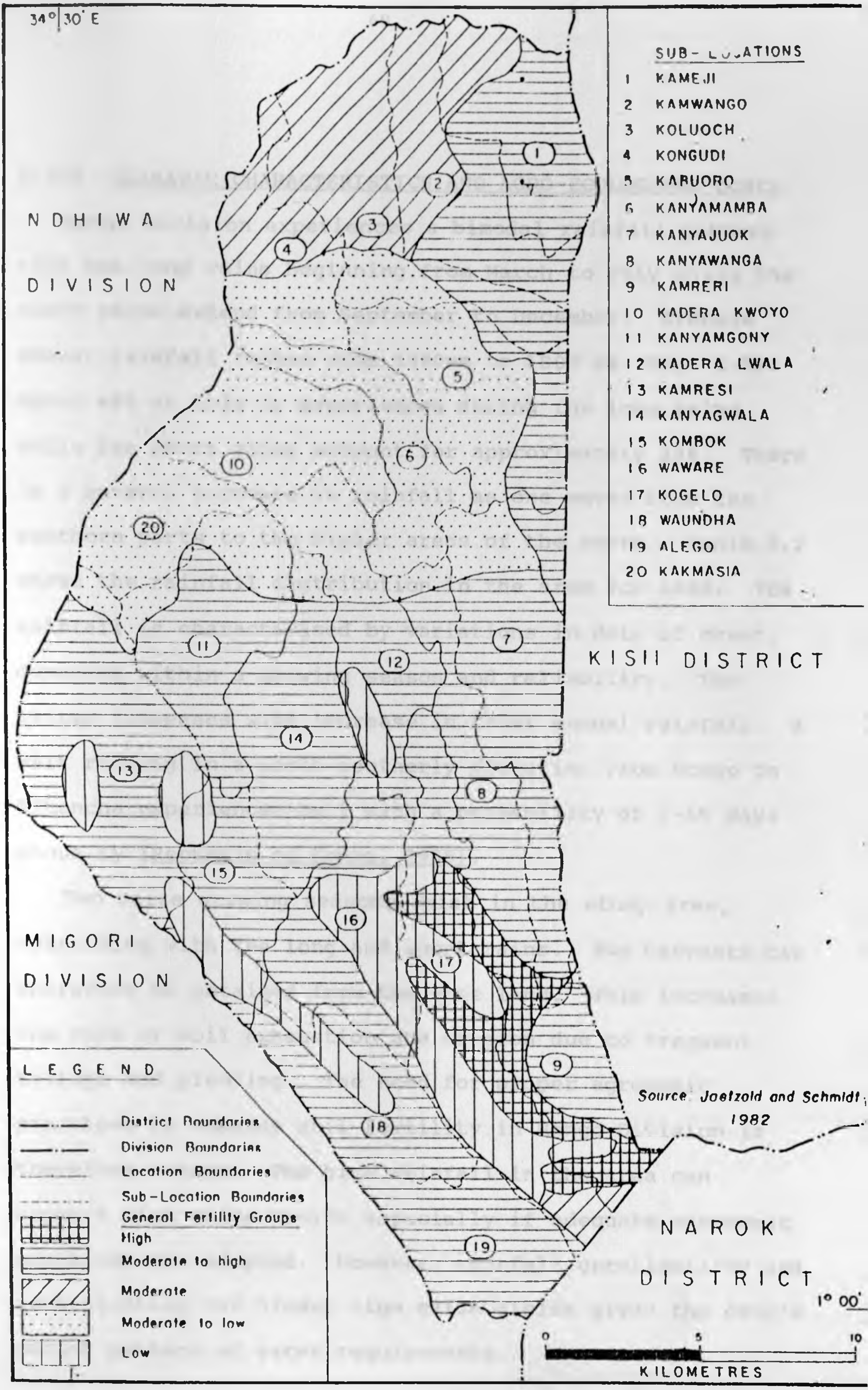


Fig. 2.4 RONGO DIVISION: SOIL FERTILITY

2:2:2 CLIMATIC CHARACTERISTICS AND AGRO-ECOLOGICAL ZONES.

Rongo Division experiences a bimodal rainfall pattern with the long rains beginning from March to July while the short rains extend from September to December. Average annual rainfall ranges from 1400mm to 1800 mm (Fig. 2.5). About 40% of this is experienced during the long rains while the short rains account for approximately 28%. There is a general increase in rainfall as one moves from the southern parts to the higher areas of the north. Table 2.2 shows the rainfall distribution in the area for 1986. The rainfall is characterised by variations in date of onset, duration within a growing season and reliability. The latter increases with increase in total annual rainfall. A belt running in a north-southerly direction from Rongo to Kihancha experiences hail with a probability of 3-15 days annually (Republic of Kenya, 1985).

Two maize growing seasons exist in the study area, coinciding with the long and short rains. Two harvests can therefore be obtained from the same land. This increases the risk of soil exhaustion and erosion due to frequent tillage and planting. The need for proper agronomic practices to enhance soil fertility in Rongo Division is therefore urgent. The high rainfall in the area can support high maize yields especially if adequate agronomic practices are adopted. However, rainfall unreliability and late planting can hinder high maize yields given the crop's strict pattern of water requirements.

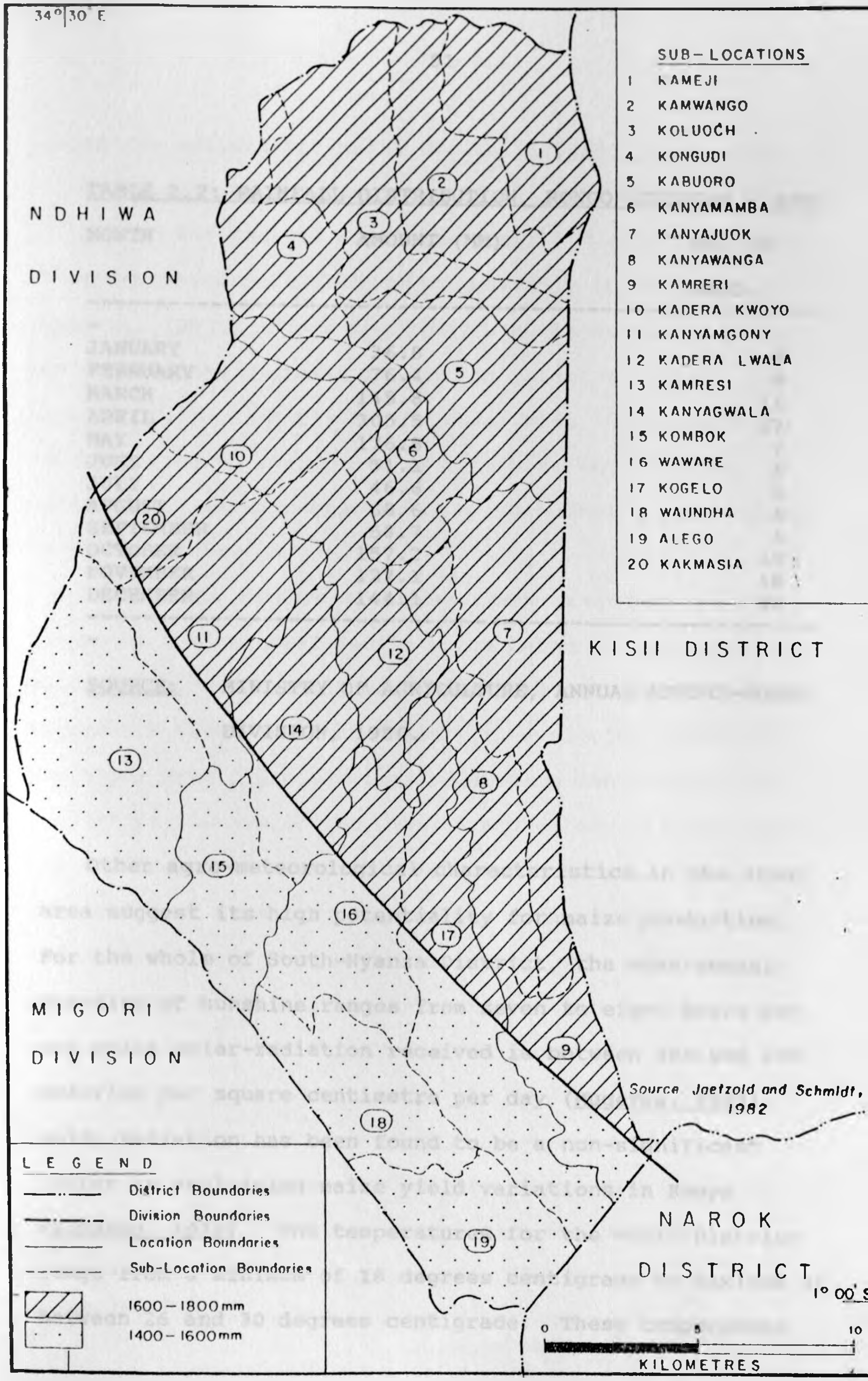


Fig.2.5 RONGO DIVISION : AVERAGE ANNUAL RAINFALL

TABLE 2.2: RAINFALL DISTRIBUTION, RONGO DIVISION - 1986

MONTH	AMOUNT (MM)	NO. OF DAYS.
JANUARY	36.8	6
FEBRUARY	76.4	8
MARCH	145.8	11
APRIL	305.5	17
MAY	176.8	7
JUNE	51.1	4
JULY	46.6	2
AUGUST	68.6	4
SEPTEMBER	58.7	4
OCTOBER	157.2	13
NOVEMBER	127.1	18
DECEMBER	144.1	20

SOURCE: MINISTRY OF AGRICULTURE, ANNUAL REPORT-RONGO DIVISION, 1986.

Other agro-meteorological characteristics in the study area suggest its high potentiality for maize production. For the whole of South-Nyanza District, the mean annual duration of sunshine ranges from seven to eight hours per day while solar-radiation received is between 300 and 400 calories per square centimetre per day (Mugerwa, 1983). Solar radiation has been found to be a non-significant factor in explaining maize yield variations in Kenya (Simango, 1976). The temperatures for the whole District range from a minimum of 18 degrees centigrade to maximum of between 26 and 30 degrees centigrade. These temperature ranges are optimal for maize growth (Acland, 1971). The relative humidity for the whole of the Lake Victoria Basin is between 80% and 90% in the morning; 70% and 80% in the afternoon varying slightly with proximity to the Lake (Mugerwa, 1983). Since the study area is on the eastern rim of the Lake Victoria Basin, its relative humidity is expected to be slightly on the lower side. High relative humidity impedes the uptake of soil nutrients and can affect maize storage especially by encouraging mould growth on stored grains.

The concept of agro-ecological zone comprises a composite agricultural region which takes into account the suitability of the total environment to particular crops. Figure 2.6 shows the four major agro-ecological zones in the study area. The marginal sugar-cane zone covers the western portion while the central and extreme eastern parts are designated as sugar-cane zone and coffee-tea zone respectively. The coffee zone covers the southern tip of the Division bordering Narok District. From the zonation, it is apparent that virtually every portion of the study area is suitable for the three cash-crops (Coffee, tea, sugar-cane).

The foregoing overview of environmental characteristics of the study area suggests that the achievement of high maize yields is feasible although this would require adequate soil management practices, the adoption of appropriate maize varieties and sound agronomic practices.

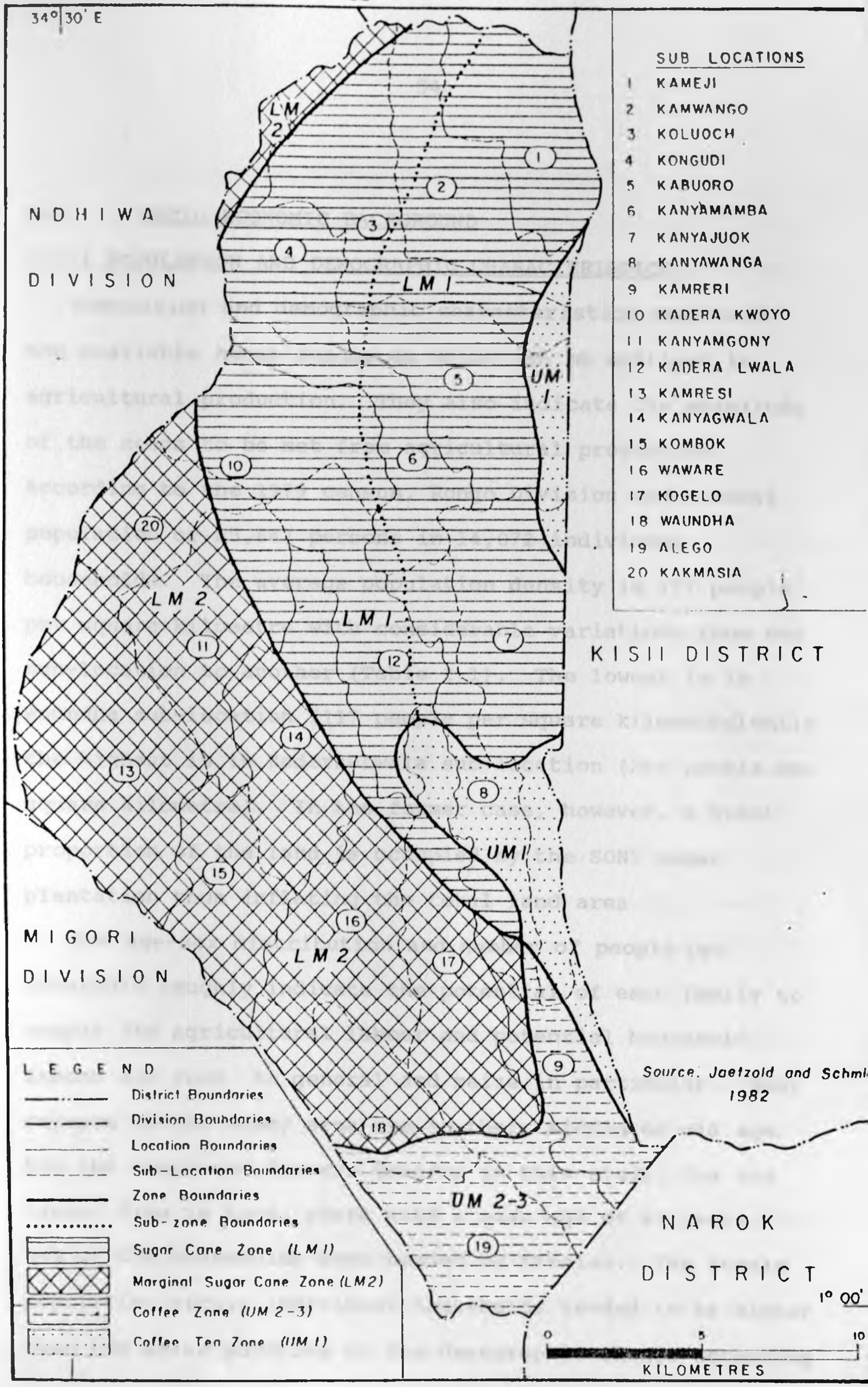


Fig.2.6 RONGO DIVISION : AGRO-ECOLOGICAL ZONES

2:3 SOCIO-ECONOMIC BACKGROUND

2:3:1 POPULATION AND DEMOGRAPHIC CHARACTERISTICS.

Population and demographic characteristics represent the available human resources which can be utilised in agricultural production. They also indicate the magnitude of the needs to be met from agricultural production. According to the 1979 census, Rongo Division had a total population of 85,647 persons in 14,072 individual households. The average population density is 177 people per square kilometre with considerable variations from one sub-location to another (Table 2.1). The lowest is in Waundha sub-location (117 people per square kilometre) while the highest is in Kadera-Lwala sub-location (264 people per square kilometre). In the former case, however, a great proportion of the land is occupied by the SONY sugar plantation thus inflating the total land area.

The age-sex distribution and number of people per household roughly indicate the potential of each family to supply its agricultural labour and potential household demand for food in general and maize in particular. Most farmers in the study area are in their middle or old age. For the sample of farmers covered in this study, the age ranged from 19 to 83 years with a mean age of 47 years. 18% of the households were headed by females. The female population within individual households tended to be higher than the males pointing to the demographic change occurring in the area and the increasing role of women in agricultural development. Each household consisted of an average of five persons, although the number ranged from 1-20 persons. The low average population per household implies that casual labour is becoming increasingly critical in agricultural production.

Of importance to agricultural development is the quality of the human resource as defined by educational and employment characteristics. For a sample of farmers in the study area, 93% of the total household heads had either no formal educational background (42.5%) or never went beyond primary school(50.5%). The low educational standards in the area has considerable bearing on the prevailing low standards of crop and livestock husbandry. 68.5% of the farmers interviewed had no regular source of income apart from farming. This is a reflection of the low educational standards since the chances of acquiring wage employment increases with educational achievements. It also reflects the tendency for the well-educated to migrate to urban areas where most wage-employment opportunities are found. The restricted opportunities for wage employment suggests that resources for financing agricultural operations are scarce in the study area.

Most rural families receive additional household income from relatives in wage-employment outside the farm. 44% of the households visited in the present study admitted receiving such transfer payments. These are mostly irregular although their role as a source of finance for agricultural purposes should not be underestimated. The problem of absent household heads were reported in only 20% of the households surveyed in this study.

While religion may not be readily appreciated as an important element in agriculture, church membership greatly helps as a vehicle for the dissemination of agricultural information. Church groups can also mobilise members for communal farming operations. In the study area most farmers belong to one of the many existing christian dominations and only 1.5% of the sample of farmers belonged to no particular church.

2:3:2 AGRICULTURAL ECONOMY OF THE STUDY AREA.

The interplay of human and environmental attributes gives character to the state of agriculture in any particular area. It is on the available land that farmers, depending on their individual characteristics, apply different proportions of inputs to support particular agricultural enterprises. This section considers the agricultural economy of the study area under three sub-headings, namely: land tenure and land use; production characteristics of maize; and finally the availability of agricultural inputs and services.

(a) LAND TENURE AND LAND USE CHARACTERISTICS.

Land ownership is an important aspect in agricultural development since it influences land-use patterns and the size distribution of farms. Security of tenure determines the intensity with which land can be utilised and the amount of long term investments a farmer can undertake. Table 2.3 presents the major types of land-ownership prevalent in the study area. Land inheritance is a common means of land acquisition in many traditional African

TABLE 2.3: LAND-TENURE SYSTEMS-RONGO DIVISION

	NO. OF FARMS	%
INHERITANCE	159	79.50
PURCHASE	20	10.00
TENANCY	2	1.00
LEASE	1	0.50

Source: Sample Farm Survey: Rongo Division, 1986/87.

communities. Under this system, land belongs to the male head of the household and is divided amongst the male children upon his death or as soon as any of the children has established an independent household. This mode of land transfer has contributed to declining sizes of individual farm units. Land acquisition through purchase has the same effect but is not very extensive in the study area. The practice is becoming more intense in areas close to the sugar-cane growing zone and in those adjacent to the major market centres such as Rongo. This trend indicates the increasing attractiveness of sugar-cane cultivation and the expanding urban land-use in the study area.

Land tenancy is not widespread in the study area and usually involves absentee or older farmers offering settlements to landless relatives. The utility of land for agricultural credit in such cases is quite limited because of the absence of security of tenure. Leasing is normally done on the basis of mutual exchange of land parcels for particular agricultural purposes over short time periods. This form of land acquisition is beneficial since it allows farmers to get access to land suitable for specific purposes without expending any money. However, because of its short term nature, it can lead to land mining. In addition, long term investments on leased land are quite rare.

It is only the possession of registered land titles that can enable a farmer to acquire credit from financial institutions. Only 62.5% of the farmers included in the present survey admitted the possession of land titles. This is probably attributable to the different methods of land acquisition prevalent in the study area and the incomplete land adjudication and registration exercise. However, when the number of farmers possessing land titles is compared to those who received credit (5.5%), it becomes apparent that the possession of registered titles alone is not a guarantee for credit.

Total amounts of land owned by farmers are not only small but continue to diminish as a result of the prevailing land tenure system and population increase. For the farms sampled, the average farm size was 4.9 hectares (standard deviation of 3.3). The number of separate plots of land per farmer ranged from one to four, roughly indicating land fragmentation. Small and diminishing farm sizes discourage economic use of labour saving machinery. They can also lead to environmental degradation attributed to continuous use without allowing for adequate fallow periods. Scarcity of land is expected to have a significant influence on maize yields and hectarages in the study area.

Small-scale arable farming and livestock raising are the most dominant enterprises in the study area. Large-scale commercial farming is restricted to the nucleus sugar plantation at Awendo. The main cash-crops grown are sugar-cane, coffee, and tobacco with maize, sorghum, beans, groundnuts and vegetables as the major food-crops. Maize is the leading staple in the Rongo Division in terms of hectarage planted (Table 2.4).

Despite the population pressure on land, uncultivated portions of land exist. This phenomenon can be explained by several reasons. Lack of farm implements, ill-health and old age restrict land cultivation in some cases. In other cases, the apparently unused land is left fallow for future cultivation. However, most uncultivated land are found in areas considered unsuitable for arable farming.

The land use patterns within individual farms reflect the high state of environmental perception amongst small-scale farmers. Maize farms tend to be located nearer to homesteads mainly to lessen the danger of destruction by grazing livestock and birds. Transportation of bulky maize harvest from the farm to the farmyard is also made easier by such location. Fertile and moist areas (near water sources) are favourite spots for locating maize fields. Frequently waterlogged parts of farms are normally avoided.

(b) <u>MAIZE-PRODUCTION CHARACTERISTICS IN THE STUDY AREA</u>:

While the specific history of maize in the study area is not well-documented, it is evident from farmers' accounts that the importance of the crop has undergone many changes since its introduction. For the whole of South-Nyanza District, maize served mainly as a cash-crop during the initial years of its introduction. It presently serves as a major food-crop following dietary changes which have occurred since its introduction.

Farmers' accounts place the introduction of maize into the study area between the 1930s and early 1950s by the colonial administration and church missionaries. The distribution of maize during this period was handled mainly by Asian traders. Workers returning home from tea and coffee plantations in the Rift-Valley popularised the consumption of maize. Such workers had been exposed to rations of maize flour then popular in plantations. Apart from the demonstration effect of returning plantation workers, the popularity of maize as a staple food was closely linked with technological advancement. Traditional methods of turning traditional cereals (sorghum and finger-millet) into flour were ill-disposed to deal with maize because of its harder and larger grain. The crop therefore became a major food item only after the introduction of hammer mills.

There are a number of advantages the crop had over traditional cereals which further added to its popularity. These included less time for maturity, a ready market, better appearance,taste and palatability. The crop had also greater protection against birds and could be prepared as a meal in a variety of ways. Except for 1986, the total hectarage devoted to maize in the study area has shown consistent increase. In 1984, 3449 hectares were planted with maize compared to 4548 hectares and 3549 hectares in 1985 and 1986 respectively. However, this trend is not expected to continue in the long run given the fact that land is becoming increasingly scarce. At the same time,

TABLE 2.4: CROP YIELD & HECTARAGES. RONGO DIVISION 1986/1988.

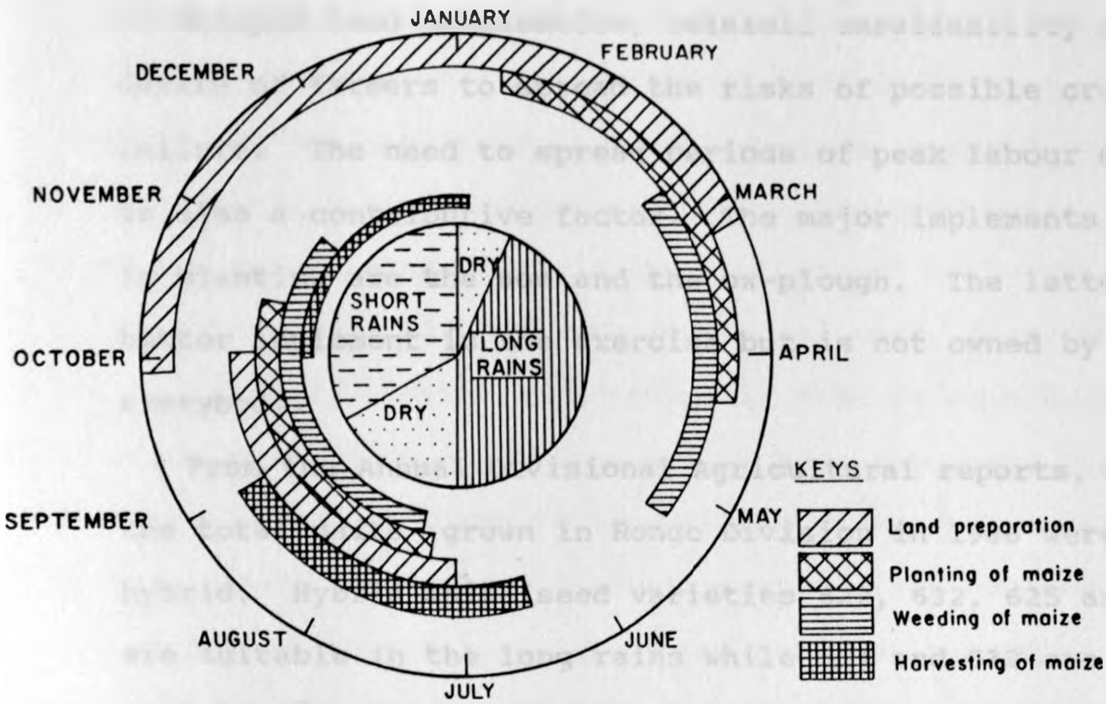
CROP	HECTARAGE		YIELD/HECTARE	
	1986	1988	1986	1988
MAIZE	3,549	5,350.7	30 BAGS	25-30 BAGS
BEANS	1,134	2,061.2	6 ,,	8-15 ,,
SORGHUM	801	1,709.4	18 ,,	8-15 ,,
CASSAVA	323	226.2	-	-
TOMATOES	94	32.0	16 TONS	20-30 TONS
BANANAS	90	8.0	-	20 TONS
VEGETABLES	66	76.0	13 TONS	10-15 TONS
SUGAR	50	-	-	-
ONIONS	39	2.9	-	8-10 TONS
FINGER MILLET	36	93.0	10 BAGS	4-6 BAGS
COFFEE	-	28.9	2-3 TONS	4,000 KGS.
TOBACCO	-	60.0	-	-
TEA	-	-	-	-
CARROTS	-	-	-	-
GROUNDNUTS	-	2,306.5	-	600 KGS.
PINEAPPLES	-	9.5	-	50 TONS
CITRUS	-	6.0	-	-
PASSION FRUIT	-	-	-	-
PAPAW	-	-	-	-
AVOCADOES	-	-	-	-
MANGOES	-	-	-	-

SOURCE: DIVISIONAL ANNUAL REPORT, MINISTRY OF AGRICULTURE, RONGO DIVISION.

there is competition from newly introduced lucrative cash-crops such as sugar-cane, coffee and tea. There will therefore be an urgent need to increase maize yields per unit area.

Fig. 2.7 shows the annual distribution of all the field operations involved in maize production in the study area. Land preparation for the long rains can begin as early as

Fig.2.7 CALENDAR OF FARM OPERATIONS



September and as late as March but the activity is mainly concentrated between the months of December and February. The main method of land preparation is the use of ox-drawn ploughs although a limited number of farmers rely only on the hoe. The manner in which land preparation is undertaken is expected to influence both yields and hectarages of maize. The main problems faced by farmers during the land preparation period include shortage of labour, lack of ox-plough teams and rainfall unreliability. The few tractors existing in the study area are almost exclusively used in the cane industry.

The planting of maize is mainly concentrated in the months of February and March for the long rains; August and September for the short rains. Late planting is a major cause of reduced maize yields. It is attributable mainly to delayed land preparation, rainfall unreliability and the desire of farmers to spread the risks of possible crop failure. The need to spread periods of peak labour demands is also a contributive factor. The major implements used in planting are the hoe and the ox-plough. The latter is a better implement in the exercise but is not owned by everybody.

From the Annual Divisional Agricultural reports, 40% of the total maize grown in Rongo Division in 1986 were hybrid. Hybrid maize seed varieties 622, 632, 625 and 614C are suitable in the long rains while 511 and 512 are suitable for the short rains. From the present sample survey, 66% of the farmers interviewed reported having planted at least one maize field with hybrid seed during the long rains of 1986. The main reasons cited for not planting hybrid seed are all related to its availability, prices and field characteristics. Inadequate maize seed outlets, restricted financial resources of poorer farmers and ignorance about the potential advantages of hybrid maize seed all inhibit its adoption in the study area. In addition, some farmers observed that hybrid seed is less resistant to drought and is more vulnerable to birds, pests and weeds than local varieties.

The application of chemical fertilizer is very minimal except in the case of coffee and Sugar-cane farmers. This is mainly due to the fact that fertilizer prices make their use in maize production uneconomical. It also involves an additional expenditure of labour which the farmers are less inclined to undergo. Some farmers complained that fertilizer application leads to rapid soil exhaustion. The most popular method of enhancing soil fertility in the study area is the application of farmyard manure. Although this involves additional work, farmyard manure is easily available and there is need to popularise farm implements such as the ox-cart to ease the work. The main type of farmyard manure is obtained from cattle sheds. Farmers who do not have cattle can exploit other sources such as dry maize stalks which is not yet widely used (Fig. 2.8).

The observation of long fallow periods and crop rotation are useful ways of enhancing soil fertility. Land scarcity is one of the major reasons for the observance of short fallow periods prevalent in the study area. Crop rotation is, however, widely practiced although there is need to instruct farmers on the careful selection of crops to rotate. Intercropping is a widespread practice in the study area. Pure maize stands were reported in only 30.5% of the farms surveyed in the present study. The practice reduces the plant population per unit area and hence yields. It is an indigenous practice in the study area which protects the farmer from the risks of possible crop failure. It also saves on the land, labour and other inputs necessary for maintaining separate fields for different crops.

The most popular crop intercropped with maize is beans. The nitrogen fixing capacity of legumes helps in supplying the high requirements of nitrogen in maize. Intercropping is also useful in protecting the soil against erosion, preserves soil moisture and impedes weed growth.

The use of agro-chemicals in the study area is restricted to protecting horticultural crops against pests. Weed control in maize fields is therefore mechanical involving the use of either the hoe or the ox-plough to pull out weeds (Fig. 2.9). This is the most time and labour-consuming operation in maize production. Weeding during the long rains begin in the month of March and extends to May. The ox-plough is a faster and more efficient weeding implement but is not yet widely used since it requires the use of specially trained oxen and additional labour (Fig. 2.10). In addition, ox-plough teams are not available to all the farmers. The weeding operation is expected to be closely related to both maize yields and hectarages. Figure 2.11 and 2.12 show the contrast between a well-weeded and poorly weeded maize field.

FIGURE 2.8: MAIZE STALKS AS FARM MANURE

FIGURE 2.9: HOE-WEEDING OF MAIZE

FIGURE 2.10: OX-PLOUGH WEEDING OF MAIZE

FIGURE 2.11: A WELL-WEEDED MAIZE FIELD

FIGURE 2.12: A BADLY-WEEDED MAIZE-FIELD.

Harvesting of maize is still a manual activity in the study area and is concentrated in the months of July and August during the long rains. The maize cobs are removed by hand in the field. The maize is then dried either in the field or at the farmstead before being kept in grain stores. The latter are in most cases traditional structures which do not adequately preserve the maize (Fig. 2.13). Modern grain stores are yet to be popularised in the study area (Fig. 2.14).

(c) AGRICULTURAL INPUTS AND SERVICES:

Besides land, any agricultural enterprise requires the availability of capital and labour. The former include seeds, fertilizer and farm implements. These must be adequately priced and supplied at convenient outlets. Agricultural services such as extension and credit facilities are necessary to ensure that recommended innovations and associated capital expenditure are undertaken by farmers.

FIGURE 2.13: TRADITIONAL GRAIN STORES

FIGURE 2.14: MODERN GRAIN STORE

(i) SEEDS AND FERTILIZER

The distribution of hybrid maize seed in Rongo Division is mainly undertaken by local stockists found in the major rural centres. Local maize seed and occasionally hybrid seed can be obtained from maize traders in the periodic rural markets. However, a number of farmers obtain maize seeds from their own harvests. Hybrid maize seed is not always available at the correct times and in the required quantities. It is estimated that 20 kilograms of hybrid maize seed is required for one hectare of land (Kenya Seed Company). While hybrid maize seed prices are still low (Kshs. 104/= per 10 kilogram bag), reliable seed distribution agencies like the Kenya Grain Growers' Cooperative Union (K.G.G.C.U) are yet to open branches in the study area. The inadequate seed distribution system may be responsible for the continued planting of local seed varieties in the area.

Chemical fertilizers are not only expensively priced but also difficult to obtain. It is estimated that only about 10-15% of the farmers use commercial fertilizer for purposes other than sugar-cane production. Prices of the main fertilizers used in the study area range between Kshs. 164.00 and Kshs. 315.00 per bag, which is clearly expensive. The K.G.G.C.U (with offices located outside the study area) and the South-Nyanza Sugar Company (SONY) company are the main suppliers of commercial fertilizers in the area. Agro-chemicals are almost exclusively used in the production of horticultural crops and are difficult to find in the study area.

Farm implements are supplied by local stockists operating hardware stores in Rongo, Awendo, Kisii and Migori. The latter two are located outside the study area. Table 2.5 shows the major farm implements and resources owned by a sample of farmers in the study area. The tractor is the most sophisticated (and expensive) farm implement in the area and is owned by only a few farmers. However, the ox-plough is within the financial capabilities of most farmers although its ownership is not yet universal. There is a particular need to introduce better ox-ploughs to broaden the range of farming activities whereby they can be utilised especially planting and weeding. Simple implements such as wheel barrows and ox-carts are yet to be integrated into the farming activities in the area.

Farm animals form an important aspect of farm resources since they can be readily turned in to cash to finance agricultural operations. They are also useful sources of farm manure besides providing the necessary energy in ploughing and transport. Livestock development should therefore form an intrinsic part of agricultural development in the area. Increased on-farm-storage of maize requires the use of modern grain stores instead of the traditional ones currently dominant.

TABLE 2.5 OWNERSHIP OF MAJOR FARM IMPLEMENTS AND RESOURCES.

IMPLEMENT/RESOURCES	NO. OF FARMERS	%
DRAUGHT ANIMALS	136	68
OX-PLOUGH	152	76
TRADITIONAL GRAIN STORES	180	90
MODERN GRAIN STORES	43	21.5
OX-CART	36	18
GOATS	96	48
SHEEP	109	54.5
TRACTOR	21	10.5
WHEEL-BARROW	38	19
POULTRY	175	87.5
CATTLE	160	80

Source: Sample Farm-Survey, 1986/87.

(ii) LABOUR

Labour availability is crucial in determining the scale, thoroughness and speed at which all agricultural operations are undertaken especially when low levels of technology prevail. Farmers in the study area depend on three types of labour namely family, casual and communal labour (Table 2.6).

Family labour is the most popular labour type utilised. It requires no cash expenditure but is limited by the exodus of young members of the rural population in search of educational and employment opportunities. Poor health and old age further limit the utility of family labour in agricultural development.

Casual labour is difficult to engage due to poor financial resources and higher wages offered in the sugar industry. Communal labour is declining in popularity as a result of disintegrating traditional family structures

TABLE 2.6: LABOUR UTILIZATION BY TYPES-RONGO DIVISION.

LABOUR TYPE	NON-USERS	USERS	%	TOTAL
COMMUNAL LABOUR	175	25	12.5	200
CASUAL LABOUR	99	101	50.5	200
FAMILY LABOUR	-	200	100	200

Source: Sample Farm Survey, Rongo Division 1986-87.

originally based on the extended family system. New forms of social organization such as women groups, church organizations and youth-groups offer new avenues through which communal labour can be mobilised to benefit individual farmers. Communal labour is based on the mutual sharing of human labour between members of a given group for the benefit of all.

(iii) CREDIT AND EXTENSION SERVICES

Credit to small-scale farmers plays the important role of financing farming operations. Only 5.5% of all the farmers interviewed received credit during the study period, the most important source of credit being the Agricultural Finance Corporation and the SONY sugar company. Other credit sources play negligible roles in the study area (Table 2.7). The credit values for a sample of recipients ranged from Kshs. 15,000 to Kshs.90,000 acquired for non-farming and farming activities especially sugar cane cultivation.

The poorer farmers are generally reluctant to apply for

TABLE 2.7 CREDIT SOURCES AND UTILIZATION RATES

SOURCE	NO. OF LOAN RECIPIENTS	PURPOSE	NO. OF APPLICANTS
AGRICULTURAL FINANCE CORPORATION	5	-General farming -Business -Cane production -Weeding	14
SONY SUGAR COMPANY	3	-Housing -Cane production	5
KENYA NATIONAL UNION OF TEACHERS	1	-General development	1
UNSPECIFIED	2	-General farming	2
LOCAL COOPERATIVES	-	-	2
TOTAL	11		24
%	5.5		12

Source: Sample Farm-Survey, Rongo Division, 1986/87.

credit because of the fear of loosing land titles and the intricate bureaucracy involved in such cases (Von Pischke, 1974;1976). Lack of collateral and ignorance of the very existence of credit institutions are further reasons for the low rates of credit utilisation in the study area. Only 12% of the total sample of farmers interviewed in this study applied for credit. Agricultural education should therefore include financial aspects of agriculture in its programmes. Extension work so far tend to concentrate on agronomic practices.

Table 2.8 shows the sources of agricultural information open to small scale farmers in the study area. Village meetings (Baraza's) convened by chiefs and sub-chiefs is the most popular source of agricultural information. Although usually convened for

TABLE 2.8 : SOURCES OF AGRICULTURAL INFORMATION

SOURCE	NO. OF FARMERS	%
VILLAGE BARAZA'S	120	60
EXTENSION VISITS	52	26
FELLOW FARMERS	112	56
NEWSPAPERS	40	20
RADIO	52	26
FARMERS' TRAINING CENTRES	6	3

Source: Sample Farm-Survey, Rongo Division, 1986/87.

administrative purposes, agricultural officers take such opportunities to disseminate agricultural information. However, such information is normally restricted to major policy announcements. Reliance on fellow farmers has got the danger of information distortion as it passes from one farmer to another.

The mass media plays a limited role as a source of agricultural information in the study area due to the shortage of media instruments such as radio and Television sets. Radio programmes need to be tailored for the specific needs of the rural farmer. High illiteracy rates in the area reduces the importance of newspapers as sources of information. In addition most newspapers and magazines in circulation in the rural areas lack agricultural specificity.

Extension services play a significant role in disseminating accurate agricultural information to farmers. Only 25.5% of farmers in the study area cited extension officers as one of their principle sources of information. Although this may be interpreted as a shortcoming of the extension officers, it should be pointed out that the main thrust of extension services in the area has shifted from visits to individual farms to group contact in selected farms owned by "contact farmers". The main problem encountered in this strategy is the poor attendance of farmers in such sessions. However, the new method can be popularised if farmers organised into village committees are given the role of appointing the contact farmers. Such farmers should also be selected on a rotational basis so that every farmer in a particular village has a chance of being selected in the long run. Given the shortage of man-power and logistical problems, the new programme has a great potential as a tool for disseminating agricultural information.

Farming groups such as women groups and youth clubs are increasingly becoming popular in the area. Such groups should form a major target of extension services in the area. In 1986, the study area had more than thirty women groups with membership ranging from fifteen to one hundred, involved in various agricultural and non-agricultural income-generating activities. Farmers' Training Centres should organise more frequent short-term training for members of such groups. Attendance of training sessions in the local Farmers' Training Centres is still minimal in the study area.

Extension work in the study area seems to concentrate on specific farming operations, crop inspection tours, soil conservation and environmental protection. There is an urgent need to broaden the content of extension services to embrace equally important aspects such as farm planning and financial management. These aspects are specially important in the transition towards small-scale commercial farming. Self-sufficiency in maize at the individual level not only requires improved farming techniques but also an efficient allocation of available resources including time, land, money, and capital to competing agricultural enterprises.

2:4 SUMMARY

The main purpose of this background to the study area was to provide a basis for the analyses attempted in the core chapters of this thesis. It reveals that efficient production of maize is feasible in the study area because of the suitable environmental conditions. Socio-economic problems, however, may greatly inhibit the realisation of this and such problems have to be empirically identified and solutions suggested. While personal endowments of farmers are rather difficult to alter, an improved access to agricultural inputs and services can greatly enhance maize-production in the study area.

The provision of basic farm inputs such as seeds and farm implements needs to be improved in the study area by establishing adequate outlet points. The utilisation of credit facilities need to be improved especially for maize farmers. New forms of social organisation need to be encouraged in the area to facilitate the mutual sharing of agricultural implements and labour. The land tenure characteristics in the area points to diminishing land sizes in the area and agricultural strategies must take this into account. Cash-crop production is bound to negatively affect future production of maize unless steps are taken to promote it through better support programmes. Maize production strategy in the area should focus on enhanced yields which requires a well organised extension service.

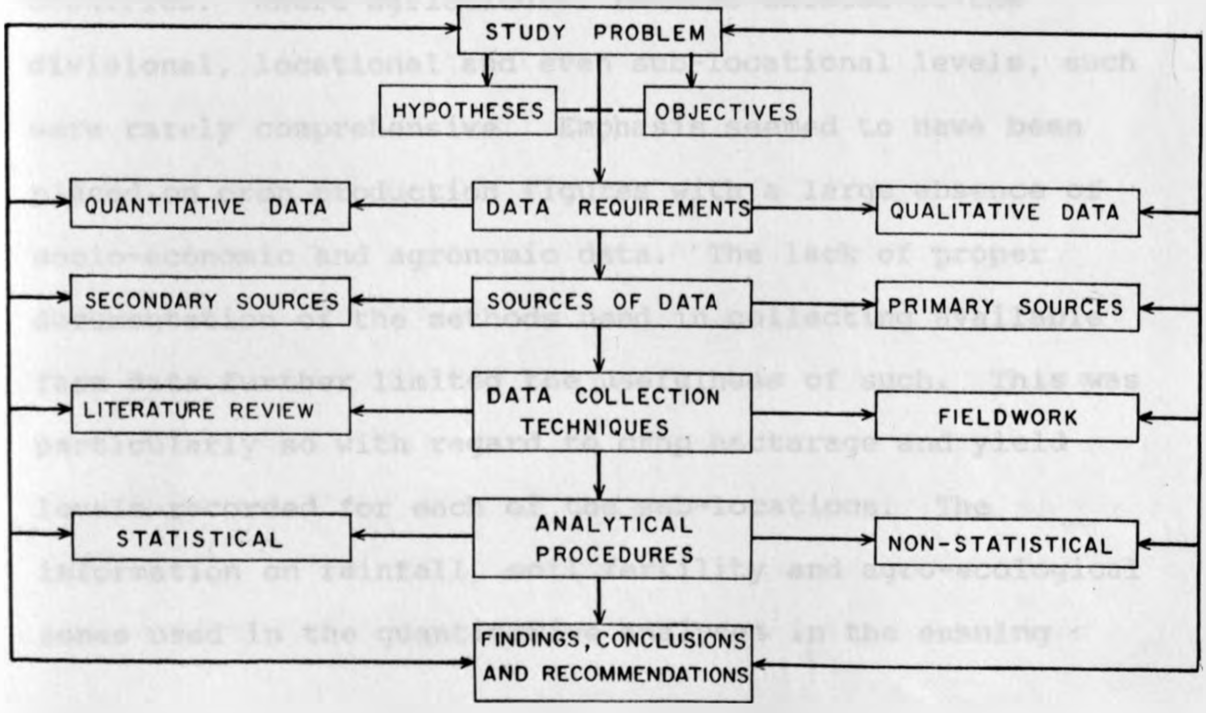
CHAPTER THREE - RESEARCH METHODOLOGY

CHAPTER THREE: RESEARCH METHODOLOGY.

3:1 INTRODUCTION

This chapter gives the main components of the research design for this study. These include the various sources of data utilised, techniques of data collection and finally the analytical procedures adopted. All these aspects of the research design are intricately interrelated within themselves and are in turn influenced by the nature of the study problem. Figure 3.1 stresses these inter-relationships. The last part of this chapter gives the major limitations faced during the study period. These limitations have a direct bearing on the reliability of the findings and associated conclusions and recommendations of this study.

Fig. 3.1 THEORETICAL RESEARCH DESIGN



3:2 SOURCES OF DATA

Both qualitative and quantitative data have been utilised in this study, derived from both primary and secondary sources. However, the bulk of data analysed here were collected from primary sources. Reliance on primary data has the disadvantage that the data collection process can be time consuming and prone to inaccuracies depending on the resources at the disposal of the researcher. Because of the scale at which this study was undertaken, disaggregated secondary data were largely unavailable. This is a common problem facing agricultural researchers working in small-scale agriculture in the developing countries where written farm records are virtually non-existent. Important sources of agricultural data such as periodic sample farm surveys and agricultural censuses are not yet as well developed as they are in the developed countries. Where agricultural records existed at the divisional, locational and even sub-locational levels, such were rarely comprehensive. Emphasis seemed to have been placed on crop production figures with a large absence of socio-economic and agronomic data. The lack of proper documentation of the methods used in collecting available farm data further limited the usefulness of such. This was particularly so with regard to crop hectarage and yield levels recorded for each of the sub-locations. The information on rainfall, soil fertility and agro-ecological zones used in the quantitative analyses in the ensuing chapters were derived from Jaetzold & Schmidt (1982).

The main sources of primary data utilised in the present study included the maize farmers, informal maize traders, community leaders, officials of the National Cereals and Produce Board (NCPB), Ministry of Agriculture, and the Agricultural Finance Corporation of Kenya (A.F.C). Secondary data came from published and unpublished sources including government statistical publications, annual reports of the Ministry of Agriculture, NCPB and A.F.C. Previous works conducted in the study area and on maize production elsewhere have also been important sources of secondary data.

3:3 PRIMARY DATA COLLECTION TECHNIQUES

Primary data collection for purposes of this study involved three basic techniques namely:

a: personal field observation and recording

b: informal interviews

c: formal interviews

3:3:1 PERSONAL FIELD OBSERVATION AND RECORDING

This method was mainly used in acquiring data pertaining to environmental characteristics, land-use patterns, farm sizes and shapes, physical farm resources and the actual nature of field operations in maize production. These observations were duly recorded on field note-books, maps and photographs. This method of data collection is limited by the fact that what is observed and the way it is interpreted lacks objectivity. The choice on what to observe and how it is interpreted is largely determined by the personal inclination of the observer and his training. Although information so collected is helpful in descriptive purposes, its use in statistical analyses is limited. Direct field observation of phenomena is also invaluable in reducing inaccuracies in information derived from formal and informal interviews of respondents.

3:3:2 INFORMAL INTERVIEWS:

These were conducted for officials of both government and non-governmental bodies involved in various ways in agricultural development in the study area. Selected community leaders and prominent farmers were also informally interviewed. These interviews took the form of discussion of topics relevant to agricultural development in general and maize production in particular. No structured questionnaires were used in such interview sessions although short notes were taken whenever it was considered appropriate. The information acquired in this nature had to be treated with caution given the fact that it tends to reflect individual biases as defined by the respondent's official position. The exercise also proved to be time consuming since the duties of government officials often led to abrupt postponement of appointments. The chief advantage of this technique is that the respondent had the freedom to volunteer information which may have been inadvertently ignored by the researcher so long as care is taken to keep the discussion within relevant grounds.

3:3:3 FORMAL INTERVIEWS.

These were conducted using prepared standard questionnaires administered to a sample of both farmers and grain traders (see Appendix 1 & 2). Because of the limited time available for the research and the poor means of transport available to the author, the assistance of recruited research assistants had to be sought. Ten research assistants were recruited for the exercise. Care was taken to ensure that they either hailed from or had a thorough local knowledge of the sub-locations they were to cover during the exercise. This was considered appropriate since the task required that the actual location of the selected sample farms be precisely established. In addition, the exercise was done on foot necessitating night travels. This would have been quite dangerous to people who are not familiar to the local situation. Familiarity with respondents also had the added advantage of allaying the suspicions normally held for strangers in the rural areas. For security reasons and to ensure cooperation of respondents, farmers were informed of the impending interviews through their respective sub-locational administrative heads. It should be noted that while postal questionnaires may be a quicker and less expensive way of collecting agricultural data, it was not used in the present case because of the high prevalence of illiteracy in the study area.

Before the beginning of the exercise, the field assistants were adequately briefed on the content of the standard questionnaires, methods of conducting interviews and recording data. After one week the questionnaire had to be modified by leaving out or rephrasing particular questions which proved to be unpopular with the respondents. Although it is not suspected in this study, it should be noted that dishonest research assistants may record information which was not actually given by the respondents. In cases where the responses were incorrectly entered by research assistants, they were duly instructed to conduct the interview once more.

3:4 SAMPLE DESIGN.

The sampling techniques adopted in this study were aimed at the selection of a sample of farms and informal maize traders respectively. A stratified random sampling procedure was employed to select a sample of 200 farms. The prepared standard questionnaires were then administered to the head of the household or appropriate representative in each of the sample farms. The sample size was considered adequate for the requirements of the statistical procedures employed in this study. Although rigorous statistical procedures exist for determining sample size, such are not only time consuming but also require prior knowledge of the expected standard deviations of variables within the study area (Clark & Hosking, 1986). This was not possible during the study.

The study area was stratified into its constituent sub-locations. A complete list of all the land parcels in each sub-location were obtained from the District Land Registry. Using the random numbers table, ten farms were randomly selected from each sub-location. The list of plot numbers selected and their respective owners were then used to locate the farms in the field. Figure 3.2 below shows the spatial distribution of the sampled farms.

A number of problems were encountered which could compromise the randomness of the sample. In the first instance, farmers who had more than one parcel of land stood a higher chance of being included in the sample. In addition, those farmers who own land through inheritance or purchase without notifying the District lands personnel were left out of the sample. The District Land Registry does not contain unreported land transactions. Secondly, absenteeism of farm owner by reason of death, sickness or imprisonment made the replacement of originally selected farms necessary. This was also true where events such as ceremonies and festivities ruled out the possibility of interviewing the farm owner. In a limited number of cases, potential respondents actually refused to be interviewed. In all the three cases, the next nearest farm was chosen as

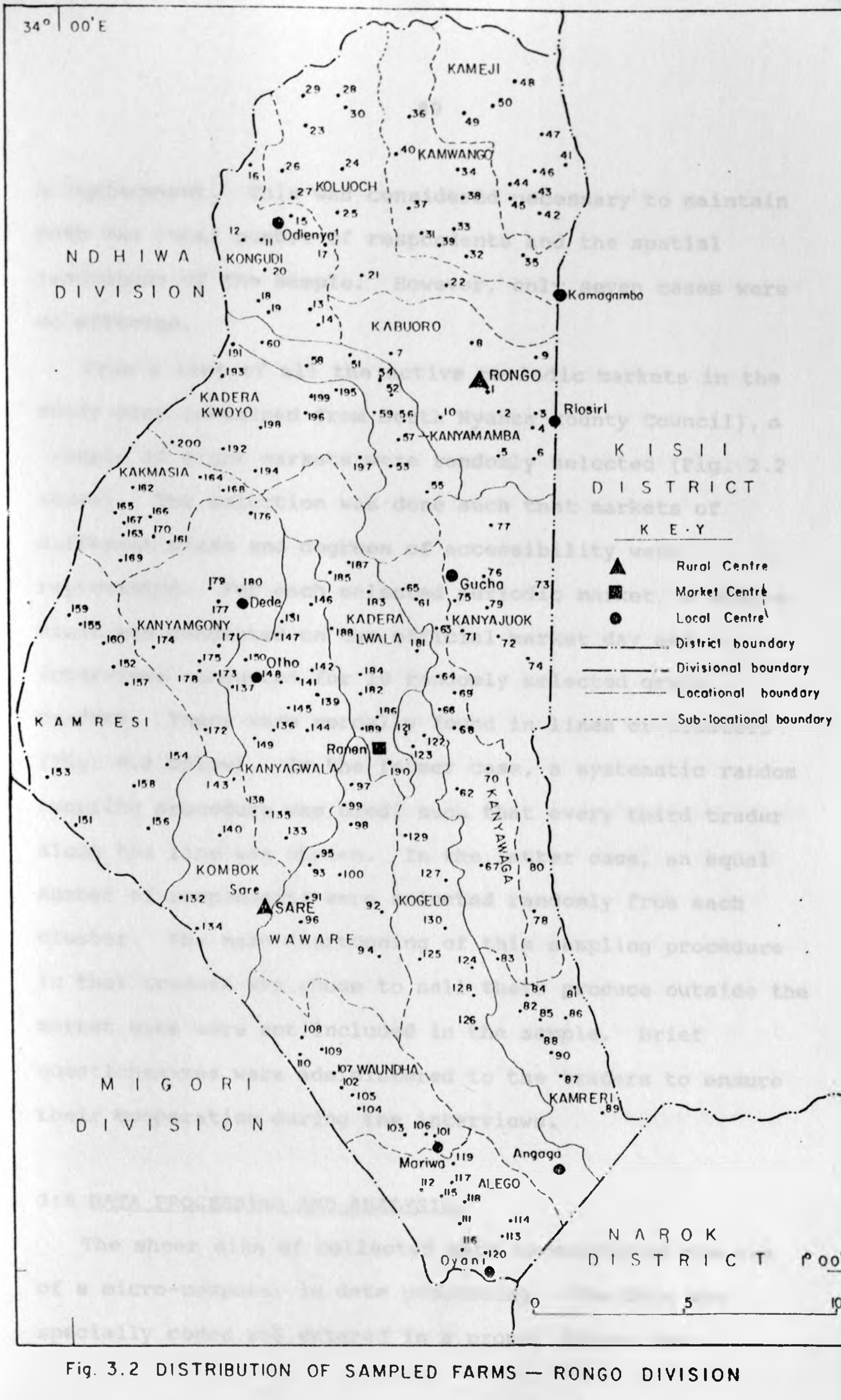


Fig. 3.2 DISTRIBUTION OF SAMPLED FARMS — RONGO DIVISION

a replacement. This was considered necessary to maintain both the total number of respondents and the spatial randomness of the sample. However, only seven cases were so affected.

From a list of all the active periodic markets in the study area (obtained from South Nyanza County Council), a sample of eight markets were randomly selected (Fig. 2.2 above). The selection was done such that markets of different sizes and degrees of accessibility were represented. For each selected periodic market, a single visit was conducted on the official market day and interviews conducted for 10 randomly selected grain traders. These were normally found in lines or clusters (Fig. 6.2 below). In the former case, a systematic random sampling procedure was used, such that every third trader along the line was chosen. In the latter case, an equal number of respondents were selected randomly from each cluster. The main shortcoming of this sampling procedure is that traders who chose to sell their produce outside the market gate were not included in the sample. Brief questionnaires were administered to the traders to ensure their cooperation during the interviews.

3:5 <u>DATA PROCESSING AND ANALYSIS:</u>

The sheer size of collected data necessitated the use of a micro-computer in data processing. The data was specially coded and entered in a proper format for subsequent computer analysis using GLIM and SPSS statistical packages. The use of tables, graphs and diagrams were resorted to for illustrative and presentation purposes.

Analysis of qualitative and quantitative data require the use of different analytical techniques. Most statistical models are not yet specially well developed to handle qualitative data as opposed to quantitative information (Wrigley, 1986). Qualitative data derived from the field interviews have proved useful for descriptive purposes. This requires a logical arrangement of the qualitative facts to serve descriptive and explanatory purposes. Qualitative information is an important explanatory tool especially in cases where reliable quantitative data is lacking. It should be noted that some important information are not easily quantified. In such cases, statistical methods of handling quantitative data become largely inadequate if not completely irrelevant. In this study, qualitative analysis has played a large role in the locational aspects of maize production, evaluation of agricultural services, and the historical aspects of maize. Qualitative information also helped in the interpretation of the results of quantitative analyses attempted in this study.

Quantitative techniques employed in data analysis in the present study can be categorised into simple descriptive and inferential statistics. Descriptive statistics are useful in screening out irrelevant variables in a particular research problem. In addition, they can be used for simple descriptive purposes in cases where application of inferential statistics is invalid. Inferential statistics involve the use of statistical models, most of which have underlying assumptions which must be met for reliable interpretation. The major analytical models employed in this study are presented below.

3:5:1 FACTOR ANALYSIS

Factor analysis is a broad term referring to a group of techniques used for data description and hypothesis testing (Rummel,1967). The technique is principally employed in the reduction of data in such a way that new and fewer derived variables from the original data set are obtained. The technique normally begins from a matrix of correlation coefficients showing intercorrelations between a set of the original variables.

The application of factor analysis in geographical research is well-established (Henshall, 1966; Henshall & King 1966; Johnston, 1978; Obara, 1983). The technique has been used in this study for both descriptive and classification purposes. It should be noted that results from the technique can be used as input in further statistical analyses, for example multiple regression analysis.

In this study, the technique has been employed in establishing the crop-combination regions in study area. Simpler methods of crop combination analysis using aggregate data exist (Weaver,1955; Coppock,1964; Odingo, 1971;). The sample data used in this study ruled out the applicability of the simpler methods.

Although the application of factor analysis is widespread in geographical analyses, the technique is faced with a number of limitations. In the first instance, factor analysis consists of very many alternative approaches which normally give different results. The choice of these approaches during data analysis is often subjective limiting the comparability of factor results. In connection with this, the interpretation of factor results may sometimes be invalid to the problem at hand. A further limitation of factor analysis often cited is that the technique is mainly a descriptive tool and offers very little in explanation especially when applied in problems with no existing theories. A more detailed treatment of the technical and theoretical limitations in the application of factor analysis can be found in several existing works (Harman, 1967; Clark, Davies & Johnston, 1974; Mather, 1976; Cattell, 1978; Shaw & Wheeler, 1985).

3:5:2 MULTIPLE REGRESSION ANALYSIS

The multiple regression model is employed to investigate relationships between a variable of interest and a set of explanatory variables. The results of a regression modelling procedure must be interpreted on the basis of experience and logic for the model does not show causal relationships. The technique is popular amongst researchers since most real world phenomena are influenced by an invariably large set of variables.

In its general form, the multiple regression model can be expressed as:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \text{---------} \beta_i X_{ji} + \epsilon_i \qquad (3.1)$$

Where Y_i = the ith observation of the dependent variable

β_0 = the regression constant (Y - intercept)

$\beta_{i's}$ = partial regression coefficients

ϵ_i = random error

$X_{ji's}$ = the ith observation of the independent variable X_j.

The regression models applied in this study are of two kinds. The regression model whereby the dependent variable is continuous while the independent variables consist of mixed continuous and categorical data has been used in this study to investigate the factors influencing:

(1) Maize yield

(2) Maize hectarage

(3) Amounts of maize sold

(4) Quantity of maize handled by traders

(5) Prices of maize

The GLIM Statistical package offers an efficient method of handling these problems since categorical variables do not need to be expressed in the form of dummy variables. Wrigley (1978) provides several forms of the regression model applicable in different research circumstances.

The main assumptions of the regression model are that the dependent variable is normally distributed, has independent observations, and has a constant variance for all values of the explanatory variables. In addition, the regression model assumes that the explanatory variables are measured without error and are linearly independent. A detailed treatment of these assumptions have been given by Draper & Smith (1966); Mather & Openshaw (1974); Cliff & Ord (1973,1981); and Clark & Hosking (1986). The nature of data utilised in the social sciences rarely meet the assumptions of conventional regression analysis. This is one of the greatest limitations in the application of the regression model. Several regression diagnostics have therefore been developed to address this problem although few statistical packages offer them (Velleman & Welsch, 1981). The main regression diagnostics currently available for use by geographers have been dealt with at length by Wrigley (1980).

The regression diagnostics employed in this study include:

(a) analysis of residuals, and

(b) analysis of leverage values.

The analysis of residuals is important in identifying outlying data points which normally occur due to measurement error. In other cases, such outliers represent special cases which may require further analysis. Residuals from the regression models have been graphed and mapped for this purpose. Leverages indicate overly influential points in the model fitting process.

Leverage points above 2P/N--------------------------(3.2)

where: P is the number of parameters

N is the number of observations

are considered influential in the model fitting process. These need not necessarily be outliers and are therefore rather difficult to identify. The GLIM statistical package has macros for calculating and plotting leverage values for a conventional regression model. However, the facility was not available for logit models.

The main aim in a regression modelling procedure is to find out the model with the fewest possible number of significant explanatory variables. Both the t-test and the F-test have been used to screen out insignificant explanatory variables. The latter has also been used to evaluate the overall significance of models. The F-statistic used in model comparison is derived from the formular:

$$F = \frac{\text{Change in Deviance/Change in degrees of freedom}}{\text{Deviance of model 1/Deviance of model 1+n}} \quad - (3.3)$$

Where: n is any number.

On the other hand, the t-statistic is derived from the formular:

T=Parameter estimate/standard error of estimate - (3.4)

These tests have to be modified to be applicable in Logit regression.

3.5.3 LOGIT REGRESSION ANALYSIS

This is a special case of the general linear multiple regression model designed to handle problems whereby the distribution of the dependent variable is binomial. Independent variables in this case can take the usual variety. The method is different from the conventional regression model in the sense that the modelling procedure uses the method of "maximum likelihood" instead of the conventional "least squares". The use of logit models has been treated at length by Wrigley, 1984.

The principle aim in logit regression is to predict the likelihood that a particular choice is made between two or more alternatives. In its general form the logit regression model may be expressed as:

$$\text{Log } (p/1-p) = a + b_1x_{11} + b_2x_{21} + b_nx_{n1} \quad - (3.5)$$

Where:

p = the probability that one out of two outcomes occurs.

a = the y-intercept

$b_{i's}$ = regression coefficients

$x_{i's}$ = explanatory variables

Logit regression is applicable in cases where the dependent variable is binary, recorded as a 0-1 response. The procedure was used in examining the major factors influencing the adoption of particular innovations in maize production, namely:

(a) Planting of hybrid seed.

(b) Fertilizer application.

(c) Adoption of both fertilizer and hybrid seed.

The interpretation of regression coefficients of a logit model is quite different from that of conventional normal regression analysis. The reported estimates for a logit model are expressed on a log odds scale. The exponential of the estimates give the odds associated with the occurrence of one out of the two possible outcomes of the binary dependent variable with respect to each parameter in the model. For ease of interpretation, the odds can be converted to a probability scale using the formular:

P = odds/1+odds - (3.6)

where:

P = the probability of occurrence of level 1 of the dependent binary variable, associated with a particular parameter.

The use of logit regression in geographical research is not yet well-developed but is likely to increase in popularity as interest shifts to the application of regression analysis to qualitative data.

3.6 RESEARCH LIMITATIONS

A general limitation in the present study is the possible inaccuracy of data collected and missing information on aspects which could have been important. This is a common problem facing all researchers in small-scale agriculture in developing countries where most farmers do not keep adequate farm records and agricultural censuses are rare. The bulk of information used in the present study was derived from primary sources of data.

The time factor placed a limitation in the study in that some relevant variables could not be dealt with in greater detail. The actual data collection exercise began in October, 1986 after the end of the season of interest which was August. As a result, collection and analysis of soil samples had to be abandoned. Results from such an exercise would have reflected soil conditions at a period other than the season of interest. In relation to this, verification of reported data especially those related to field operations through personal field observation was virtually impossible since the maize crop in question had already been harvested. Once again, reliance had to be on the sincerity of the farmers interviewed.

The general lack of crop records at the divisional level has resulted in the exclusion of temporal dimensions of the problem at hand from the analysis. Although it would have been desirable to cover the whole of South-Nyanza District, this study is restricted to only one of its constituent administrative units (Rongo Division) due to resource constraints. Covering the whole District would have required more time and money than were available for the study. A larger administrative unit is advantageous in terms of availability of secondary data. However, what has been sacrificed in areal coverage has been compensated for by the detail with which studying the smaller areal unit has made possible.

CHAPTER FOUR - SPATIAL ANALYSIS OF MAIZE PRODUCTION.

CHAPTER FOUR - SPATIAL ANALYSIS OF MAIZE PRODUCTION.

4.0 INTRODUCTION:

This chapter examines three interrelated facets of maize production. In section one, crop combination analysis has been attempted using the factor analysis model in order to identify the major crop combinations in the study area. It should be noted that although it would have been important to include livestock and enterprise combinations, such an exercise was considered to be outside the scope of this study (Weaver, Hoag & Fenton, 1956; Coppock, 1964). The major factors influencing yield and hectarage variations are investigated in section two and three respectively. The multiple linear regression model has been utilised in both cases.

It is important to note the interrelatedness of the three sections of this chapter. Maize is not grown in isolation but together with several other crops which compete with it not only for land but also other necessary agricultural inputs. This competition takes different dimensions according to the crop combination in existence. It is obvious that this competition, depending on its nature, has an influence on both maize yields and hectarage. Crop combination analysis is therefore attempted in section one as a prelude to the yield and hectarage analyses in sections two and three.

The gross yield of maize realised by a farmer is perhaps the most important factor in maize cultivation and is itself a function of both yields per unit area and the total amount of land devoted to the crop. Different levels of gross maize output can be achieved depending on the values assumed by the two variables.

4:1 CROP COMBINATIONS: DATA ANALYSIS AND RESULTS.

4.1.1 DATA ANALYSIS

The factor analysis model has been employed here on crop data for a sample of two hundred farms surveyed during the study period in order to identify the basic crop combinations in the study area. The factor model used here is for the purpose of description and not statistical hypothesis testing.

Table 4.1 shows the summary statistics of hectarages under the different crops and their frequency of occurrence. The most frequently occurring crops are maize, sugar and beans. The next group of crops include cassava, groundnuts, potatoes, sorghum, bananas and horticultural crops. The least occurring crops are coffee, finger-millet, fruits, timber, peas, rice, tobacco, and simsim. The same pattern is registered when the total hectarage under each crop is considered. Figure 4.1(a) and 4.1(b) are comparable; the most frequently occurring crops are also the major users of land. These are maize, sugar and beans. It is expected that the main crop combinations would revolve around the three major crops identified.

TABLE 4:1 SUMMARY STATISTICS FOR CROPS RECORDED OVER A SAMPLE OF FARMS (FARM-SURVEY RONGO DIVISION 1986/87)

CROPS	FREQUENCY OF OCCURRENCE (%)	TOTAL HECTARAGE	MEAN	ST.DEV	MIN.	MAX.
MAIZE (MAIZ)	100	212.79	1.06	0.83	0.10	7.28
SUGAR (SUGA)	65.0	131.57	0.66	0.83	0.0	4.86
BEANS (BEAN)	57.5	63.07	0.31	0.71	0.0	7.49
CASSAVA (CASA)	38.0	20.09	0.10	0.20	0.0	1.62
GROUNDNUT (GROU)	34.5	28.35	0.14	0.28	0.0	1.82
SORGHUM (SORG)	32.5	22.87	0.11	0.24	0.0	2.02
SWEET POTATOES (POTA)	32.5	12.38	0.06	0.12	0.0	0.81
BANANAS (BANA)	24.0	13.92	0.07	0.16	0.0	1.01
HORTICULTURAL CROPS (HORT)	21.0	-	0.04	0.10	0.0	0.65
COFFEE (COFF)	11.0	7.82	0.04	0.14	0.0	1.21
FINGER MILLET (FMIL)	8.50	2.58	0.01	0.04	0.0	0.20
FRUITS (FRUI)	5.00	2.23	0.01	0.07	0.0	0.81
TIMBER	3.50	2.25	0.01	0.07	0.0	0.57
PEAS	2.50	1.11	0.01	0.04	0.0	0.40
RICE	1.50	0.51	0.003	0.02	0.0	0.20
TOBACCO	1.00	0.23	0.001	0.01	0.0	0.13
SIMSIM	1.00	0.40	0.002	0.02	0.0	0.20

ST.DEV= STANDARD DEVIATION
MIN.=MINIMUM VALUE
MAX.=MAXIMUM VALUE

Source: Sample Farm Survey - Rongo Division (1986/87).

It was decided that only those crops with at least 5% of occurrence should be included in the factor analysis procedure. This was done mainly to leave out insignificant crops which could have only clouded the results.

The factor analysis model begins with a correlation matrix showing the intercorrelations between all the variables included in the analysis, in this case, the crop hectarages. The correlation matrix reveals important characteristics in the data set and was inspected as a prelude to subsequent analysis.

The correlation matrix for the twelve crops included in the analysis is shown in table 4.2. It shows that most of the crops have very low intercorrelations, that is, the occurrence of any particular crop is not highly associated with the occurrence of the others. Most of the correlations are below 0.4. Notable exceptions are those between maize and beans (0.53); maize and groundnuts (0.40). Both groundnuts and beans are frequently intercropped with maize thus the high correlations registered. The high correlations between beans and potatoes (.43), beans and bananas (.42), beans and sorghum (.41), beans and groundnuts (.43) can be explained by the fact that all the crops are major food items with comparable ecological requirements. Highly correlated crops should appear in the same crop combination.

The major problem in factor analysis is the decision on how many independent factors to extract from an original data set. A popular approach to this problem is the plotting and examination of eigenvalues of each variable (<u>Cattell, 1966</u>). The eigenvalues displayed in table 4.3

have been plotted in figure 4.2. The plot reveals that the information represented by the twelve original variables can be meaningfully collapsed into four independent factors or crop combinations.

The eigenvalues, percentage of variance of the four factors extracted using principal axis factoring procedure is displayed in table 4.4. In total, the four factors account for 33.7 % of the total variation in crop occurrence. This low figure is actually expected since there are a multitude of other factors responsible for crop occurrence not included in the analysis.

Factor analysis results are made clearer through the rotation of results. Two rotation methods were used in this analysis namely, the varimax and quartimax rotation. The former ensures that the columns of the factor matrix consist of very high and low loadings with intermediate values reduced as much as possible. In the latter, the same is achieved for the rows of the factor matrix. The unrotated factor matrix is presented in Table 4.4 to emphasise this point although the discussion of the results will be based on the rotated factor matrix (table 4.5b.). It is evident that the factor matrix from varimax and quartimax rotations have comparable results (Table 4.5a and b).

Fig. 4.1 BAR GRAPHS SHOWING THE FREQUENCY DISTRIBUTION AND TOTAL LAND OCCUPANCE OF THE MAJOR CROPS IN RONGO DIVISION (1986/87)

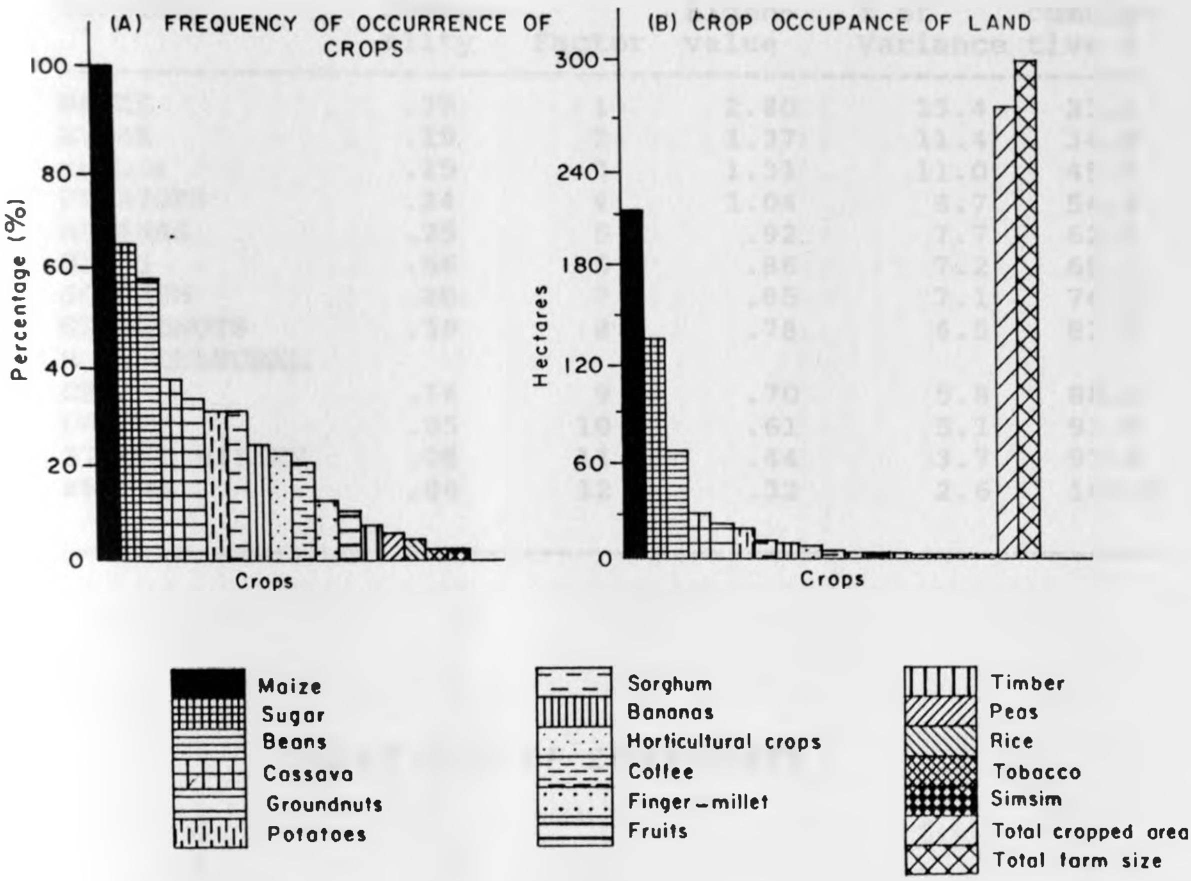


TABLE 4.2 CORRELATION MATRIX FOR SELECTED CROPS.

	MAIZ	SUGA	CASA	POTA	BANA	BEAN	SORG	GROU	HORT	COFF	FMIL	FRUI
MAIZ	1.0											
SUGA	.21	1.0										
CASA	.22	.07	1.0									
POTA	.26	.15	.23	1.0								
BANA	.32	.24	-.01	.14	1.0							
BEAN	.53	.33	.13	.43	.42	1.0						
SORG	.20	.17	.13	.24	.06	.41	1.0					
GROU	.40	.31	.21	.18	.09	.43	.17	1.0				
HORT	.21	.01	.10	-.02	.01	-.01	.04	-.04	1.0			
COFF	-.05	.12	-.06	-.08	.06	-.07	-.11	-.02	-.06	1.0		
FMIL	.01	-.13	.17	-.03	-.11	.01	.02	-.01	-.06	-.06	1.0	
FRUI	.04	-.03	-.06	-.03	-.01	-.03	-.003	-.06	.23	-.05	-.05	1.0

Note: See table 4:1 above for the key.

TABLE 4:3 INITIAL STATISTICS FOR FACTOR VARIABLES

Variable	Commun-ality	Factor	Eigen-value	% of Variance	cumula-tive %
MAIZE	.39	1	2.80	23.4	23.4
SUGAR	.19	2	1.37	11.4	34.8
CASSAVA	.15	3	1.31	11.0	45.7
POTATOES	.24	4	1.04	8.7	54.4
BANANAS	.25	5	.92	7.7	62.1
BEANS	.56	6	.86	7.2	69.2
SORGHUM	.20	7	.85	7.1	76.3
GROUNDNUTS	.30	8	.78	6.5	82.8
HORTICULTURAL CROPS	.14	9	.70	5.8	88.6
COFFEE	.05	10	.61	5.1	93.7
FINGER MILLET	.08	11	.44	3.7	97.4
FRUITS	.06	12	.32	2.6	100.0

Fig. 4.2 PLOT OF EIGENVALUES

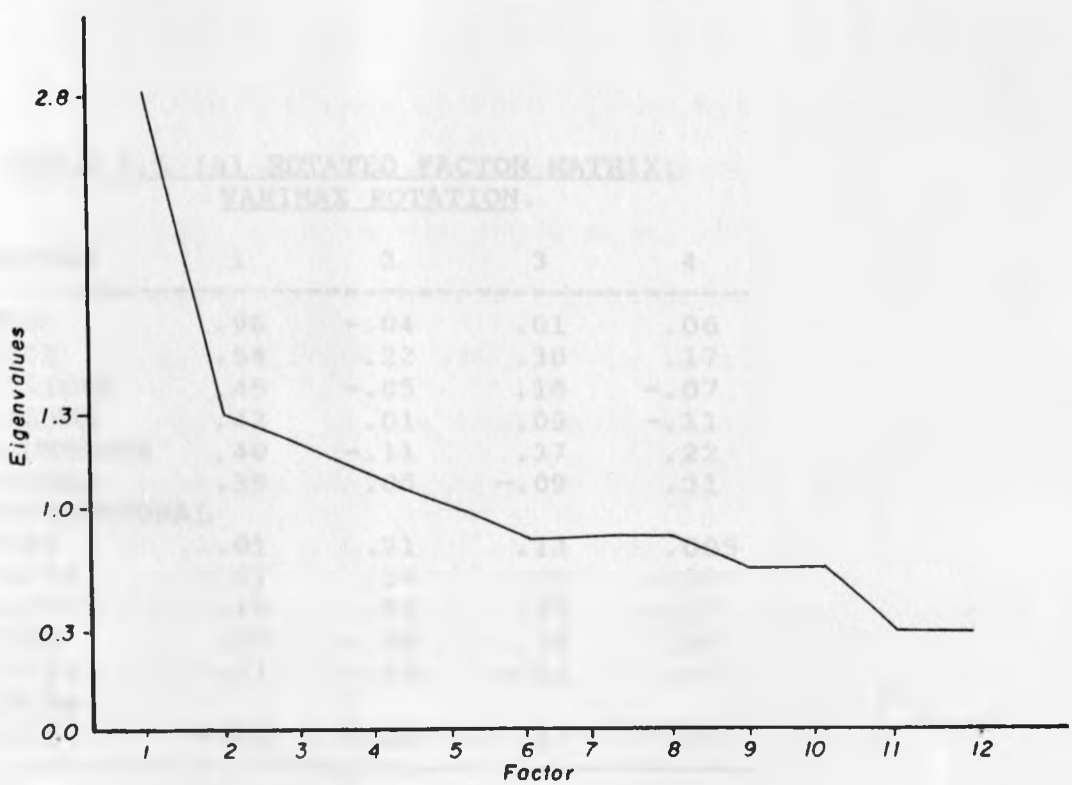


TABLE 4:4 UNROTATED FACTOR MATRIX

FACTORS	1	2	3	4	COMMUNALITY
BEANS	.93	-.14	-.06	-.28	.97
MAIZE	.63	.21	-.04	.10	.46
GROUNDNUT	.52	-.07	.10	.26	.35
SWEET POTATOES	.45	-.02	.15	-.09	.23
SUGAR	.42	-.12	-.21	.27	.20
BANANAS	.40	-.08	-.31	-.001	.26
SORGHUM	.40	.02	.12	-.15	.31
HORTICULTURAL CROPS	.08	.70	-.18	.02	.53
FRUITS	-.03	.30	-.16	-.12	.12
CASSAVA	.29	.20	.46	.22	.38
FINGER MILLET	-.02	.02	.34	-.06	.12
COFFEE	-.06	-.14	-.20	.24	.12
EIGENVALUE	2.33	.73	.61	.38	-
% OF VARIANCE	19.4	6.10	5.10	3.20	-
CUMULATIVE %	19.4	25.50	30.60	33.80	-

TABLE 4.5 (a) ROTATED FACTOR MATRIX: VARIMAX ROTATION.

FACTORS	1	2	3	4
BEANS	.98	-.04	.01	.06
MAIZE	.54	.22	.30	.17
POTATOES	.45	-.05	.16	-.07
SORGHUM	.42	.01	.09	-.11
GROUNDNUTS	.40	-.11	.37	.22
BANANAS	.39	.05	-.09	.31
HORTICULTURAL CROPS	.01	.71	.13	.005
FRUITS	-.01	.34	-.09	-.03
CASSAVA	.16	.01	.57	-.17
SUGAR	.32	-.05	.15	.43
COFFEE	-.11	-.09	-.02	.31
FINGER MILLET	-.02	-.10	.17	-.29

TABLE 4.5 (b) ROTATED FACTOR MATRIX: QUARTIMAX ROTATION.

FACTORS	1	2	3	4
BEANS	.96	-.05	-.20	-.07
MAIZE	.62	.22	.17	.08
GROUNDNUTS	.49	-.11	.27	.14
POTATOES	.46	-.05	.06	-.13
SORGHUM	.41	.0005	.0003	-.17
BANANAS	.40	.05	-.17	.25
SUGAR	.40	-.05	.07	.38
HORTICULTURAL CROPS	.05	.71	.13	-.01
FRUITS	-.03	.34	-.08	-.03
CASSAVA	.25	.01	.52	-.20
COFFEE	-.07	-.08	.001	.33
FINGER MILLET	-.02	-.10	.17	-.28

4.1.2 DISCUSSION OF RESULTS.

(1) CROP COMBINATIONS

Table 4.5 (b) shows the four factors extracted and the corresponding loadings of each of the original variables. These factors actually represent the major crop combinations found in the study area. For ease of interpretation, only the first four crops with the highest loadings on each factor are used to identify the particular factor. Factor 1 is the most basic of all the crop combinations and accounts for 19.4 % of the total variation in the original data set. This crop combination is therefore the most typical in the study area. This crop combination is made up of beans, maize, groundnuts, and potatoes. This can be labelled the "food-cash crop" combination taking into account the comparatively high loadings of sorghum, bananas and sugar-cane on it. Although beans, bananas and groundnuts are food items in the study area, it is important to note that they double as important cash crops of local significance. The existence of this combination brings to fore the emerging conflict between food and cash crop production mainly represented by the co-occurrence of both sugar-cane and maize. Although food crop production is dominant in this combination, cane cultivation is expected to rise in the long-run. The probable effects of sugar cane production on both yields and hectarages of maize is explored in section two and three below. The high loading of beans in this crop combination reflects the common practice of intercropping it with maize. These two crops together with groundnuts form important food items in the study area.

The second crop combination extracted (factor 2) is made up of horticultural crops (mainly vegetables), citrus fruits and maize. This can be labelled as "subsistence-food-crop" combination characterised by a general absence of cash crops. It is important to note that maize is represented in this combination reflecting the fact that the crop forms a basic food item in the study area. While horticultural crops and citrus fruits can be readily sold for cash, they are not very profitable ventures right now due to marketing problems. This combination is probably typical of the very poor farmers of the study area or the very old whose interests are mainly geared towards meeting every day subsistence needs. This combination serves a vital purpose but cannot contribute significantly to the economic development of the study area until such time that adequate marketing outlets are laid down. It is this combination which has the greatest potential for increased maize production since competition from cash-crops is still minimal.

The third crop combination consists of cassava, groundnuts, finger-millet and maize. This combination can be termed "marginal-food-crop" combination. Cassava is a drought resistant food crop which can survive in infertile soils and is invariably used as a substitute staple food to maize. The same is true of finger millet. The negative loadings of both beans and bananas on this factor emphasise the relatively marginal environmental conditions under which this particular crop combination exists. It is important to realise that maize is still represented in this combination emphasising the fact that it can survive under a variety of environmental conditions. However, it is probable that the yields of maize in this combination are likely to be quite low necessitating the growing of supplementary staples such as cassava and finger millet. The existence of this crop combination suggests that environmental variables are probable factors influencing variations in maize production in the study area. This possibility is examined in sections two and three below.

The fourth crop combination identified accounts for only 3.2% of the total variation in the original data set and consists of sugar, coffee and bananas. This can be termed the "cash-crop" combination as it represents the two principal cash-crops of the study area. This combination should be typical of the richer farmers who can afford to rely on the marketing system for their domestic food needs. In this crop combination, maize has almost completely been replaced by the principal cash-crops. Special efforts therefore need to be directed towards areas where this combination exists to ensure an equitable growth of both cash-crops and food crops. This combination is also significant in the sense that it indicates what can happen in future as the growth of the cash crops continue to expand in the area. The importance of the physical environment is seen here by the negative loadings of drought resistant crops such as cassava, finger-millet, potatoes and sorghum.

(2) SPATIAL PATTERNS OF CROP COMBINATION REGIONS

Fig. 4.3a,b,c and d show the spatial distribution of the major crop combinations (factors) identified in the study area.

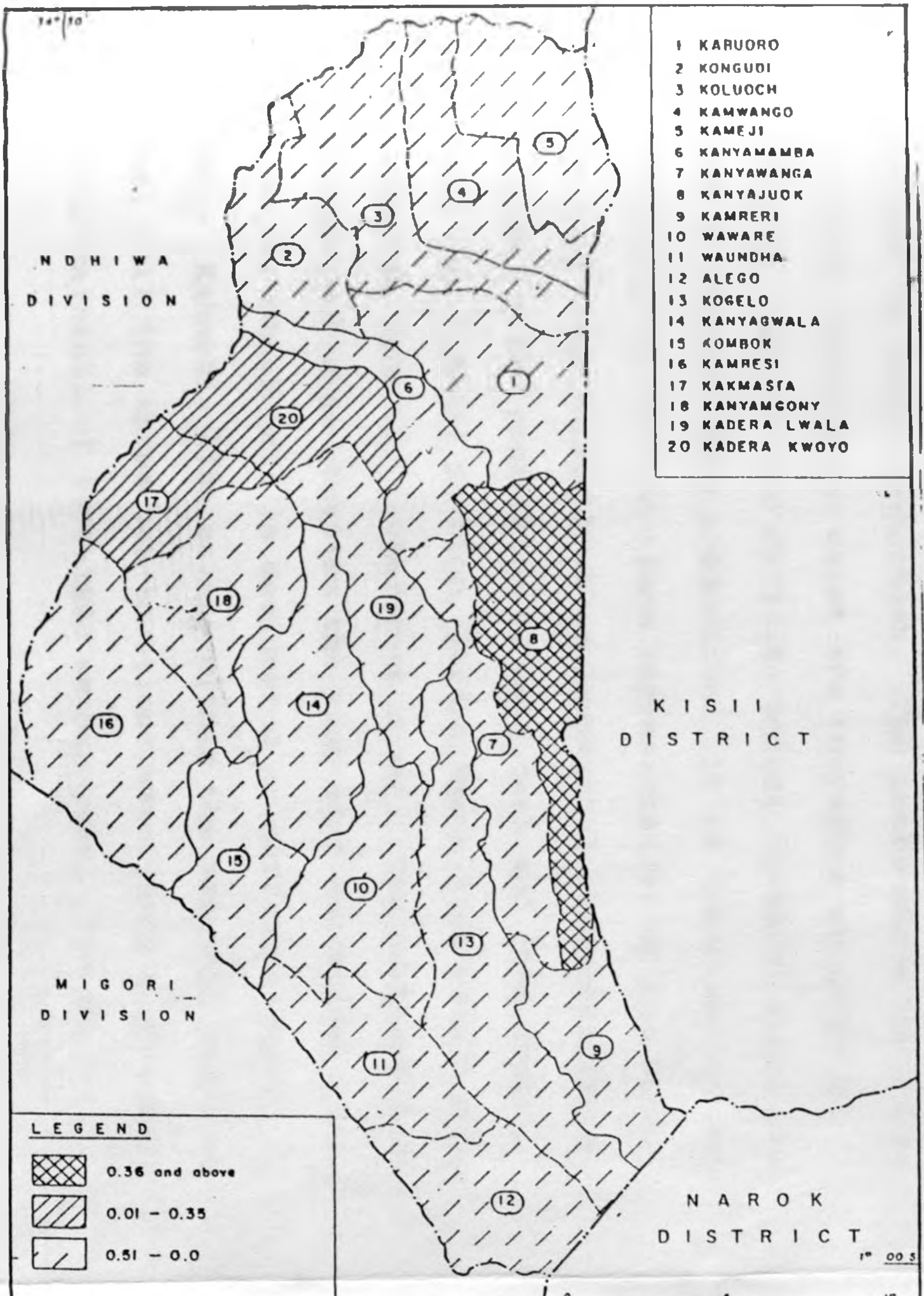
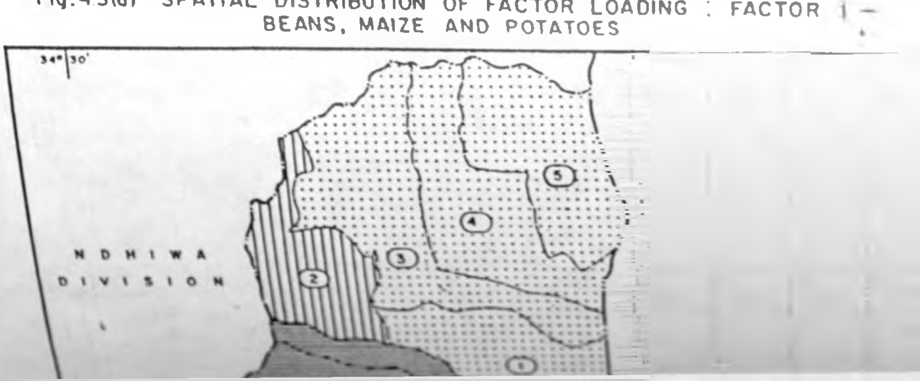


Fig. 4.3(a) SPATIAL DISTRIBUTION OF FACTOR LOADING : FACTOR 1 – BEANS, MAIZE AND POTATOES



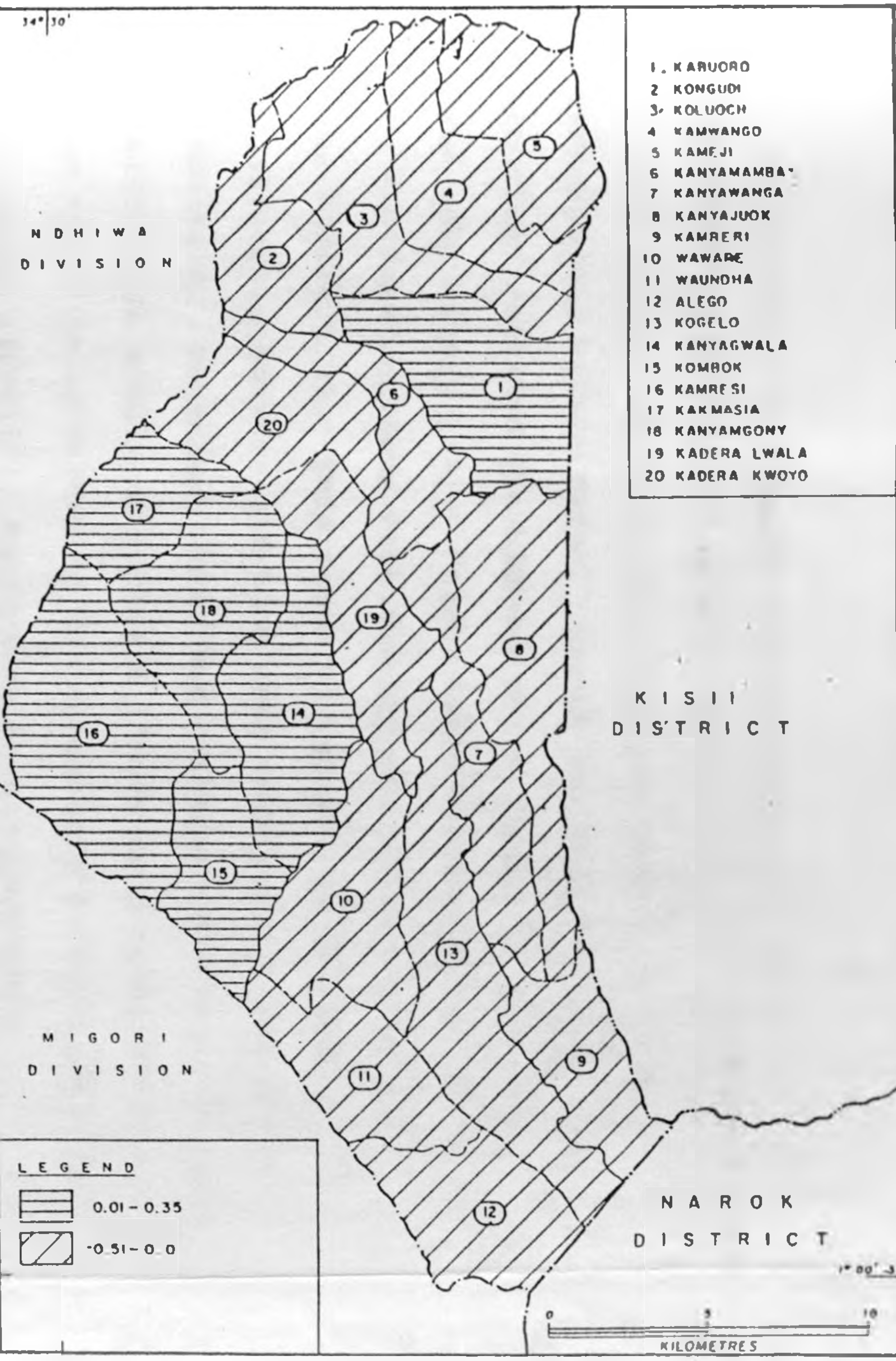
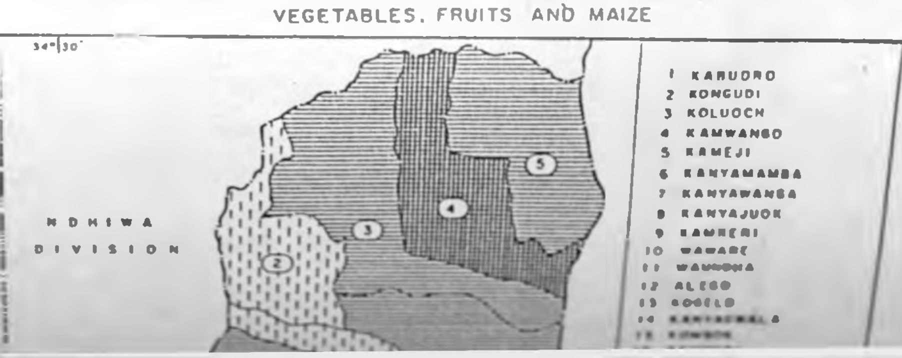


Fig. 4.3(b) SPATIAL DISTRIBUTION OF FACTOR LOADING FACTOR 2 – VEGETABLES, FRUITS AND MAIZE



As expected, the basic crop combination (factor 1 - food-cash crop) shows a more dispersed pattern although it is more typical of three sub-locations namely Kanyajuok, Kakmasia and Kadera Kwoyo. Except for Kanyajuok, the sub-locations recorded the highest maize yields in the study area (see Figure 4.4). Kadera Kwoyo and Kanyajuok are also the two sub-locations with the highest maize hectarages (see Figure 4.9). This seems to suggest an existing relationship between existing crop combinations and maize production. Kanyajuok which has comparatively lower maize yields loads highly on factor 4 ("cash-crop combination). From these observations it can reasonably be.concluded that cash-crops especially sugar-cane have a depressive influence on maize production. The areas where the "food-cash crop" combination exist are therefore expected to experience future food deficits unless adequate steps are taken to promote food production. It is important to note that the three sub-locations representative of the food-cash crop combination have environmental characteristics suitable to the production of both cash and food crops. Except for a small portion, Kadera Kwoyo lies within agro-ecological zone LM1 (sugar-cane zone). The northern half of Kanyajuok also occupies the same agro-ecological zone while the other half is designated as coffee-tea zone (UM1). Kakmasia lies mainly within the marginal sugar-cane zone. All the three sub-locations experience high average annual rainfall of 1600-1800 mm per year. The fertility of soils found in the sub-locations range between moderate to low except for Kanyajuok whose soils are classified mainly as moderate to highly fertile. These are the areas where the conflict between maize and cash-crop production is likely to intensify in the immediate future.

"Subsistence-food" crop combination is represented mainly in the western part of the study area covering Kakmasia, Kanyamgony, Kamresi, Kanyagwalla and Kombok in addition to Kabuoro in the north. Except for Kabuoro, the administrative units have maize yields ranging from moderately high to high (see Figure 4.4). Kabuoro has comparatively low yields, estimated to lie between 10 and 20 bags per hectare. None of the units registered maize hectarages averaging over 1.6 hectares per farmer. This perhaps reflects the subsistence nature of the general agriculture in the area. These areas are important food producing areas since cash-crop production has yet to become a major enterprise. The northern portion of this crop combination region experience higher average annual rainfall (1600-1800 mm) in comparison to lower portion (1400-1600 mm). All the soil fertility groups are represented in this region although moderate to highly fertile soils predominate. The region principally occupies agro-ecological zone LM2 - marginal sugar-cane zone except Kabuoro which is within the sugar-cane zone. Since all the major environmental attributes of the study area are represented within this crop combination region, it is logical to deduce that the existence of this crop combination is more related to socio-economic factors which prevent the cultivation of cash-crops. Except for Kabuoro, the whole region is far removed from the major market centres and the existing communication links both of which play an important role in cash-crop production. The environmental characteristics of the region are not severely limiting to cane production. Since the region is located in close proximity to the nucleus sugar plantation at Awendo, it is expected that the region is likely to become a major cane producer once the socio-economic problems hindering the transition to cash-crop production are solved. This further implies a reduction in the future food production potential in the study area.

"Marginal-food-crop" combination (factor 3) region mainly occupies areas of comparatively marginal environmental conditions. The crop combination is most typical of Kadera Kwoyo and Kanyamamba sub-locations. The two sub-locations have soils ranging in fertility from moderate to low and experience high average annual rainfall of between 1600 and 1800mm. In addition, they are within the sugar-cane zone. The insignificance of sugar in this region seem to be attributable to the fact that it is far removed from the nucleus sugar-plantation in the division. The main limiting environmental factor to crop production seem to be soil fertility. It is therefore forecast that since fertility enhancing practices like the application of fertilizer is more economical in cane rather than maize production, the production of maize faces potential competition from cane. This is however a long term possibility. Presently, better soil management practices need to be intensified in the area to improve the yields of food crops grown including maize. Presently the region experiences some of the highest maize yields in the study area.

The "cash-crop" combination (factor 4) region is mainly located in the southern sub-locations close to the nucleus sugar plantation (Waware and Kogelo). The sugar cultivated in this region can easily be transported to the nearby SONY sugar factory. The other sub-location belonging to this class but far removed from the sugar plantation is Kamwango in the north. Coffee production is more evident in the northern parts of the study area bordering Kisii District. Kamwango lies within the agro-ecological zones LM1 and UM1, sugar-cane zone and coffee-tea zone. Waware and Kogelo lie mainly within agro-ecological zone LM2, the marginal sugar-cane zone. The southern parts of Kogelo is classified as agro-ecological zone UM2, the coffee zone. Except for the lower portions of Waware and Kogelo, the rest of the cash-crop combination region experiences high average annual rainfall (1600-1800mm). All the soil fertility groups are represented in the region. The location of the cash-crop combination region is therefore closely related to environmental conditions conducive to the cultivation of the two principal cash-crops in the region (coffee, sugar-cane) and the location of the nucleus sugar estate at Awendo. All the sub-locations in region register medium maize yields (21-30 bags per hectare) apart from Waware where yields average 31 bags per hectare and above. It is important to note that a belt extending from Koluoch in the north to Kamreri in the south has the lowest maize yields (10-20 bags/hectare) in the study area. This belt also loads positively on factor 4, the cash-crop combination. It can be concluded that cash-crop production especially sugar has a negative influence on maize yields. The three sub-locations loading highly on factor 4 all have the lowest average hectarage of maize per farmer (0.5-1.0 hectares). The overall implication of these results is that the fourth crop combination region (cash-crop combination) is the least important in maize production where cash-cropping has almost completely replaced the staple foods. Special efforts would be required in these areas to promote maize production alongside the cash-crops. It is in these same areas that the marketing channels of maize should be well developed since most of the farmers will increasingly rely on the marketing system to meet their food needs especially maize which is the major staple.

(3) <u>CONCLUSIONS</u>

The factor results above are significant in a number of ways. The procedure has shown that crops do not occur haphazardly within the small scale farming sector but in distinct combinations, each posing different implications for maize production in the study area. They have demonstrated that although maize is the most widespread crop in the study area, its relative significance vary spatially according to the existing crop-combinations. Cash crops especially sugar cane have been identified as possible factors influencing variations in maize production. In the same way climatic aspects are possible factors influencing maize production. Lastly, the procedure has identified on the ground distinct regions requiring different policy approaches relevant to maize production. It is presently important that research results be easily applicable within smaller localities. This often has more practical significance than general recommendations of broader area studies.

4:2 MAIZE YIELD: DATA ANALYSIS AND RESULTS.

The basic aim in this section is to explain observed maize yield variations on the basis of a set of thirty independent variables. These have been carefully selected on the basis of previous research and personal experience. Figure 4.4 shows the spatial variations in maize yield observed in the study area. The highest yields, averaging 31 bags per hectare and above are found in the central belt beginning from kanyamamba, kadera-kwoyo and Kakmasia sub-locations in the east. This belt is immediately surrounded by a zone of medium maize yields (21 -30 bags per hectare). The lowest yields are recorded in the eastern belt running from Koluoch in the north to Kamreri in the south. Generally, maize yields decline from east to the west of the study area. A complete list of variables, their symbols, types and value labels are presented in appendix 3. The multiple linear regression modelling procedure has been used to obtain the most parsimonious model explaining the observed maize yield variations. Variables 1-3 represent environmental attributes while variables 4-10 represent agronomic factors. Socio-economic attributes are represented by variables 11-30.

4:2:1 MODELLING PROCEDURE

The modelling procedure involved the fitting of a series of regression models, each one an improvement over the preceding one in terms of the total amount of variation (in the response variable) explained and on how close the model meets regression assumptions. Preceding this process was the calculation of summary statistics for all the variables. Following this exercise, the levels of some of the independent variables were accordingly reduced.

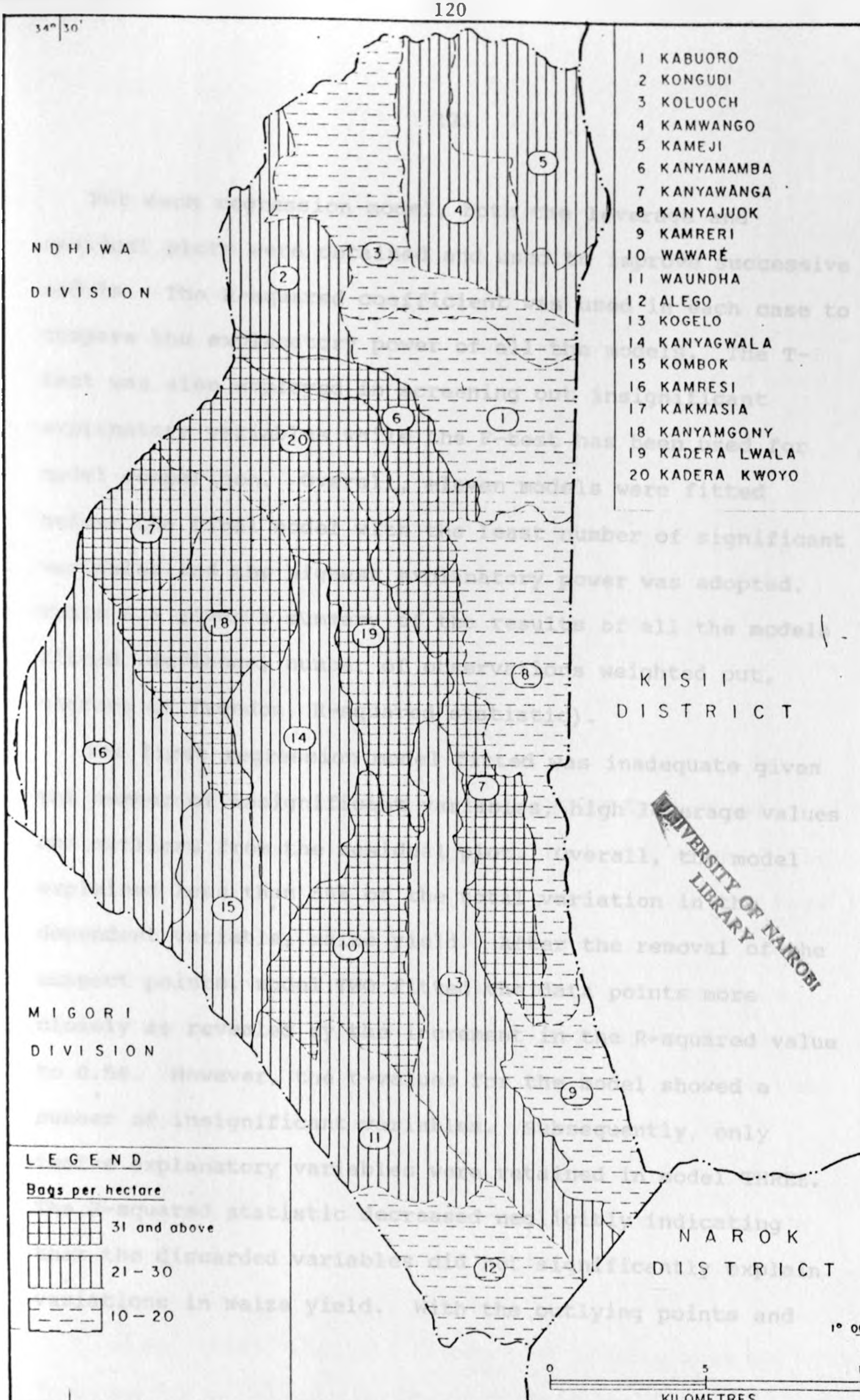


Fig.4.4 OBSERVED MAIZE YIELD VARIATIONS : RONGO DIVISION

For each regression model, both the leverage and residual plots were obtained and used to improve successive models. The R-squared coefficient was used in each case to compare the explanatory power of all the models. The T-test was also employed in screening out insignificant explanatory variables while the F-test has been used for model comparison. Overall, eleven models were fitted before the final model with the least number of significant variables and the highest explanatory power was adopted. Table 4.6 gives a summary of the results of all the models fitted (deviance, number of observations weighted out, degrees of freedom, R-squared statistic).

The first regression model fitted was inadequate given the number of insignificant variables, high leverage values and outliers from the residual plot. Overall, the model explained less than 50% of the total variation in the dependent variable, maize yield. After the removal of the suspect points, model TWO fitted the data points more closely as revealed by the increment in the R-squared value to 0.56. However, the t-values for the model showed a number of insignificant variables. Subsequently, only twelve explanatory variables were retained in model THREE. The R-squared statistic decreased negligibly indicating that the discarded variables did not significantly explain variations in maize yield. With the outlying points and

TABLE 4.6 SUMMARY TABLE FOR ALL MODELS FITTED ON MAIZE YIELD

MODEL	DEVIANCE	D.F	OBS.	RSQ.	POINTS WEIGHTED OUT
NULL	70412	199	200	-	-
ONE	44857	159	200	0.36	-
TWO	31217	153	194	0.56	6
THREE	33577	173	194	0.52	6
FOUR	28991	168	189	0.58	11
FIVE	28929	166	187	0.59	13
SIX	28929	166	187	0.59	13
SEVEN	27045	154	187	0.62	13
EIGHT	26790	152	182	0.62	18
NINE	26780	151	180	0.62	20
TEN	26780	151	179	0.62	21
ELEVEN	27741	163	179	0.61	21

D.F =DEGREES OF FREEDOM
OBS.=NUMBER OF OBSERVATIONS WEIGHTED OUT
RSQ.=R-SQUARED VALUE OF MODEL
NOTE: FOR THE TERMS IN EACH MODEL SEE APPENDIX 4.

high leverage points identified in model THREE removed, model FOUR fitted showed an improvement in the value of the R-squared statistic. In model FIVE, two more outliers were removed but this had no effect on the overall fit of the model. The R-squared statistic remained at the previous level while no large changes were noticed in the values of parameter estimates. In model SIX, the order in which the explanatory variables were entered was altered, each entered in order of the magnitude of its t-value. No marked changes occurred in the parameter estimates and the R-squared value remained stable at 0.58. This is evidence of model stability.

In model SEVEN, possible interaction effects were investigated by introducing interaction terms between variables already in the model. These included the interaction effects between rainfall and soil type, seed and soil type, seed type and rainfall, age and education. Two outlying points were revealed in this model. The model was refitted without these in model EIGHT. Only one interaction effect proved significant. The model was refitted without the insignificant interaction effects in model NINE. Upon closer examination, the significant interaction effect (rainfall and seed type) was only apparent and disappeared with the removal of one data point in model TEN.

The final model adopted in this modelling procedure was model ELEVEN consisting of ten significant explanatory variables. The model explained approximately 61% of the total variation in the dependent variable (Maize yield) from one hundred and seventy nine observations. An examination of the excluded data points revealed that five of them recorded either very low or very high yield levels. This is a possible result of measurement errors during the data collection period. The probable reasons for the rest of the outliers and influential points were not obvious.

4:2:2 INTERPRETATION AND DISCUSSION OF RESULTS

The parameter estimates and the correponding t-values for the final model are displayed in table 4.7 below. The leverage and residual plots of the same model are in appendix 5 and 6 respectively. The residuals have also

TABLE 4.7: RESULTS OF REGRESSION MODELLING OF MAIZE YIELD.

PARAMETER	PARAMETER ESTIMATE	STANDARD ERROR	T-VALUE
1*	33.71	4.93	6.84
Maize hectarage (HMA)	-7.68	2.04	-3.75
Low rainfall: 1400-1600 mm (AAR-2)	-9.34	2.89	-3.24
Agro-ecological zone 2 -marginal sugar cane zone-(GAEZ-2)	10.21	2.73	3.73
Agro-ecological zone 3 -coffee/tea zone (GAEZ-3)	-0.02	3.01	-0.01
Moderately fertile soils (GSOT-2)	-13.51	4.24	-3.19
Soils of low fertility (GSOT-3)	-1.10	2.37	-0.46
Number of maize fields (NOP)	2.94	1.05	2.80
First weeding date -March (FWD-2)	-2.51	2.62	-0.96
First weeding date -April or later (FWD-3)	-11.85	4.02	-2.95
Intercropping (INT)	-6.66	2.26	-2.95
Sugar hectarage (HSU)	-3.43	1.63	-2.10
Farm-size (FAR)	0.86	0.44	1.96
Local Seed (GSEE-2)	-0.28	2.40	-0.12
Second Generation Hybrid Seed (GSEE-3)	-13.90	6.33	-2.20
All Seed Types (GSEE-4)	8.89	3.55	2.50

* ANCHOR CATEGORY REPRESENTING INTERCEPT, HIGH RAINFALL (1600-1800 MM), AGRO-ECOLOGICAL ZONE 1 (SUGAR-CANE ZONE), HIGHLY FERTILE SOILS, FIRST WEEDING DATE-FEBRUARY OR EARLIER, NO INTERCROPPING, AND HYBRID SEED.

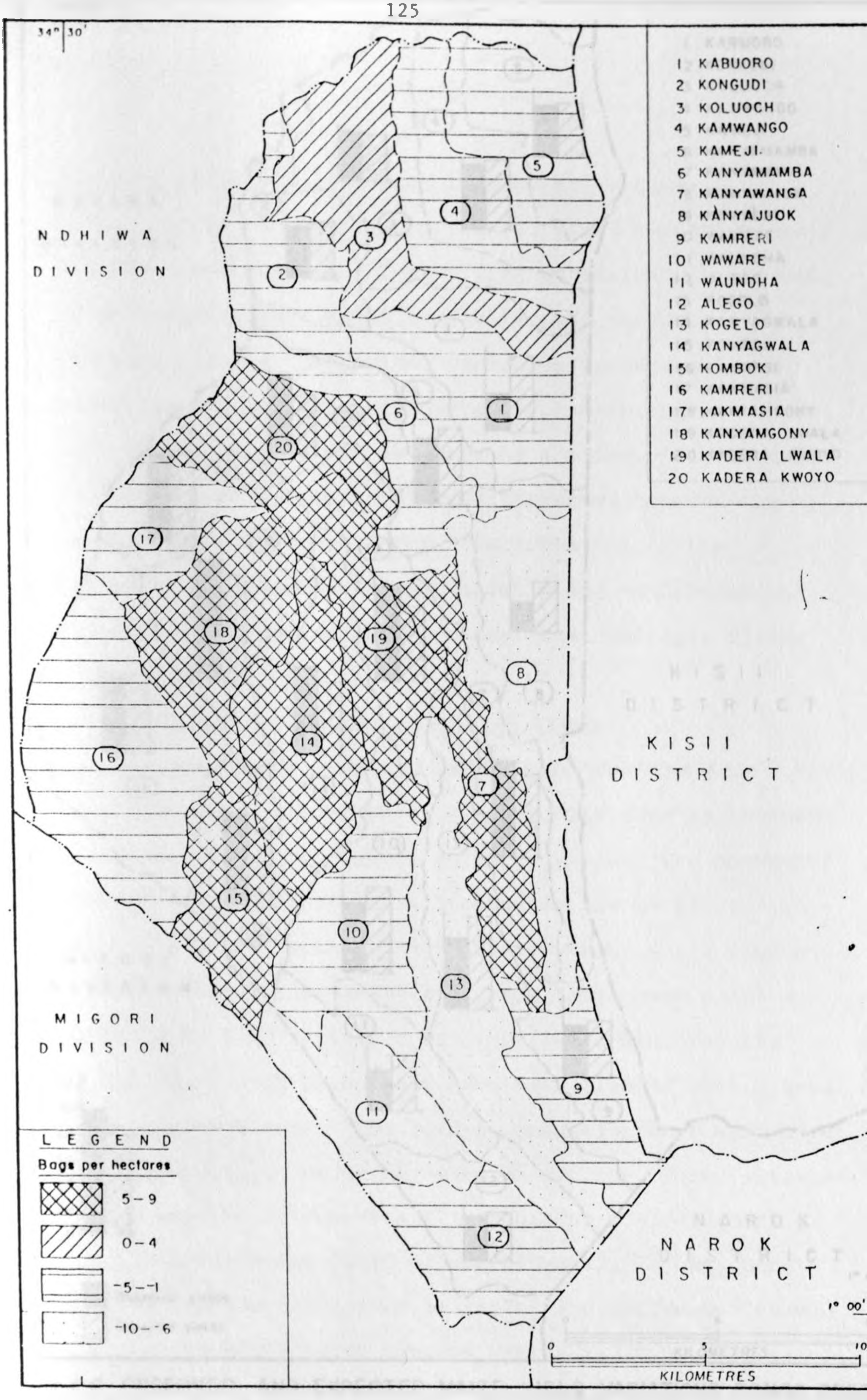


Fig.4.5 MAP OF RESIDUALS MAIZE YIELD ANALYSIS: RONGO DIVISION

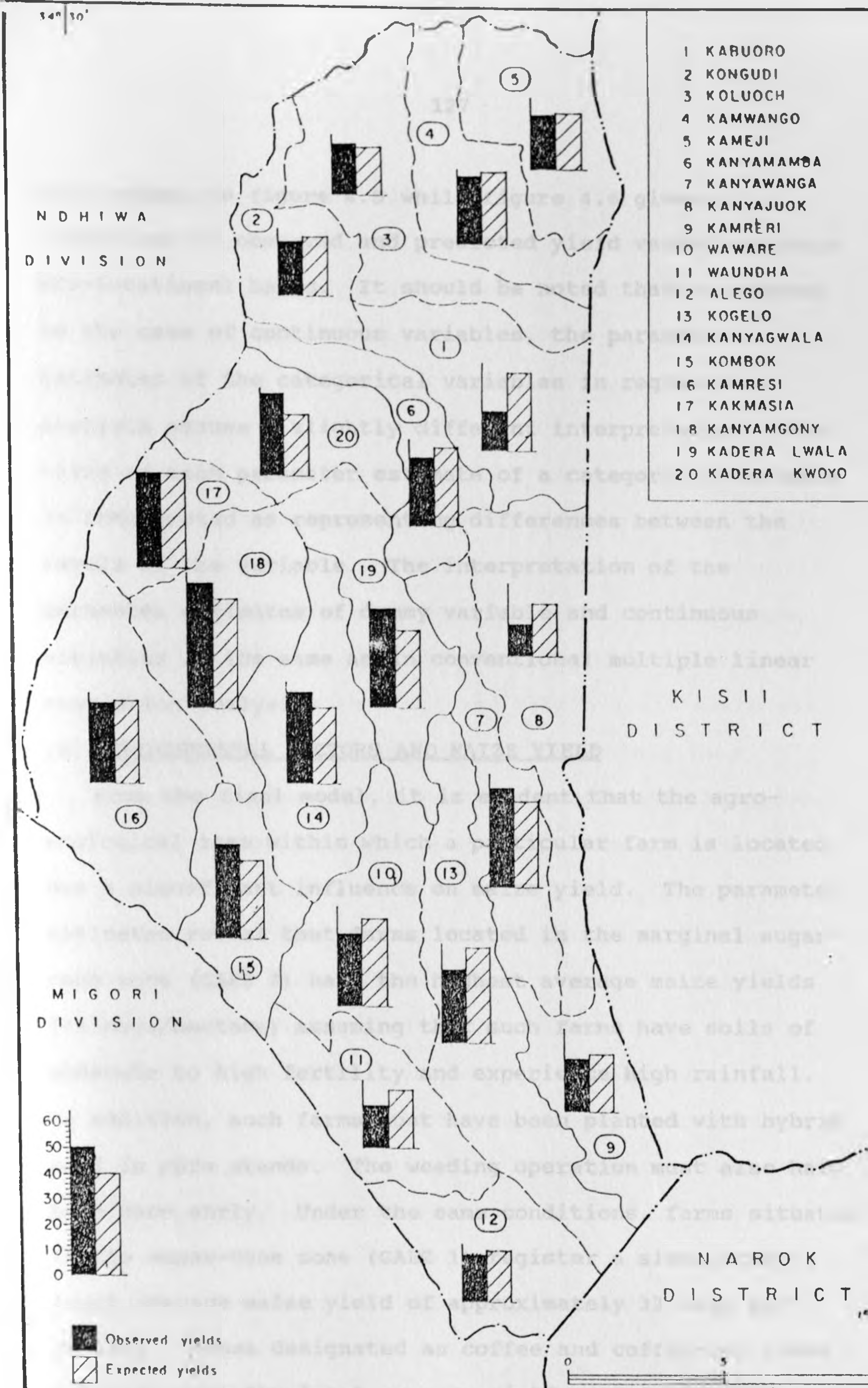


Fig.4.6 OBSERVED AND EXPECTED MAIZE YIELD VARIATIONS: RONGO DIVI

been mapped in figure 4.5 while figure 4.6 gives a comparison of observed and predicted yield variations on a sub-locational basis. It should be noted that as opposed to the case of continuous variables, the parameter estimates of the categorical variables in regression analysis assume a slightly different interpretation. The value of each parameter estimate of a categorical variable is interpreted as representing differences between the levels of the variable. The interpretation of the parameter estimates of dummy variable and continuous variables is the same as in conventional multiple linear regression analysis.

(a) ENVIRONMENTAL FACTORS AND MAIZE YIELD

From the final model, it is evident that the agro-ecological zone within which a particular farm is located has a significant influence on maize yield. The parameter estimates reveal that farms located in the marginal sugar-cane zone (GAEZ 2) have the highest average maize yields (44 bags/hectare) assuming that such farms have soils of moderate to high fertility and experience high rainfall. In addition, such farms must have been planted with hybrid seed in pure stands. The weeding operation must also have been done early. Under the same conditions, farms situated in the sugar-cane zone (GAEZ 1) register a significantly lower average maize yield of approximately 33 bags per hectare. Areas designated as coffee and coffee-tea zones (GAEZ 3) have the least average yields (33.7 bags/hectare) although negligibly and insignificantly different from those in the sugar-cane zone (GAEZ 1). From these results it can be concluded that areas less suitable to the two principal cash crops namely sugar-cane and coffee have the highest potential for maize. A possible explanation for this observation is the fact when maize is in competition with the two crops, farmers tend to disproportionately allocate available farm resources in favour of the latter. This suggests the adverse effects cash-crop production is likely to have on food-crop production in the study area and other areas where the same conditions exist.

The close relationship between rainfall and maize yield is confirmed by the regression coefficients. They indicate that areas of low average annual rainfall (1400-1600mm) have significantly less yields than areas of high average annual rainfall (1600-1800mm) by approximately 9 bags. However, this relationship holds only in farms lying within the marginal sugar-cane zone with fertile soils. In addition, hybrid maize seed must have been planted in pure stands and weeded early (february) in such farms.

Soil fertility status is also a significant variable explaining maize yield variations in the study area. The parameter estimates show that farms located in areas of medium soil fertility have significantly less yield (22.2 bags/hectare) than farms situated in areas of high soil fertility (33.71 bags/hectare). Areas of low soil fertility also show the same trend although the difference is not significant (32.6 bags/hectare). Farms found in this category constitute only 6% of the total sample. This result calls for the adoption of fertility enhancing practices in areas of low soil fertility for greater maize yields.

(b) MAIZE-YIELD AND AGRONOMIC PRACTICES:

While suitable environmental conditions are necessary for the achievement of high maize yields, adequate agronomic practices are also required. The only significant agronomic variables isolated from the modelling procedure are weeding date, intercropping and type of seed planted.

Farms weeded in the month of february or earlier have higher yields than those weeded in March by about three bags. However, this difference is not statistically significant and could therefore be a chance occurrence. This could be interpreted that maize weeded in February and March do not have any yield differences on account of the weeding operation. Maize fields weeded in April or later, however, have significantly lower maize yields (by about 12 bags) than those weeded in February or earlier. These results indicate the high responsiveness of maize to care. Early weeding prevents the competition for soil nutrients associated by weed growth. Weeding is the most demanding of all the field operations in maize production whether in terms of the size of labour or the time required. Late weeding may therefore be a reflection of the difficulties faced by farmers to raise the necessary labour required during this period. On the other hand it may be the cumulative effect of both delayed land preparation and late planting. Problems contributing to late planting and delayed land preparation should therefore be alleviated to enhance maize yields. Because of the limitations facing the utilisation of family labour, there is a need to increase farmers' financial resources to enable them hire casual labour at reasonable rates of remuneration during the weeding period. Encouraging farming groups whereby communal labour can be utilised is also a supplementary measure which can be taken to solve the problem of late weeding.

Intercropping affects maize yields through its reduction of the plant population (maize) per unit area. In other instances, crops interplanted with maize may have identical nutritional requirements as maize thereby leading to competition which can reduce yields. The parameter estimates indicate that pure stands of maize have significantly higher yields than intercropped maize by about 7 bags. Due to various reasons, intercropping is widely practiced in the study area (70.5 % of the sample intercropped) and is likely to continue. However, to reduce the negative effect the practice has on maize yields, there should be a careful choice of the crops intercropped with maize. These should exclude crops such as sugar-cane, sorghum and finger-millet currently intercropped with maize by some farmers. The legumes such as beans and groundnuts have complementary nutritional requirements with maize and are therefore better alternatives.

The development of suitable hybrid maize varieties and their consequent adoption by farmers has been a major strategy in boosting maize production in Kenya. The parameter estimates show that hybrid seed has a higher average yield than local seed by about 0.2 bags although this difference is not significant. Second-generation hybrid has a significantly lower yield than hybrid seed by about 13 bags. The highest yields are recorded in cases whereby combinations of all the three major seed types are planted.

Several implications arise from these results. The negligible difference registered between yields obtained from hybrid and local seed confirm farmers' claims that the former is no better than the latter. While hybrid seed get better yields than local seed in experimental stations, this is not true in the small-scale maize farms because of the inferior agronomic practices. Hybrid seed demands great care in the field without which its yield potential decreases. Under circumstances of improper care, local seed can give higher yields than hybrid seed given the former's adaptability to the local environment. The negligible difference in yield levels between the two seed types predicted by the regression model should therefore be interpreted as indicative of the poor agronomic practices prevalent in the small-scale farming sector.

Second generation hybrid seed poses the greatest problem to the achievement of high maize yields. These seeds are normally planted by farmers on the belief that they have identical genetic properties to the original hybrid seed they are derived from. On the contrary, hybrid seed looses most of its genetic qualities after the first harvest due to contamination from other seed varieties. It is because of this that the purchase of fresh hybrid seed is recommended for each season. In fact, second generation hybrid has a lower yield potential than even local seed varieties. There is therefore an urgent need to caution farmers against this practice especially for those who practice it out of ignorance. The practice may also be a symptom of financial difficulties and inadequate seed distribution system in the study area. Both can inhibit farmers from purchasing fresh hybrid seed every season.

(c) MAIZE YIELD AND SOCIO-ECONOMIC FACTORS.

The total hectarage under maize, number of separate maize fields, farm size and the total hectarage under sugar are the four socio-economic variables significantly related to maize yield.

For every unit increase in maize hectarage, there is a corresponding drop in maize yield of approximately 8 bags. Given all the agricultural resources at the farmers' disposal, smaller hectarages of maize are likely to be worked more intensively than larger ones. This result points to the possible misallocation of resources within the small-scale farming sector. Faced with scarce agricultural inputs, farmers tend to maximise their maize output by expanding the total land devoted to the crop without a corresponding investment in variable inputs such as adequate seed, fertilizer application, proper weeding and early planting. The maintenance of more than one separate piece of maize field is a strategy adopted by farmers against the possibilities of crop failure attributed to rainfall uncertainty. The practice also represents farmers' efforts to utilise only the most favourable environmental attributes which are never uniform even at the single farm level. In addition, the practice enables farmers to space their field operations thus increasing the chances of better management practices. The parameter estimates indicate a significant and positive relationship between the number of separate maize fields and yields.

Farm size has a positive and significant relationship with maize yield. This observation should not be interpreted as indicative of a positive influence larger farm sizes and maize fields have on yields. A possible explanation for the relationship is that larger farm sizes have several advantages over smaller ones with respect to yields. In the first instance, the observation of long fallow periods and its positive effect on soil fertility is more possible in larger farms. In addition, the practice of intercropping on account of land scarcity is less likely with abundant supply of land. Given the negligible application of fertilizer within the small scale farming sector, farmers will continue to rely on the natural fertility of the soils. The observed relationship between farm size and maize yield points to the danger that increasing population pressure on available land poses to maize production in the study area.

The regression model predicts a decrease of 3 bags in maize yield with every unit increase in sugar-cane hectarage planted by a farmer. Sugar-cane not only competes with maize for fertile land but also the major agricultural inputs necessary for proper crop husbandry. The allocation of these resources between the competing enterprises depends largely on the expected returns from each enterprise. Sugar-cane not only fetches higher prices than maize but also has a ready market provided by the factory situated at Awendo. The crop also enjoys better supportive services including land preparation services, transport and an efficient extension service. Due to all these advantages farmers are expected to allocate more of their resources towards sugar-cane than maize thus depressing maize yields. With decreasing farm sizes and the expansion of the SONY sugar factory at Awendo, maize production is expected to be on the decline unless special measures are taken to reverse the expected trend. Supportive services specific to maize should be initiated, mainly dealing with a more intensified extension and credit support. The credit may be specially arranged for specific field operations in maize cultivation and could be in kind and not in cash to avoid possible misuse. The administration of these services should be targeted mainly at sugar-cane farmers and SONY sugar could bear part of the responsibility of administering such services.

4:3:0 MAIZE HECTARAGE: DATA ANALYSIS AND RESULTS.

Although the results above indicate that hectarage expansion has a depressive effect on maize yield, it can serve as a short term measure for increasing maize output especially in cases where idle land exits. For the sample covered in this study, sizes of land devoted to maize varied from a minimum of 0.1 hectares to a maximum of 7 hectares. The average size of maize fields was 1.1 hectares with a standard deviation of 0.8 hectares. From these figures, it is evident that maize fields are generally small although wide variations exist. Figure 4.7 below shows the spatial variations in maize hectarage. The highest hectarages are registered in the east and west of the study area while the lowest (0.5-1.0 hectares) are found in the northern and southern sub-locations.

Environmental factors are expected to influence maize hectarage indirectly through their influence on the

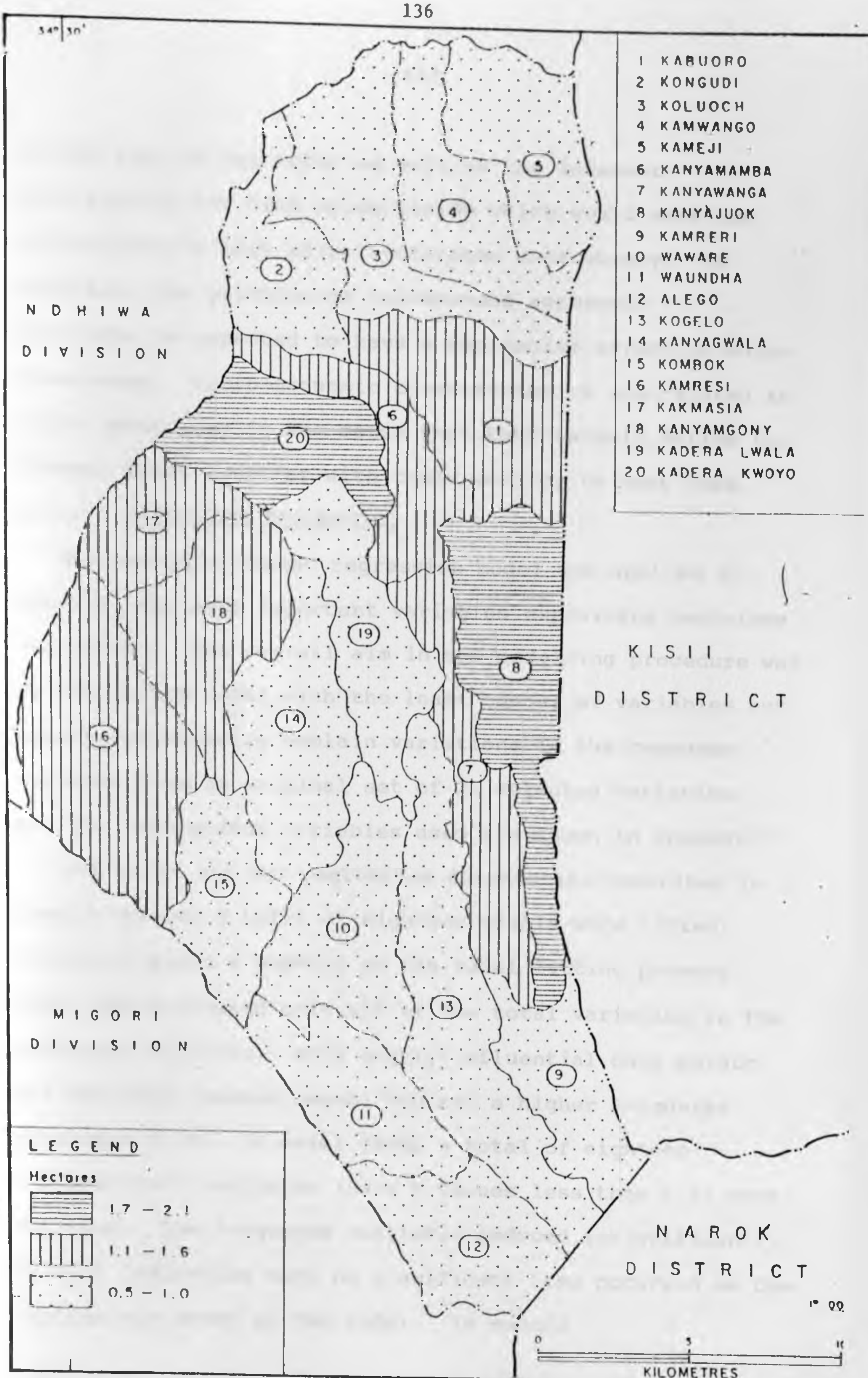


Fig. 4.7 OBSERVED MAIZE HECTARAGE VARIATIONS : RONGO DIVISION

workability of the soils as well as the inherent potentiality for high maize yields which would make the cultivation of high maize hectarages unnecessary. In addition, the practice of recommended agronomic practices is expected to have a depressive effect on maize hectarages. Socio-economic characteristics are related to maize hectarages in the sense that they largely define the farmers needs together with their ability to meet them.

4:3:1 MODELLING PROCEDURE.

The multiple linear regression model was applied to identify the most important variables explaining hectarage variations. The overall aim in the modelling procedure was to obtain the model with the least number of variables but which significantly explain variations in the response variable from an original set of 29 selected variables. All the independent variables used are shown in appendix 7.

Utilising all the regression diagnostics described in chapter three, a total of eighteen models were fitted. Table 4.8 gives a summary of the model fitting process. Model ONE explained only 55% of the total variation in the dependent variable. With highly influential data points and outliers removed, model TWO had a higher R-squared statistic 0.75. In model THREE a total of eighteen insignificant variables (with t-values less than 1.2) were excluded. The R-squared statistic reduced insignificantly by 0.01 indicating that no significant loss occurred on the explanatory power of the model. In models

FOUR and FIVE, identified leverage values were removed while retaining the same number of variables. The R-squared statistic improved to 0.78. The same variables were introduced in model SIX in order/magnitude of their t-values. One outlier was identified. This was removed in

TABLE 4.8 SUMMARY TABLE FOR ALL MODELS FITTED ON MAIZE HECTARAGE

MODEL	DEVIANCE	D.F	OBS.	RSQ.	NUMBER OF UNITS WEIGHTED OUT
NULL	138.38	199	200	-	-
ONE	62.369	161	200	0.55	-
TWO	33.294	156	195	0.76	5
THREE	34.607	176	195	0.75	5
FOUR	30.420	170	189	0.78	11
FIVE	30.325	169	188	0.78	12
SIX	30.325	169	188	0.78	12
SEVEN	30.317	168	187	0.78	13
EIGHT	30.317	169	187	0.78	13
NINE	30.738	171	187	0.78	13
TEN	30.738	171	187	0.78	13
ELEVEN	26.587	153	187	0.81	13
TWELVE	27.535	159	187	0.80	13
THIRTEEN	25.895	153	177	0.81	23
FOURTEEN	32.312	169	187	0.77	13
FIFTEEN	31.903	167	187	0.77	13
SIXTEEN	29.874	168	187	0.78	13
SEVENTEEN	30.165	170	187	0.78	13
EIGHTEEN	30.165	170	187	0.78	13

D.F=DEGREES OF FREEDOM
OBS.=NUMBER OF OBSERVATIONS IN THE MODEL
RSQ.=R-SQUARED VALUE
NOTE: FOR THE TERMS IN EACH MODEL SEE APPENDIX 8.

model SEVEN whereby one variable (number of farms) lost its significance. This was subsequently omitted in model EIGHT. The t-values for all the terms in model 8 showed that the variable, educational level, was no longer significant. This was omitted in model nine. The remaining variables were entered in model 10 in order of the magnitude of their t-values.

A number of possible interaction effects were explored in model ELEVEN. Insignificant interaction effects were removed in model TWELVE whereby ten additional influential points were identified. These together with the interaction effect between soil type and length of fallow period were removed in model THIRTEEN. The interaction effect between soil and seed type were removed in model FOURTEEN while reinstating the ten leverage points weighted out earlier. The interaction effect between soil type and length of fallow period was reintroduced in model FIFTEEN. In model SIXTEEN, the interaction effect between number of maize fields and soil type was removed without significantly affecting the explanatory power of the model. In model SEVENTEEN, the interaction effect between soil type and length of fallow period was removed after being found insignificant. The final model fitted and adopted to explain hectarage variations was model EIGHTEEN consisting of eleven significant variables. The results of the model are displayed in table 4.9. The corresponding leverage and residual plots of the model are shown in appendix 9 and 10 respectively while figure 4.8 is a map of residuals from the same model. Figure 4.9 gives a comparison of the observed hectarage variations and corresponding values

TABLE 4.9: RESULTS OF REGRESSION MODELLING OF MAIZE HECTARAGE.

PARAMETER	PARAMETER ESTIMATE	STANDARD ERROR	T-VALUE
1 (Intercept)*	0.72	0.20	3.54
Number of maize fields (NOP)	0.28	0.04	7.55
Land preparation date: January/February (GLPD-2)	-0.44	0.13	-3.43
Land preparation date -March/later (GLPD-3)	-0.54	0.14	-3.97
Moderately fertile soils (GSOT-2)	-0.69	0.18	-3.94
Soils of poor fertility (GSOT-3)	-0.12	0.08	-1.46
Farm-size (FAR)	0.05	0.01	3.64
Agro-ecological zone 2 -marginal sugar-cane zone (GAEZ-2)	-0.27	0.08	-3.59
Agro-ecological zone 3 -coffee/tea zone(GAEZ-3)	-0.16	0.09	-1.71
Local seed (GSEE-2)	-0.20	0.08	-2.68
Second generation hybrid seed (GSEE-3)	-0.17	0.15	-1.12
All seed types (GSEE-4)	-0.01	0.10	-0.11
Ox-plough ownership (OXP)	0.39	0.15	2.64
Coffee hectarage (HCO)	-0.91	0.37	-2.45
Farm owner present (OWN)	0.20	0.08	2.42
Length of fallow (FAL)	-0.08	0.04	-1.98
maize fields and ox-plough ownership (NOX)	-0.09	0.05	-1.80

* represents: Land preparation date-December or earlier (GLPD 1), Highly fertile soils (GSOT 1), Sugar-cane zone (GAEZ 1), Planting of Hybrid seed (GSEE 1).

predicted from the model.

4:3:2 INTERPRETATION AND DISCUSSION OF RESULTS.

The model explains 78% of the total variation in maize hectarage. This is a considerable improvement over model ONE which had a total number of twenty nine variables explaining only 54% of the total variation in the dependent variable. The main variables identified as significantly related to maize hectarage are conveniently discussed under three subheadings, namely: environmental, agronomic and socio-economic factors.

(a) MAIZE HECTARAGE AND ENVIRONMENTAL FACTORS.

The parameter estimates indicate that farms located in agro-ecological zone 1 (sugar-cane zone) tend to have more land devoted to maize than the two other zones. It should be noted that agro-ecological zone 2 (marginal sugar-cane zone) has the least amount of land devoted to maize. This seems to suggest that the areas most appropriate to the main cash crops (GAEZ 1&3) namely sugar cane, coffee and tea tend to have higher maize hectarages. It is interesting to note that, agro-ecological zone 2 (marginal sugar-cane zone) which has the least land under maize was also identified in section 4:2 above as having the greatest yield levels. These results seem to conform with the inverse relationship established between hectarage size and maize yields in section 4:2 above. They also suggest that sugar-cane competes with maize mainly for the inputs required for the enhancement of yields rather than land.

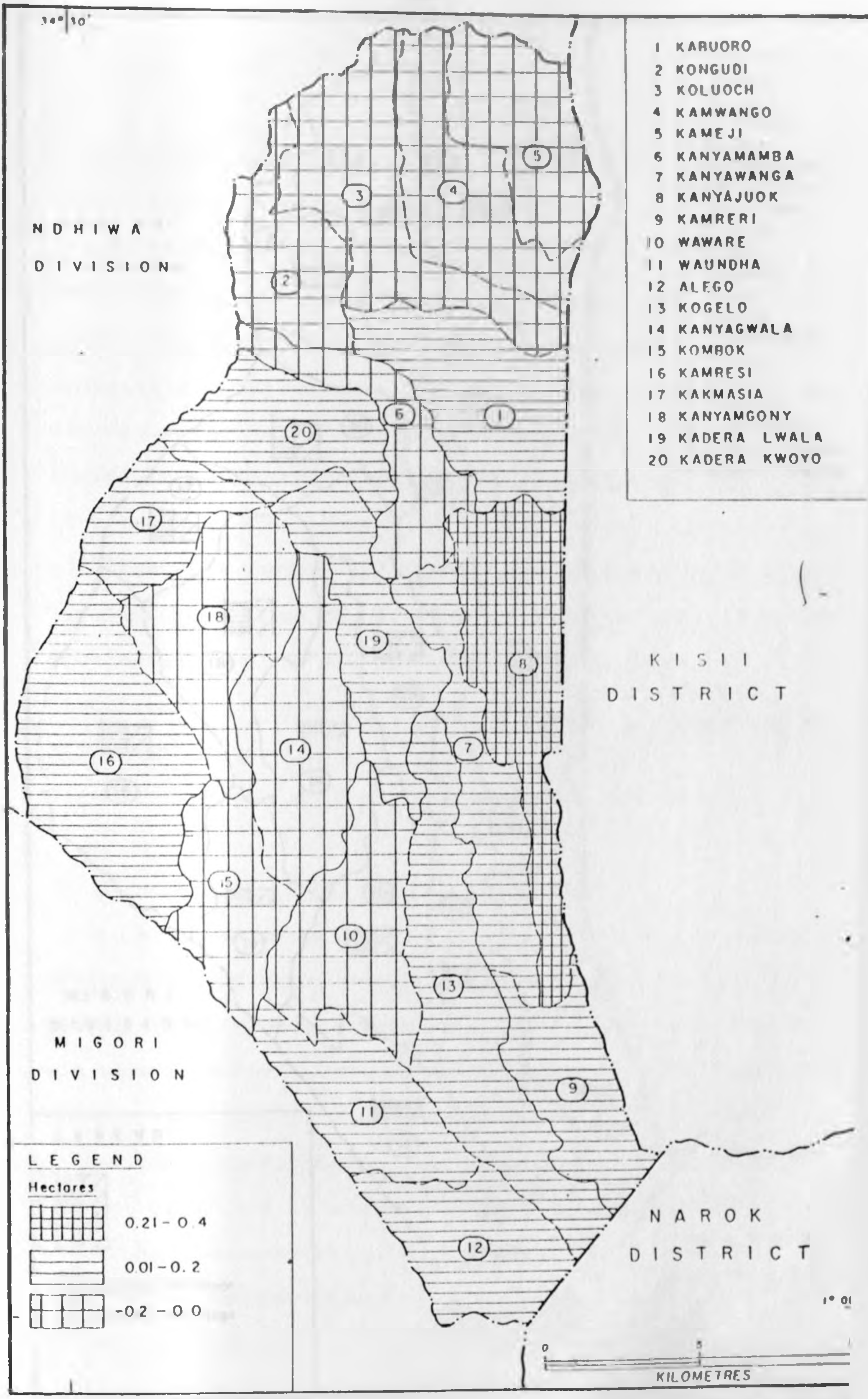


Fig.4.8 MAP OF RESIDUALS MAIZE HECTARAGE ANALYSIS : RONGO DIVISI

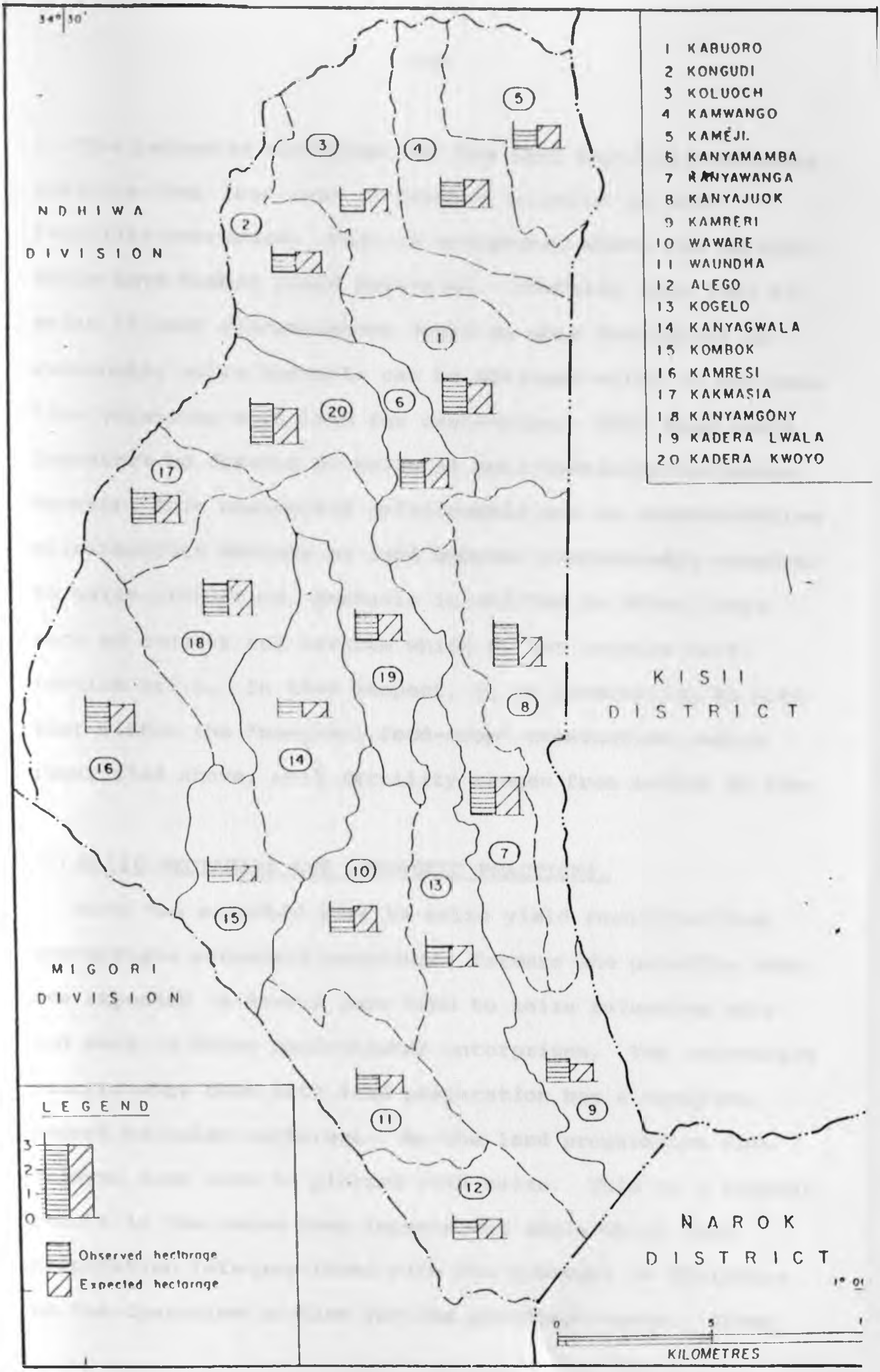


Fig. 4.9 OBSERVED AND EXPECTED MAIZE HECTARAGE VARIATIONS : RON
DIVISION

The parameter estimates for the soil fertility variable indicate that less land is devoted to maize as soil fertility decreases. This is unexpected since the fertile soils have higher yield potential. Devoting less land to maize in such circumstances would be more beneficial as reasonable maize harvests can be obtained while at the same time releasing more land for cash-crops. More land would therefore be devoted to maize as soil fertility decreases. However, this unexpected relationship can be representative of situations whereby as land becomes increasingly marginal to maize production, emphasis is shifted to other crops such as cassava and sorghum which do not require very fertile soils. In this respect, it is interesting to note that within the "marginal food-crop" combination region identified above, soil fertility ranges from medium to low.

(b) <u>MAIZE HECTARAGE AND AGRONOMIC PRACTICES.</u>

With the expected rise in maize yield resulting from appropriate agronomic practices, farmers who practice such are expected to devote less land to maize releasing more and more to other agricultural enterprises. The regression results show that late land preparation has a negative impact on maize hectarage. As the land preparation date delays, less land is planted with maize. This is a logical result in the sense that farmers who begin their land preparation late are faced with the pressure of finishing up the operation in time for the planting season. Given the shortage of labour and equipment prevalent in the small-scale farming sector, farmers have to prepare less land for timely planting to occur. This points to the need to help farmers acquire the necessary equipment and labour if maize hectarages are to be expanded especially in areas where idle land exists.

Hybrid seed tends to be planted in larger areas than either local seed varieties or second generation hybrid seed. The planting of a combination of all seed types (which has comparable yields with hybrid seed) tends to be done on hectarages not significantly different from those devoted to hybrid maize seed. This suggests that those farmers who can afford hybrid seed are also well placed to prepare bigger lands for the crop probably indicating their superior ability to raise all the required farm resources.

As the length of fallow period increases, less land tends to be devoted to maize. Long fallow periods increase the inherent fertility of the soil necessary for high maize yields. This possibly removes the pressure from the farmer to expand hectarage under maize. In the absence of adequate soil fertility enhancing practices, shorter fallow periods are likely to be reflected in lower yields. This can lead the farmer to expand the amount of land devoted to maize in order to either maintain or improve the level of maize output. The observance of long fallow periods can also be a reflection/difficulties faced during the land /of preparation period resulting in less land planted with maize.

(c) MAIZE HECTARAGE AND SOCIO-ECONOMIC FACTORS.

The socio-economic variables with positive and significant relationships to the total amount of land under maize include number of separate maize fields and farm size. Total amount of land under maize increases with farm size. The amount of land available to each farmer for maize cultivation is expected to continue diminishing as a result of population pressure on land and competition from the newly introduced cash crops. This trend shows that increasingly less land will be devoted to maize. This calls for an intensification of land use by the application of increasing amounts of inputs not only to preserve soil fertility but also to increase the level of maize yields.

An ox-plough team consisting of at least two oxen and a plough is the most widespread means of land preparation in the study area. The ownership of such a team or its equivalent (tractor) has a significant influence on maize hectarage. The parameter estimates indicate that owners of ox-plough teams have larger amounts of land under maize than those who do not have by about 0.3 hectares. This result suggest that land preparation problems are major factors inhibiting maize production in the study area. There is therefore a need to improve the farmers accessibility to the means of land preparation. Tractors are not only expensive but also in short supply in the study area. Moreover, the few tractors available are more often used in the sugar-cane industry. The small sizes of the maize farms would also make it uneconomic for a farmer to purchase a tractor. Two alternatives may therefore be exploited. Tractor hire services should be made available at reasonable rates to enable farmers with no ox-plough teams prepare their maize fields in time and larger units. For the sample covered in this study, farmers with ox-plough teams constituted 60.5% of the total sample. On the other hand, communal groupings can be encouraged so that such farmers pool their resources together for the benefit of all the members. In addition, livestock development should be consciously pursued as part and parcel of agricultural crop development. Better ox-ploughs should be designed and made widely available to the farmers so that the range of activities in which the implement can be utilised is expanded and made more efficient.

Special arrangements could alternatively be made to delegate duties to an appropriate agency like the NCPB and the Kenya Grain Growers Cooperative Union (K.G.G.C.U) to initiate programmes particularly aimed at lessening the land preparation problem in maize cultivation. An example of such a programme is the arrangement by the SONY sugar company in which it undertakes all the land preparation tasks for the sugar farmers. The appropriate costs are later recovered from the proceeds of sugar deliveries to the factory. Due to the multiplicity of market outlets for maize (see chapter six), such an arrangement may be difficult to execute. However, it could be helpful if the SONY sugar company extended its land preparation services to cover maize for they would still have a better chance of recovering their costs. Such an arrangement can benefit sugar-cane growers who are the most likely to neglect major food-crops such as maize.

The total amount of land devoted to coffee is negatively and significantly related to maize hectarage. A unit increase in coffee hectarage lowers maize hectarage by about one hectare. This indicates that coffee is a better competitor for land than maize. Given the fact that coffee cultivation is yet to be widespread in the study area, there is a possible future decline in maize hectarages as more farmers take up coffee cultivation. Measures must therefore be taken to ensure that maize yields per hectare are raised since it is apparent that the maize requirements of the farmers will have to be met from increasingly diminishing land areas. The need to increase farmers' accessibility to important farm inputs for intensified maize production therefore needs to be emphasised.

The problem of absentee landownership has long been known to have undesirable influence on agricultural development. Household heads (usually men) absent from their farms constitute this group and they are normally absent for reasons of employment mainly in the urban areas.

The spouse or a labourer is left in such cases to oversee the management of the farm although the absent farm owner can be consulted over major farming decisions. The farm owner also has the responsibility of financing major farming operations. The parameter estimates indicate that the presence or absence of farm owners is a significant variable explaining hectarage variations in maize production. Farms for which the land owners are absent have less land devoted to maize by about 0.1 hectares. Cases of absentee farm owners constituted 20% of the total sample covered in this study. In 82% of these cases, farm management was left on the hands of the female spouse. It is reasonable to suggest that women need greater control in farming decisions especially when they are left behind to manage farms. The use of oxen in land preparation is a demanding task which requires great expenditure of raw human labour. Women are ill disposed to perform this task. It may be added that for families whose male heads are in employment in urban areas, the pressure to meet food needs from the farm are rather less because transfer payments received can be utilised in the purchase of grain and other foodstuffs. All these can explain the negative effect the absence of farm-owners have on maize hectarages.

The interaction effect between the number of fields and ownership of an ox-plough team is also significant. This shows that the possession of ox-plough teams and an increasing number of separate maize fields have the effect of reducing average sizes of maize fields. This reflects the possibility that those without ox-plough teams tend to cultivate maize in larger land units. This group of farmers normally rely on hired tractors and ox-plough teams making it convenient to cultivate fewer but larger maize fields.

4.4 SUMMARY OF FINDINGS AND CONCLUSIONS.

The multiple regression modelling procedure attempted in section two isolated a total of ten independent variables explaining the observed variations in maize yield from an original set of thirty. The twenty variables left out of the model need not be irrelevant but in the present circumstances it is only the ten which emerged as the most significant. The results need not necessarily indicate causative effects of the explanatory variables. The discussion of results and the suggestions presented must be viewed in the light of these limitations.

The regression results indicated that environmental attributes are major explanatory variables in maize yield variations. To reduce the depressive influence of low rainfall on maize yield, it is suggested that adequate hybrid maize seed varieties be popularised in the low rainfall areas of the study area together with the promotion of early planting. Extension work on the adoption of hybrid should therefore be more specific to particular areas. Agro-ecological zones most suited to cash-crop production should receive a more intensified maize promotion campaign. This is given more weight by the observed negative impact of sugar-cane on maize yields. While cash crop production is essential as a means of improving farm incomes, care must be taken that it does not compromise the ability of the farmer to meet his/her own food needs. Given the better remuneration from cash crops, a decline in maize production is a likely phenomenon if identical supportive services are not extended to food crops. Soil conservation measures should be intensified not only in areas of low fertile soils but even in the more fertile areas because such are going to deteriorate in future as a result of continuous use.

Apart from the measures to conserve and improve environmental conditions, better crop management practices must be given prominence. Hybrid seed in particular should be popularised with the corresponding high standards of crop husbandry. The latter is more of a socio-economic problem and can be alleviated through farmer educational programmes and credit support. The planting of second-generation hybrid seed and the inappropriate choice of crops to intercrop with maize are undesirable practices which can be stopped without any significant demand on the farmers' expenditure. Early weeding is possible if the needed farm equipment and labour are made available at the farm level. This is best achieved by increasing the farmers' accessibility to farm credit. New forms of communal participation in agricultural development such as women groups, church groups could be helpful in providing necessary labour requirements in maize production.

The problem of scale of operations must be addressed in the small-scale farming sector. Farmers must be increasingly made aware of the advantages smaller farm units have over larger ones when correct husbandry methods are practiced. The intensification of production to save on land is impossible if the ability of the farmer to afford necessary agricultural inputs and apply them skillfully is limited. The conclusion to be drawn from the foregoing analysis is that low maize yield in the small-scale agricultural sector is the result of improper agronomic practices caused by shortfalls in the provision of necessary agricultural inputs and skills. The introduction of cash-crops is doing very little to reverse this trend.

The amount of land under maize cultivation has been shown to be highest in areas most suitable to the major cash-crops namely sugar-cane and coffee. The latter has a significant and negative effect on maize hectarage. Both results have important implications for maize production. In the first instance, they indicate that the introduction of cash crops in the area is reducing land under maize. For the same level of maize output to be achieved or improved as cash-crop production becomes more popular, crop intensification methods must be adopted. In general, hectarages planted with maize decline as soil fertility decreases reflecting the increasing importance of peripheral food crops like sorghum, finger-millet and cassava in areas with infertile soils.

Factors reducing maize hectarages include late land preparation, planting of seed varieties other than hybrid and the absence of farm owners. The first problem may be alleviated through the provision of credit facilities or the organization of farmers into communal groups sharing the implements necessary for land preparation. The problem of absent land owners however is more of a cultural problem. Women heads of such households should be given a freer hand in handling all the farm matters. Land titles should be shared between the male and female heads of a household. Credit facilities should also show a shift of emphasis from males to females.

Ownership of an ox-plough team and large farm are positively related to maize hectarage. Farm sizes are bound to decrease in future due to population pressure as well as demand for land made by the newly introduced cash-crops such as sugar-cane and coffee. This limits the reliance on hectarage expansion as a strategy for increasing maize production. The accessibility of farmers to major land preparation implements such as the ox-plough should be improved through several means already suggested above. Uncultivated portions of land still exist in the study area although not in all cases is this a symptom of excess land. Such lands exist in several instances as land reserved for pasture, settlement or as portions unsuitable for crop production. Because of the raw human energy required in ox-ploughing, better farm machinery should be made available to farmers in the long run. These should be specially designed for small farm units and should also be within affordable price levels.

In conclusion, maize production has been shown in this chapter to be characterised by low yields attributable mainly to inadequate agronomic practices. The introduction of cash-crops especially sugar-cane is adversely affecting maize production due to their competition with maize for both land and inputs. It can therefore be concluded that future food production in the area is certain to decline unless efforts are taken to reduce the undesirable effects of cash-crop production. Such efforts should emphasize better crop husbandry methods for higher yields since it is apparent that enhanced maize production in future will certainly depend upon improved yields rather than hectarage expansion. Consequently, greater extension efforts coupled with material support to a wider spectrum of farmers will be quite necessary.

CHAPTER FIVE - ADOPTION OF INNOVATIONS IN MAIZE PRODUCTION.

CHAPTER FIVE: ADOPTION OF INNOVATIONS

5:0 INTRODUCTION.

This chapter aims at identifying the major factors influencing the adoption of hybrid seed varieties and related innovations within the small-scale farming sector. Hybrid maize seed varieties suitable for virtually every agro-ecological zone in Kenya have successfully been developed over the last 25 years. The adoption of these improved seed varieties amongst farmers has been one of the most important reasons for the increase in maize production which has been witnessed in the country since the early 1960s. However, the adoption of hybrid seed together with related innovations has been easier for the large-scale rather than the small-scale farming sector. The adoption of these innovations within the small-scale farming sector has been characterised by a number of trends namely:

- The outright rejection of hybrid seed and related innovations.
- Discontinuous use of hybrid seed whereby farmers revert to local seed varieties after an initial planting of the former.
- The partial adoption of the complete package of innovations which accompany hybrid seed.
- The adoption of the complete package of innovations (hybrid seed and all the related innovations).

The main concern of this chapter is to investigate the main factors which influence the likelihood that a particular farmer will adopt hybrid seed either singly or in conjunction with the related innovations. Hybrid seed is normally made available to farmers as part of a complete package of innovations which include timely land preparation, early planting, correct plant population and spacing, proper weeding, fertilizer application and use of pesticides (Rundquist, 1984). This chapter will address itself to only two of the innovations, hybrid seed and fertilizer application although the others are equally important.

It is hypothesised that environmental factors influence the likelihood of adoption of particular agricultural innovations including the planting of hybrid seed and the application of fertilizer. If environmental attributes are such that reasonable yields are achieved, the farmer may not see the need for a better innovation especially if such involves either some element of risk or additional expenditure. The perception of a problem normally depends on its severity. It is therefore expected that farms located in agriculturally high potential areas (i.e with high rainfall and fertile soils) would have a lesser likelihood of adopting hybrid maize seed and associated innovations.

Before an innovation is adopted, potential adopters must be made aware of its very existence and the advantages it has over the practice it is supposed to replace. The role of information is therefore paramount in the adoption of innovations. Besides, the superiority of any new innovation must be physically demonstrated to potential adopters. In cases whereby an innovation requires the use of a new product, such a product must be made available to the farmers at affordable prices. This stems from the fact that small-scale farmers are less inclined to make additional expenditure in their farming operations if the expected returns are not readily obvious. The adoption of an innovation therefore involves several stages of decision making on the part of the potential adopter. These decisions are shaped not only by environmental conditions prevalent at the farm but also the socio-economic circumstances of the potential adopter. Personal characteristics of individual farmers also play an important role in the decision making process regarding the adoption of innovations. A number of variables have therefore been selected measuring environmental and socio-economic conditions facing potential adopters as well as their individual attributes (see appendix 11). It is from these that the best predictors of the likelihood of adoption of particular innovations are to be isolated by the modelling procedure attempted below.

Since hybrid maize seed is normally presented to farmers as a package consisting of inseparable innovations, the pattern of adoption by farmers is expected to be such that the most involving innovations are adopted by the least number of farmers (see Figure 5.1 below). The largest number of adopters are expected to fall in the group that has adopted hybrid seed but in combination with local seed varieties. This group represents the farmers who for various reasons cannot afford enough hybrid seed varieties for all their fields. Those who are trying hybrid seed for the first time are also included in this group. The second adoption group are those who apply either manure or fertilizer regardless of seed type planted. These are expected to be fewer than the first group since the application of fertilizer/manure is often more involving in terms of energy spent and financial expenditure. The next in the hierarchy of adopters constitute those farmers who have planted hybrid seed alone without mixing it with other local varieties. This group represents those who have passed the experimental stage and do not face any problems in terms of the availability of hybrid seed varieties. Fourth in the hierarchy are those who have adopted a combination of both hybrid seed and fertilizer application. However, in this group both innovations are only partially adopted since application of manure and the planting of local seed varieties continue at the same time. The highest in the hierarchy of adopters are those who plant hybrid seed only in combination with commercial fertilizer. These are the ones closest to the recommended ideal and should be the smallest in number.

A comparison of the theoretical hierarchy (Figure 5.1) and the actual distribution of adopters of the various innovation categories (Table 5.1) show their close association. The apparent anomaly between the theoretical expectation and the figures from the actual sample is probably caused by the particularly high levels of farm-yard manure application amongst maize farmers in the study

Fig. 5.1 THEORETICAL DISTRIBUTION OF ADOPTERS

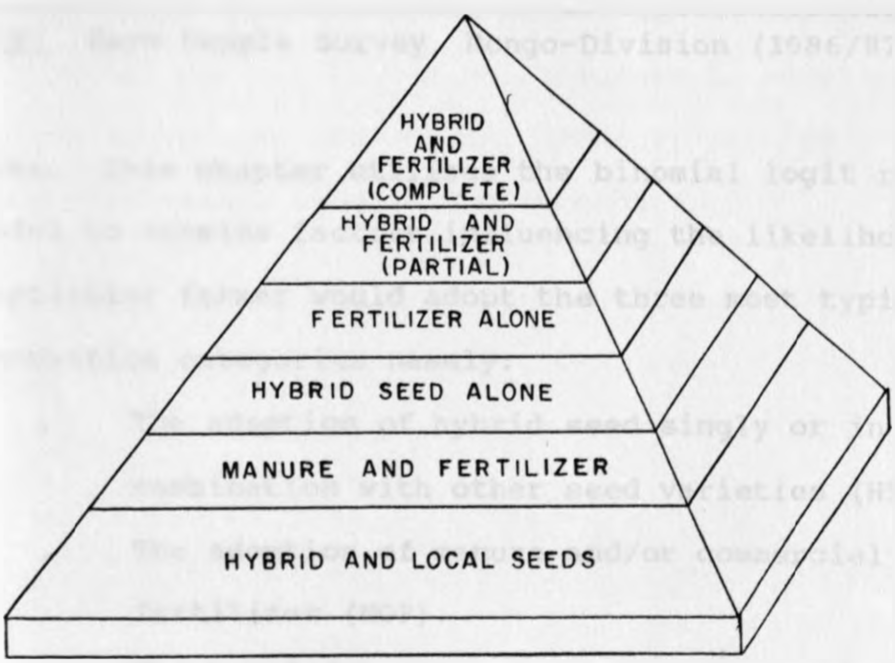


TABLE 5.1: THE DISTRIBUTION OF ADOPTERS FOR DIFFERENT CATEGORIES OF INNOVATIONS- RONGO DIVISION.

CATEGORY.	TOTAL NO. OF ADOPTERS	% OF TOTAL-FARMERS.
1. HYBRID SEED IN COMBINATION WITH LOCAL SEED VARIETIES (HYS)	132	66.0
2. MANURE AND/ OR FERTILIZER (MOF)	152	76.0
3. HYBRID SEED ONLY (HYB)	107	53.5
4. FERTILIZER ONLY (AOF)	25	12.5
5. HYBRID SEED & LOCAL SEEDS/ FERTILIZER AND/OR MANURE (HFP)	111	55.5
6. HYBRID SEED -FERTILIZER COMBINATION (HFC)	19	9.50

SOURCE: Farm Sample Survey, Rongo-Division (1986/87)

area. This chapter utilises the binomial logit regression model to examine factors influencing the likelihood that a particular farmer would adopt the three most typical innovation categories namely:

- The adoption of hybrid seed singly or in combination with other seed varieties (HYS).
- The adoption of manure and/or commercial fertilizer (MOF).
- The partial adoption of manure/hybrid seed combined (HFP).

5:1 THE ADOPTION OF HYBRID SEED ALONE OR WITH OTHER SEED VARIETIES.

From preliminary data analysis, it is apparent that the adoption of hybrid seed either singly or in combination with other seed varieties tends to vary with environmental characteristics of a given farm as well as with individual and other socio-economic attributes of farmers. Table 5.2 gives a breakdown of the number of adopters of innovation categories for different levels of selected categorical variables.

The location of a farm in agro-ecological zone 2 (marginal sugar cane zone) seems to favour the likelihood of adoption of hybrid seed either singly or in combination with other seed varieties while average annual rainfall experienced apparently has no influence on adoption rates of this particular innovation. Younger farmers (below 65 years) and female farmers are according

TABLE 5.2 FARMERS ADOPTING DIFFERENT INNOVATIONS FOR SELECTED CATEGORICAL VARIABLES.

VARIABLE	LEVELS	TOTAL FARMS	TOTAL ADOPTERS HYS	MOF	HFP	PERCENTAGE HYS	MOF	HFP
AGRO-ECOLOGICAL ZONE:								
	1-SUGAR CANE ZONE	89	58	68	45	65	76	51
	2-MARGINAL SUGAR CANE ZONE	71	51	54	44	72	76	62
	3-COFFEE-TEA ZONE	40	23	30	22	58	75	55
AVERAGE ANNUAL RAINFALL:								
	1-HIGH (1600-1800mm)	149	99	115	79	66	77	53
	2-LOW (1400-1600mm)	51	33	37	32	65	73	63
SOIL FERTILITY:								
	1-HIGH	127	84	101	76	66	80	60
	2-MEDIUM	15	9	14	9	60	93	60
	3-LOW	58	39	37	26	67	64	45
AGE:								
	1-18-44 YRS	90	65	68	54	72	76	60
	2-45-64 YRS	85	55	63	47	65	74	55
	3-65YRS& OVER	25	12	21	10	48	84	40
SEX:								
	1-MALE	164	106	122	84	65	74	51
	2-FEMALE	36	26	30	27	72	83	75
OCCUPATION:								
	1-NONE	63	44	50	38	70	79	60
	2-EMPLOYED	137	88	102	73	64	75	53
RELIGION:								
	1-NONE	52	32	39	26	62	75	50
	2-S.D.A*	90	63	72	53	70	80	59
	3-OTHER	58	37	41	32	64	71	55
EDUCATIONAL LEVEL:								
	1-NONE	85	44	59	35	52	69	41
	2-PRIMARY	101	78	82	67	77	81	63
	3-SECONDARY	14	10	11	9	71	79	64

*S.D.A - SEVENTH DAY ADVENTIST CHURCH

SOURCE: FARM SURVEY- RONGO DIVISION 1986/87 to the findings better adopters of the innovation. The engagement of a farmer in non-farm employment also seem to discourage the partial adoption of hybrid seed. The same applies to farmers belonging to "other" religious affiliations and those having primary level of education. However, these preliminary observations must undergo more rigorous statistical analysis before meaningful conclusions can be made. This has been attempted below using the multiple logit regression model with adoption of the innovation as the dichotomous dependent variable.

5:1:1 MODELLING PROCEDURE

The overall aim of the modelling procedure was to obtain the regression model with the least number of independent variables but which significantly explained the likelihood of adoption of the innovation. The first model fitted therefore had the largest number of possible explanatory variables. The comparison of one model and another has been achieved through the application of the F-statistic based on changes in "deviance" (total sum of squares) and degrees of freedom from one model to another. The decision to exclude variables from subsequent modelling has been carried out on the basis of the magnitude of 't-values' obtained from each model for the parameters. The first model fitted consisted of the following terms (see appendix 11 for key to the acronyms):

HYS = 1+GAEZ+AAR+GSOT+HMA+HSU+HCO+FAR+DROT+OXP+WLB+COM+CAS+POP+REG+CRE+EXT+OWN+GAGE+GSEX+GOCC+GEDU+GREL+HYSK+DSMK+DSRK+INN+INB+KNC - (5.1.1)

This model reduced the overall deviance by 185.73 (from 256.41 to 70.68) with 166 degrees of freedom. The parameter estimates of the model and the corresponding 't-values' are displayed in table 5.3 below.

Taking the 't-value' of 1.0 as the cutoff point, a total of 12 variables out of the original 28 were retained in the subsequent model. The second model therefore had the following variables arranged in order of the magnitude of their t-values:

HYS=1+CAS+GEDU+DSRK+HMA+DSMK+GAGE+REG+EXT+WLB+COM+INN+DROT - (5.1.2)

The model reduced the deviance to 196.29 (degrees of freedom= 185). The parameter estimates, standard errors and the corresponding 't-values' are displayed in table 5.4 below. Using a minimum t-value of 1.6 as the cut-off point, the third model fitted consisted of the following 8 variables:

HYS=1+GEDU+HMA+DSRK+CAS+DSMK+EXT+GAGE+WLB - (5.1.3)

This model reduced the deviance to 201.90 (d.f=189). The parameter estimates, standard errors and the corresponding 't-values' for the model displayed in table 5.5 shows that all the variables included can be retained in the model. The next model fitted was basically the same as model three above except that an interaction term between educational level (GEDU) and age (GAGE) was introduced. This model contained the following terms:

HYS=1+GEDU+HMA+DSRK+CAS+DSMK+EXT+GAGE+WLB+GAGE.GEDU - (5.1.4)

The model reduced the overall deviance to 200.15 (degrees of freedom=186). The regression results of this model displayed in table 5.6 suggests that the interaction term can be excluded from the model without losing the explanatory power of the model.

TABLE 5.3 PARAMETER ESTIMATES AND CORRESPONDING T-VALUES FOR MODEL ONE-ADOPTION OF HYBRID SEED SINGLY OR IN COMBINATION WITH OTHER SEED VARIETIES.

PARAMETER**	ESTIMATE	ST.ERROR	'T-VALUE'
1***	-1.86	1.49	-1.25
GAEZ(2)	0.29	0.57	0.50
GAEZ(3)	-0.06	0.60	-0.11
AAR(2)	0.46	0.59	0.78
GSOT(2)	-0.58	0.87	-0.67
GSOT(3)	-0.48	0.49	-0.97
HMA	0.88	0.37	2.36*
HSU	0.31	0.32	0.96
HCO	-1.35	1.44	-0.94
FAR	0.05	0.08	0.63
DROT	-0.63	0.62	-1.00*
OXP	0.32	0.47	0.67
WLB	0.53	0.36	1.50*
COM	0.88	0.65	1.33*
CAS	1.27	0.44	2.90*
POP	0.01	0.09	0.16
REG	0.66	0.41	1.59*
CRE	-0.89	0.99	-0.90
EXT	0.71	0.49	1.46*
OWN	-0.51	0.71	-0.71
GAGE(2)	-0.52	0.47	-1.12*
GAGE(3)	-1.17	0.62	-1.90*
GSEX(2)	-0.09	0.69	-0.13
GOCC(2)	0.17	0.45	0.39
GEDU(2)	1.23	0.45	2.72*
GEDU(3)	0.21	0.92	0.23
GREL(2)	0.42	0.50	0.85
GREL(3)	0.23	0.53	0.44
HYSK	-0.14	0.43	-0.32
DSMK	0.35	0.16	2.14*
DSRK	-0.67	0.25	-2.67*
INN	-0.47	0.42	-1.13*
INB	-0.09	0.44	-0.21
KNC	-0.02	0.46	-0.04

* Terms retained in model 2 below.
** For full parameter names, see appendix 11.
*** Parameter 1 is anchor category representing level 0 and 1 of the categorical variables in the model.

ST. ERROR IS STANDARD ERROR

TABLE 5.4: REGRESSION RESULTS FOR SECOND MODEL-PARTIAL ADOPTION OF HYBRID SEED.

PARAMETER**	ESTIMATE	ST.ERROR	'T-VALUE'
1	-1.69	0.72	-2.34
CAS	1.02	0.38	2.70*
GEDU(2)	1.21	0.39	3.11*
GEDU(3)	0.54	0.78	0.69
DSRK	-0.57	0.20	-2.83*
HMA	0.94	0.32	2.93*
DSMK	0.33	0.14	2.34*
GAGE(2)	-0.38	0.42	-0.92
GAGE(3)	-1.05	0.56	-1.87*
REG	0.56	0.38	1.49
EXT	0.86	0.45	1.91*
WLB	0.51	0.31	1.63*
COM	0.56	0.58	0.96
INN	-0.36	0.37	0.97
DROT	-0.62	0.56	-1.10

* VARIABLES RETAINED IN MODEL 3 - CUT-OFF POINT IS MINIMUM 'T-VALUE' OF 1.6.
** FOR FULL PARAMETER NAMES SEE APPENDIX 11.

ST. ERROR IS STANDARD ERROR

TABLE 5.5: REGRESSION RESULTS OF MODEL THREE: - PARTIAL ADOPTION OF HYBRID SEED.

PARAMETER***	ESTIMATE	ST.ERROR	'T-VALUE'	P-VALUE**
1	-1.59	0.65	-2.43	0.17
GEDU(2)	1.32	0.37	3.54*	0.43
GEDU(3)	0.74	0.75	0.99	0.30
HMA	0.92	0.32	2.91*	0.34
DSRK	-0.49	0.19	-2.59*	0.11
CAS	0.90	0.36	2.51*	0.33
DSMK	0.26	0.13	1.95*	0.21
EXT	0.90	0.44	2.03*	0.33
GAGE(2)	-0.31	0.40	-0.77	0.13
GAGE(3)	-0.97	0.55	-1.78*	0.07
WLB	0.55	0.31	1.74*	0.26

* SIGNIFICANT VARIABLES (P=0.05)
** P-VALUES IS PROBABILITY VALUE
*** FOR FULL PARAMETER NAMES SEE APPENDIX 11.

ST.ERROR IS STANDARD ERROR.

TABLE 5.6: REGRESSION RESULTS OF MODEL 4 - PARTIAL ADOPTION OF HYBRID SEED.

PARAMETER	ESTIMATE	ST. ERROR	'T-VALUE'
1	-1.46	0.71	-2.05*
GEDU(2)	0.99	0.59	1.66*
GEDU(3)	0.55	0.81	0.68
HMA	0.95	0.33	2.92*
DSRK	-0.51	0.19	-2.63*
CAS	0.97	0.37	2.64*
DSMK	0.27	0.14	1.94*
EXT	0.92	0.44	2.06*
GAGE(2)	-0.47	0.57	-0.82
GAGE(3)	-1.75	0.84	-2.09*
WLB	0.57	0.32	1.79*
GEDU(2).GAGE(2)	0.26	0.80	0.32
GEDU(2).GAGE(3)	1.46	1.14	1.28
GEDU(3).GAGE(2)	2.25	13.72	0.16
GEDU(3).GAGE(3)	0.00	aliased	0.00

* significant at p=0.05
ST.ERROR IS STANDARD ERROR.

TABLE 5.7 SUMMARY OF MODELLING PROCEDURE: ADOPTION OF HYBRID SEED

MODEL	DEVIANCE	D.F	CHANGE IN DEVIANCE	IN D.F	F-STATISTIC CALCULATED	F-STATISTIC TABULATED
NULL	256.41	199	-	-	-	-
1	70.68	166	185.73	33	13.21	1.00
2	196.29	185	-125.61	-19	6.61	1.57
3	201.90	189	-5.61	-4	1.31	2.37
	201.90	189	54.51	10	5.10*	1.83
4	200.15	186	1.75	3	0.54	2.60

* Model three compared to null model

The model finally adopted to explain the likelihood of partial adoption of hybrid seed is therefore model three whose results are displayed in table 5.5 above. Table 5.7 gives a comparative summary of all the four models fitted on adoption of hybrid seed.

5:1:2 <u>INTERPRETATION AND DISCUSSION OF RESULTS</u>

The results of model 3 displayed above (Table 5.5) indicate that on average, the likelihood of planting hybrid seed is 0.17. Parameter 1 is the anchor category against which all the other terms in the model are judged as having a negative or positive influence on the likelihood of adoption. It represents levels 0 and 1 of the categorical variables in the model. The p-values in the last column of the table are the computed probabilities associated with the parameters in the model. For example, the probability value of 0.17 associated with the anchor category can be interpreted to mean that on average, the model predicts that 17% of a given sample of small-scale farmers are likely to plant hybrid seed.

No environmental attribute was isolated as a significant explanatory variable in the model. Two personal characteristics of farmers isolated as important were educational level(GEDU) and ones age group (GAGE). The effect of having basic primary education (GEDU-2) in comparison to no education at all is to increase the likelihood of adoption to 0.43. For any given sample, 43% of farmers reported as having basic primary education are expected to plant hybrid seed. The possession of secondary education and above (GEDU-3) also increases the likelihood (0.30) but to a lower level. The higher the age of a farmer, the less likely that one would plant hybrid seed. Only 13% and 7% of farmers in their middle and old age

(GAGE-2 & GAGE-3) respectively are likely to adopt the innovation. These results are consistent with the expectation that better education and youthful age are positive factors in the adoption of any new innovation. This is the reason why the exodus of younger people from the rural to urban areas is expected to have a negative influence in agricultural production. Universal basic education especially in the lines already established in Kenya's 8:4:4 educational system must be seen as a potential boost to future agricultural production.

A unit increase in hectarage of maize (HMA) planted increases the likelihood of adoption from 0.17 to 0.34. This implies that adoption is related to the scale of operations of the farmer. The farmers likely to have greater hectarages devoted to maize are the richer ones. This result therefore reinforces Rundquist's (1984) earlier finding that hybrid adoption is related to the position of the potential adopter in the socio-economic matrix. The same argument can apply to the regression estimates for use of casual labour (CAS) and the number of wheel barrows (WLB) owned by a particular farmer. The use of casual labour increases the likelihood of adoption to 0.33. That is, in a sample of farmers utilising casual labour in their farming operations, 33% are expected to plant hybrid in comparison to 17% of those who do not. In the same manner, a unit increase in the number of wheel barrows owned by a farmer increases the likelihood to 0.26. Both wheel-barrow ownership and use of casual labour may both be taken as surrogate variables measuring the economic status of the farmer because both are only likely amongst the richer small-scale farmers.

The influence of physical infrastructure on the likelihood of adoption is suggested by the estimates for the two variables: distance to the nearest road (DSRK) and distance to the nearest market centre (DSMK). The further a particular farm is from the road the less likely is the planting of hybrid seed. The likelihood is reduced to 0.11 with a unit increase in the distance. If this distance is taken as a surrogate measure of accessibility to information centres then the result suggests a strong relationship between adoption and accessibility. An increasing distance from farm to the nearest market centre unexpectedly increases the likelihood of adoption. However, this result can be interpreted to mean that the market centres considered are not major information centers relevant to hybrid adoption.

As is expected, extension services (EXT) have a positive influence on the planting of hybrid seed. It is expected that 33% of those visited by extension officers would plant hybrid seed. This points to the fact that extension services still play a significant role in the adoption of modern farming practices and therefore need to be strengthened.

5:2 ADOPTION OF FARM-YARD MANURE AND/OR COMMERCIAL FERTILIZER

A casual examination of table 5.2 above suggests that the agro-ecological zone within which a particular farm is located is not likely to be an important variable influencing the likelihood of adoption of farmyard manure and/or commercial fertilizer. The same applies to total annual rainfall. However, residual soil fertility status is likely to be an important variable just as the age categories of farmers. In the two cases, farmers above 65 years of age and farms with high soil fertility status had a larger proportion of adopters of the innovation. Farms with low soil fertility showed the least adoption rate. While sex is likely to be an important variable, the reverse is true of occupational status of farmers and their religious affiliation. Educational level is apparently a significant variable since farmers with no educational background were found to have the lowest adoption rate in comparison to those with primary and secondary educational levels.

5:2:1 MODELLING PROCEDURE

As in the previous section, the modelling procedure began with the model with the largest possible number of relevant explanatory variables. The null model had a deviance value of 220.43 with 199 degrees of freedom. The first model fitted reduced the deviance to 174.5 with 164 degrees of freedom. The model consisted of the following terms (see appendix 11 for key to the acronyms):

MOF=1+GAEZ+AAR+GSOT+HMA+HSU+HCO+FAR+DROT+OXP+WLB+COM
+CAS+POP+REG+CRE+EXT+OWN+GAGE+GSEX+GOCC+GEDU+GREL
+MOFK+DSMK+DSRK+ANI+KNC+OXC+INN+INB
- (5.2.1)

The parameter estimates, standard errors and 't-values' of the model are shown in table 5.8 below.

Taking a t-value of 0.8 as the cut-off point below which variables are excluded from subsequent modelling, the second model fitted consisted of the following terms:

MOF=1+GEDU+GSOT+HSU+CRE+GAGE+GSEX+ANI+DROT+EXT+WLB
+KNC+POP+GAEZ+CAS+DSRK+MOFK
- (5.2.2)

The model reduced the deviance to 177.35 (d.f=179). The regression results for the model are displayed in table 5.9 below.

With a minimum 't-value' of 1.4 as the cut-off point for removing terms from the modelling procedure, the third model fitted on the adoption of farmyard manure and/or commercial fertilizer consisted of the following terms:

MOF=1+GEDU+GSOT+GSEX+HSU+ANI+WLB+CRE+GAGE+KNC+EXT
- (5.2.3)

This model reduced the deviance to 183.86 (d.f=186). The parameter estimates, however, revealed that a number of variables in the model were not significant and could be excluded without affecting the explanatory power of the model. The results are displayed in table 5.10. Insignificant variables in the model (with 't-values' less than 1.6) were subsequently left out in model four (4) fitted. Model four therefore consisted of the following terms:

$$MOF=1+GEDU+GSOT+GSEX+ANI+HSU+WLB \qquad - (5.2.4)$$

The model reduced the deviance to 190.70 with 191 degrees of freedom. The regression results shown in table 5.11 below indicate that all the variables included in the model significantly explained variations in the dependent variable.

TABLE 5.8: REGRESSION RESULTS OF MODEL ONE - ADOPTION OF FARM-YARD MANURE AND/OR COMMERCIAL FERTILIZER

PARAMETER**	ESTIMATE	ST.ERROR	T-VALUE
1	-0.54	1.57	-0.34
GAEZ(2)	-0.63	0.60	-1.04*
GAEZ(3)	-0.32	0.64	-0.50
AAR(2)	-0.003	0.62	-0.005
GSOT(2)	1.26	1.20	1.05*
GSOT(3)	-1.11	0.53	-2.10*
HMA	0.25	0.38	0.68
HSU	-0.61	0.33	-1.86*
HCO	-0.67	1.57	-0.43
FAR	-0.001	0.09	-0.01
DROT	-1.01	0.70	-1.43*
OXP	-0.02	0.55	-0.03
WLB	0.63	0.46	1.34*
COM	-0.04	0.68	-0.06
CAS	0.44	0.45	0.98*
POP	0.15	0.12	1.25*
REG	-0.22	0.44	-0.50
CRE	-1.75	0.96	-1.83*
EXT	0.74	0.53	1.40*
OWN	-0.43	0.75	-0.57
GAGE(2)	0.06	0.48	0.14
GAGE(3)	1.27	0.74	1.71*
GSEX(2)	1.20	0.79	1.52*
GOCC(2)	-0.31	0.50	-0.63
GEDU(2)	1.16	0.48	2.43*
GEDU(3)	1.10	1.10	1.00*
GREL(2)	0.19	0.51	0.37
GREL(3)	0.10	0.55	0.18
MOFK	0.35	0.44	0.81*
DSMK	0.01	0.17	0.07
DSRK	-0.20	0.24	-0.82*
ANI	0.02	0.02	1.51*
KNC	0.65	0.51	1.28*
OXC	0.38	0.61	0.63
INN	0.08	0.43	0.19
INB	0.12	0.47	0.26

* Terms retained in second model
** See appendix 11 for full names of the parameters.
ST.ERROR IS STANDARD ERROR.

TABLE 5.9: REGRESSION RESULTS FOR MODEL 2 - ADOPTION OF FARM-YARD MANURE AND/OR COMMERCIAL FERTILIZER.

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE
1	-0.72	0.97	-0.74
GEDU(2)	1.09	0.45	2.44*
GEDU(3)	0.96	0.96	1.00
GSOT(2)	1.20	1.15	1.04
GSOT(3)	-1.14	0.49	-2.31*
HSU	-0.65	0.30	-2.12*
CRE	-1.50	0.86	-1.73*
GAGE(2)	-0.01	0.46	-0.01
GAGE(3)	0.99	0.70	1.43*
GSEX(2)	1.34	0.61	2.18*
ANI	0.03	0.01	2.12*
DROT	-0.88	0.67	-1.31
EXT	0.68	0.50	1.36*
WLB	0.77	0.36	2.12*
KNC	0.64	0.46	1.40*
POP	0.12	0.11	1.14
GAEZ(2)	-0.52	0.48	-1.09
GAEZ(3)	-0.45	0.57	-0.79
CAS	0.44	0.42	1.05
DSRK	-0.11	0.19	-0.61
MOFK	0.31	0.42	0.74

* TERMS RETAINED IN MODEL THREE ** SEE APPENDIX 11 FOR KEY.

TABLE 5.10: REGRESSION RESULTS FOR MODEL THREE (3) - ADOPTION OF FARM-YARD MANURE AND/OR COMMERCIAL FERTILIZER.

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE
1	-0.25	0.48	-0.52
GEDU(2)	1.10	0.42	2.62*
GEDU(3)	0.65	0.92	0.71
GSOT(2)	1.61	1.08	1.49
GSOT(3)	-1.05	0.40	-2.59*
GSEX(2)	1.33	0.57	2.34*
HSU	-0.54	0.28	-1.93*
ANI	0.03	0.01	2.18*
WLB	0.54	0.32	1.66*
CRE	-1.06	0.82	-1.29
GAGE(2)	0.04	0.42	0.09
GAGE(3)	0.98	0.67	1.47
KNC	0.64	0.44	1.45
EXT	0.56	0.47	1.19

* TERMS RETAINED IN MODEL FOUR ** SEE APPENDIX 11 FOR KEY.

TABLE 5.11: REGRESSION RESULTS - MODEL 4 - ADOPTION OF FARM-YARD MANURE AND OR COMMERCIAL FERTILIZER

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE	PROBABIL-ITY
1	0.22	0.39	0.56	0.55
GEDU(2)	0.94	0.39	2.40*	0.76
GEDU(3)	0.26	0.79	0.32	0.62
GSOT(2)	1.24	1.06	1.17	0.81
GSOT(3)	-1.15	0.39	-2.92*	0.28
GSEX(2)	1.18	0.55	2.14*	0.80
ANI	0.03	0.01	2.58*	0.56
HSU	-0.51	0.27	-1.92*	0.43
WLB	0.55	0.31	1.74*	0.68

* SIGNIFICANT VARIABLES (P=0.05)
** SEE APPENDIX 11 FOR KEY.

However, model 5 was fitted to explore the possible effect of the interaction term between educational level (GEDU) and gender group (GSEX). The model therefore consisted of the following terms:

$$MOF=GEDU+GSOT+GSEX+ANI+HSU+WLB+(GEDU.GSEX) \qquad - (5.2.5)$$

Model 5 insignificantly reduced the deviance to 188.62 with 189 degrees of freedom suggesting that the interaction term could be excluded from the model without any loss in its explanatory power. The results of model 5 are shown in table 5.12 below while table 5.13 is a comparative summary of all the models fitted. Model four was therefore adopted as the best model explaining the likelihood of adoption of farm-yard manure and/or commercial fertilizer amongst small scale maize farmers.

TABLE 5.12: REGRESSION RESULTS FOR MODEL FIVE (5) - ADOPTION OF FARM-YARD MANURE AND/OR COMMERCIAL FERTILIZER.

PARAMETER	ESTIMATE	ST. ERROR	T-VALUE
1	0.12	0.40	0.31
GEDU(2)	1.14	0.43	2.67
GEDU(3)	0.21	0.83	0.25
GSOT(2)	1.22	1.08	1.12
GSOT(3)	-1.25	0.41	-3.06
GSEX(2)	1.63	0.69	2.34
ANI	0.03	0.01	2.60
HSU	-0.52	0.27	-1.92
WLB	0.63	0.33	1.93
GEDU(2).GSEX(2)	-1.52	1.11	-1.37
GEDU(3).GSEX(2)	3.34	9.17	0.36

ST.ERROR IS STANDARD ERROR.

TABLE 5.13 SUMMARY OF MODELLING PROCEDURE - ADOPTION OF FARM-YARD MANURE AND/OR COMMERCIAL FERTILIZER.

MODEL	DEVIANCE		CHG IN	CHG IN	F-STATISTIC	
MODEL	DEVIANCE	D.F.	DEV.	D.F.	CALCUL.	TABULATED
NULL	220.43	199	-	-	-	-
1	174.50	164	45.93	35	1.23	1.00
2	177.35	179	-2.85	-15	0.13	1.57
3	183.86	186	-6.51	-7	0.94	2.01
4	190.70	191	-6.84	-5	1.37	2.21
	190.70	191	29.73	8	3.72*	1.94
5	188.62	189	2.08	2	1.04	3.00

*model 4 compared to null model

5:2:2 INTERPRETATION AND DISCUSSION OF RESULTS

The final model adopted in explaining the likelihood of adoption of farm-yard manure and or commercial fertilizer was model 4 whose results are displayed in table 5.11 above. The parameter estimates can be interpreted with respect to their signs (positive or negative). A negative value indicates a decrease in the likelihood of adoption of the innovation while the reverse is true of positive values. For example, the value 0.94 indicates that compared to farmers with no educational background, those with primary level of education (GEDU-2) are more likely to adopt the innovation. The same is true for those with secondary level of education and above (GEDU- 3) although they are less likely to adopt the innovation compared to those with primary level of education. On the other hand, a unit increase in hectarage under sugar-cane cultivation (HSU) lowered the likelihood of adoption of farm-yard manure. The last column of the table shows the probability associated with each term in the regression model. For example, the probability of 0.55 associated with parameter 1 indicates that in general, the likelihood of adoption of the innovation for any given farmer is 0.55. By extension, 55% of farmers in a given area are expected to practice the application of manure and/or commercial fertilizer. The effect of having primary level of education is to raise the probability of adoption to 0.76. Consequently, 76% of farmers with primary level of education are likely to be adopters of the innovation in comparison with 62% of farmers with secondary level of education.

The model has isolated only two personal characteristics of farmers which significantly affect the likelihood of adoption of farm-yard manure and/or commercial fertilizer, namely educational level and gender. It is shown that at least some level of literacy is required for the adoption to take place. It is important to note that secondary level of education and above (GEDU-3) is not a critical variable. The reason for this may be because the more educated a person is within the small-scale farming sector, the less interested such a person would be in farming activities compared to their primary level counterparts whose opportunities for off-farm employment are very limited. The regression results show that households headed by females (GSEX-2) are more likely to adopt the innovation than otherwise. From the model it is expected that about 80% of female headed households would adopt the innovation. This finding calls for an urgent need to restructure agricultural support programmes to encourage a greater and more active involvement of women. It has been found that extension services, for example, depend a great deal on the village barazas as dissemination points of information. However, these village barazas are almost exclusively attended by male heads of households.

The only environmental variable isolated as significant in the likelihood of adoption of farm-yard manure and/or commercial fertilizer is residual soil fertility. Farms in areas of medium soil fertility (GSOT-2) are more likely to apply farmyard manure and /or commercial fertilizer than those with fertile soils. The innovation is expected to be practiced in about 81% of such farms. It is in these areas that the natural fertility of the soil needs to be supplemented by manure or fertilizers. This result is, however, not significant. Those farms located in the least fertile areas (GSOT-3) are significantly less likely to adopt the innovation. In fact, only 28% of such farms are expected to practice fertilizer and/or manure application. This might be explained by the fact that a greater expenditure on fertilizers would be required which the farmers might not find economical. These results suggest that extension officers should base their advice to farmers with due regard to variations in the environmental attributes of a given area. For instance, emphasis should be placed on soil conservation measures rather than manure/ fertilizer application in areas having highly fertile soils. Efforts to popularise the application of farm-yard manure should be greatest in areas of infertile soils. It should be noted that the results also suggest that the greater the potential of a given land, the greater the likelihood of adopting the innovation. This is probably because the lower the land potential, the greater the risk that any investment expended in land improvement may go to waste.

The other variables found critical in the adoption of this innovation are number of farm animals (ANI) and wheel barrows (WLB) one owns, in addition to total hectarage planted with sugar-cane (HSU). The first two variables are obviously connected with the actual application of manure. The more farm animals a farmer owns, the greater the availability of farm-yard manure. The wheel barrow is a useful implement in the transfer of farm-yard manure from the homestead to the farm. These results suggests that livestock development should be pursued more aggressively as an integral part of crop production. It was observed earlier on that sugar-cane production significantly reduces maize yield rather than hectarage. The results here further reinforce the negative effect of cane cultivation on maize production. This influence is probably related to the possibility that cane farmers find it more profitable to expend additional time, energy and money in the application of manure or commercial fertilizer on cane rather than maize fields. A unit increase in sugar cultivated reduces the likelihood of manure/fertilizer application in maize production. This suggests that if sugar-cane cultivation has to co-exist with maize production, the cane farmers should be given special incentives to restrain them from diverting all their resources to cane cultivation at the expense of self-sufficiency in food.

5:3 PARTIAL ADOPTION OF HYBRID SEED/FERTILIZER COMBINATION

Table 5.2 above indicates that the following are likely to be significant explanatory variables in the partial adoption of hybrid seed/fertilizer combination: agro-ecological zone within which a particular farm is located, average annual rainfall experienced at the farm, soil fertility status at the farm; age, sex, occupation and educational level of the farmer. The religious affiliation of the farmer, however, does not seem to be an important variable since the adoption rates between the different religious affiliations were found to be comparable (50%, 59%, 55%). These preliminary observations will be further tested through logit regression as has been done in the foregoing subsections.

5:3:1 MODELLING PROCEDURE

Using the variables listed in appendix 11, the first logit regression model fitted consisted of the following terms (see appendix 11 for key to the acronyms):

HFP=1+GAEZ+AAR+GSOT+HMA+HSU+HCO+FAR+DROT+OXP+WLB+COM
+CAS+POP+REG+CRE+EXT+OWN+GAGE+GSEX+GOCC+GEDU+GREL
+HYPK+DSMK+DSRK+INN+INB+KNC+ANI+OXC
- (5.3.1)

The model reduced the deviance to 188.80 with 164 degrees of freedom from a deviance of 274.83 and 199 degrees of freedom in the null model. The parameter estimates, standard errors and corresponding 't-values' for the model are shown in table 5.14 below.

Using a minimum 't-value' of 0.8 as the cut-off point below which terms are excluded from subsequent models, the second model fitted comprised of the following terms:

HFP=1+GEDU+CAS+GSEX+DROT+AAR+DSRK+GSOT+ANI+EXT+CRE
+REG+HMA+WLB+COM+POP+GAGE+GREL+OXC
- (5.3.2)

The regression results of the model are displayed in table 5.15 below. The model increased the deviance to 191.44 with 177 degrees of freedom. This gives an insignificant F-value of 0.19 which indicates that the exclusion of variables GAEZ, HSU, HCO, FAR, OXP, OWN, GOCC, HYPK, DSMK, INN, INB, and KNC is justified. Variables with t-values less than 1.60 were subsequently excluded from model three (3) below. The model consisted of the following variables:

HFP=1+GEDU+GSEX+CAS+AAR+HMA+DROT+DSRK+ANI+CRE+WLB+GSOT
+REG+EXT
- (5.3.3)

This model reduced the deviance to 199.90 with 184 degrees of freedom. This gives an F-value of 1.11 indicating that no significant loss of explanatory power occurred in the model following the exclusion of the variables COM, POP,GAGE, GREL and OXC. The parameter estimates for the model are displayed in table 5.16. An inspection of the estimates revealed that the variable REG was no longer significant. This was subsequently excluded from model 4. Model 5 and model 6 investigated the interaction effects between average annual rainfall and soil type; educational level and gender category respectively. Model four fitted excluded the variable REG (land registration) and consisted of the following terms:

HFP=GEDU+GSEX+CAS+AAR+HMA+DROT+DSRK+ANI+CRE+WLB+GSOT +EXT - (5.3.4)

This model increased the deviance insignificantly to 201.35 with 185 degrees of freedom (F-value = 0.68) implying that the exclusion of the variable REG did not significantly affect the model. The results of the model are displayed in table 5.17 below. The fifth model fitted explored the interaction effect between average annual rainfall and soil fertility status. This model was of the following form:

HFP=1+GEDU+GSEX+CAS+AAR+HMA+DROT+DSRK+ANI+CRE+WLB+GSOT+ EXT+AAR.GSOT - (5.3.5)

TABLE 5.14: REGRESSION RESULTS FOR MODEL ONE (1) - PARTIAL ADOPTION OF HYBRID SEED AND/OR COMMERCIAL FERTILIZER.

PARAMETER**	ESTIMATE	ST. ERROR	T-VALUE
1	-3.84	1.08	-3.56
GEDU(2)	1.49	0.43	3.43*
GEDU(3)	0.87	0.88	0.99*
CAS	1.25	0.41	3.07*
GSEX(2)	1.71	0.55	3.09*
DROT	-1.46	0.70	-2.09*
AAR(2)	1.25	0.50	2.49*
DSRK	-0.41	0.20	-2.07*
GSOT(2)	0.28	0.83	0.34
GSOT(3)	-0.82	0.46	-1.81*
ANI	0.02	0.01	2.03*
EXT	0.72	0.44	1.62*
CRE	-1.68	0.88	-1.90*
REG	0.69	0.40	1.70*
HMA	0.68	0.30	2.25*
WLB	0.68	0.37	1.82*
COM	0.98	0.65	1.52*
POP	0.14	0.09	1.49*
GAGE(2)	-0.45	0.45	-1.02*
GAGE(3)	-0.79	0.62	-1.28*
GREL(2)	0.47	0.47	1.00*
GREL(3)	0.61	0.50	1.22*
OXC	0.47	0.52	0.91*

*TERMS INCLUDED IN MODEL TWO (2)
** FULL NAMES OF THE PARAMETERS ARE IN APPENDIX 11.
ST. ERROR IS STANDARD ERROR.

This model reduced the deviance to 201.29 with 184 degrees of freedom. The insignificant calculated F-statistic for the model (F=0.05) indicate that the interaction term between average annual rainfall and soil fertility status does not significantly improve the explanatory power of the model. The results of this model are shown in table 5.18 below. The sixth model fitted investigating the possible influence of the interaction of educational level (GEDU) and gender (SEX) group on the

TABLE 5.15 REGRESSION RESULTS FOR MODEL TWO (2) PARTIAL ADOPTION OF HYBRID SEED/COMMERCIAL FERTILIZER.

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE
1	-3.84	1.08	-3.56*
GEDU(2)	1.49	0.43	3.43*
GEDU(3)	0.87	0.88	0.99
CAS	1.25	0.41	3.07*
GSEX(2)	1.71	0.55	3.09*
DROT	-1.46	0.70	-2.09*
AAR(2)	1.25	0.50	2.49*
DSRK	-0.41	0.20	-2.07*
GSOT(2)	0.28	0.83	0.34
GSOT(3)	-0.82	0.46	-1.81*
ANI	0.02	0.01	2.03*
EXT	0.72	0.44	1.62*
CRE	-1.68	0.88	-1.90*
REG	0.69	0.40	1.70*
HMA	0.68	0.30	2.25*
WLB	0.68	0.37	1.82*
COM	0.98	0.65	1.52
POP	0.14	0.09	1.49
GAGE(2)	-0.46	0.45	-1.02
GAGE(3)	-0.79	0.62	-1.28
GREL(2)	0.47	0.47	1.00
GREL(3)	0.61	0.50	1.22
OXC	0.47	0.52	0.91

* SIGNIFICANT TERMS RETAINED IN MODEL THREE (3) BELOW.
** SEE APPENDIX 11 FOR FULL NAMES OF PARAMETERS.

adoption of hybrid seed/fertilizer combination consisted of the following terms:

HFP=1+GEDU+GSEX+CAS+AAR+HMA+DROT+DSRK+ANI+CRE+
WLB+GSOT+EXT+GEDU.GSEX

— (5.3.6)

The model significantly increased the deviance to 213.53 with 186 degrees of freedom (F=5.30). This indicates that the inclusion of the interaction term leads to a poorer fit of the model. The full results of the model are displayed in table 5.19 below. Table 5.20 gives a comparative summary of the six models fitted.

TABLE 5.16 REGRESSION RESULTS FOR MODEL THREE (3) - PARTIAL ADOPTION OF HYBRID SEED/COMMERCIAL FERTILIZER COMBINATION

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE
1	-2.69	0.66	-4.07*
GEDU(2)	1.38	0.41	3.40*
GEDU(3)	1.05	0.79	1.33
GSEX(2)	1.77	0.53	3.32*
CAS	1.10	0.39	2.85*
AAR(2)	1.08	0.45	2.41*
HMA	0.68	0.28	2.39*
DROT	-1.43	0.67	-2.14*
DSRK	-0.32	0.17	-1.86*
ANI	0.02	0.01	2.28*
CRE	-1.56	0.85	-1.84*
WLB	0.75	0.32	2.36*
GSOT(2)	0.41	0.74	0.55
GSOT(3)	-0.90	0.43	-2.10*
REG	0.45	0.37	1.20
EXT	0.78	0.43	1.81*

* SIGNIFICANT TERMS RETAINED IN MODEL(4) BELOW (P=0.05).
** SEE APPENDIX 11 FOR FULL NAMES OF PARAMETERS.

TABLE 5.17 REGRESSION RESULTS FOR MODEL FOUR - PARTIAL ADOPTION OF HYBRID SEED/COMMERCIAL FERTILIZER

**PARAMETER	ESTIMATE	STANDARD ERROR	T-VALUE	PROB-ABILITY
1	-2.44	0.62	3.95	0.08
GEDU(2)	1.48	0.40	3.69	0.28
GEDU(3)	1.04	0.78	1.33	0.20
GSEX(2)	1.81	0.54	3.38	0.35
CAS	1.12	0.38	2.92	0.21
AAR(2)	1.04	0.44	2.34	0.20
HMA	0.68	0.28	2.42	0.15
DROT	-1.41	0.67	-2.11	0.02
DSRK	-0.34	0.17	-2.01	0.11
ANI	0.02	0.01	2.28	0.08
CRE	-1.59	0.84	-1.90	0.02
WLB	0.78	0.32	2.45	0.16
GSOT(2)	0.31	0.72	0.43	0.11
GSOT(3)	-0.91	0.43	-2.12	0.03
EXT	0.81	0.43	1.91	0.16

** SEE APPENDIX 11 FOR FULL NAMES OF PARAMETERS

TABLE 5.18 REGRESSION RESULTS FOR MODEL FIVE - PARTIAL ADOPTION OF HYBRID SEED /COMMERCIAL FERTILIZER

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE
1	-2.46	0.63	-3.92
GEDU(2)	1.49	0.40	3.70
GEDU(3)	1.03	0.78	1.32
GSEX(2)	1.82	0.54	3.38
CAS	1.12	0.38	2.92
AAR(2)	1.09	0.49	2.23
HMA	0.68	0.28	2.41
DROT	-1.41	0.67	-2.10
DSRK	-0.33	0.17	-1.92
ANI	0.02	0.01	2.28
CRE	-1.60	0.84	-1.90
WLB	0.78	0.32	2.43
GSOT(2)	0.33	0.72	0.45
GSOT(3)	-0.86	0.47	-1.86
EXT	0.81	0.43	1.91
AAR(2).GSOT(3)	0.00	aliased	0.00
AAR(2).GSOT(3)	-0.25	1.07	-0.23

** SEE APPENDIX 11 FOR PARAMETER NAMES

TABLE 5.19 REGRESSION RESULTS FOR MODEL SIX - PARTIAL ADOPTION OF HYBRID SEED/COMMERCIAL FERTILIZER.

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE
1	-2.01	0.55	-3.63
GEDU(2)	1.28	0.40	3.17
GEDU(3)	1.05	0.81	1.30
GSEX(2)	1.53	0.60	2.57
CAS	0.89	0.36	2.50
HMA	0.51	0.26	1.95
DROT	-1.78	0.64	-2.75
DSRK	-0.21	0.16	-1.34
ANI	0.02	0.01	2.17
CRE	-1.44	0.79	-1.83
WLB	0.71	0.30	2.33
EXT	0.76	0.41	1.88
GEDU(2).GSEX(2)	-0.33	1.03	-0.32
GEDU(3).GSEX(2)	5.02	8.99	0.56

** SEE APPENDIX 11 FOR PARAMETER NAMES

TABLE 5.20 SUMMARY OF MODELLING PROCEDURE- PARTIAL ADOPTION OF HYBRID SEED/FERTILIZER

MODEL	DEVIANCE	D.F	CHANGE IN DEVIANCE	CHANGE IN D.F	F-STATISTIC CALCULATED	F-STATISTIC TABULATED
NULL	274.83	199	-	-	-	-
1	188.80	164	86.03	35	2.13	1.00
2	191.44	177	-2.64	-13	0.19	1.57
3	199.90	184	-8.46	-7	1.11	2.01
4	201.35	185	-1.45	-1	1.33	3.84
	201.35	185	73.48	14	4.82*	1.57
5	201.29	184	0.06	1	0.05	3.84
6	213.53	186	12.18	-1	10.61**	3.84

* model 4 compared to null model
**model 6 compared to model 4
D.F IS DEGREES OF FREEDOM.

5.3.2 INTERPRETATION AND DISCUSSION OF RESULTS

The best model adopted from the modelling procedure to explain the likelihood of partial adoption of hybrid seed/commercial fertilizer combination was model four whose results are displayed in table 5.17 above. The negative sign for the estimate for parameter 1 indicates that in average, there is a greater tendency amongst farmers not to adopt the innovation. The probability estimate associated with the same parameter show that the model predicts that for a given sample of small-scale farmers, only 8% would be expected to partially adopt the planting of hybrid seed in combination with the application of commercial fertilizer and/or farmyard manure. This figure is actually lower than the corresponding figures predicted for the adoption hybrid seed (17%) and the application of farm-yard manure and/or commercial fertilizer (55%). This agrees with the earlier suggestion that the most demanding innovations are also the least likely to be adopted.

Environmental variables associated with the adoption of the innovation are average annual rainfall and soil type. The parameter estimates for the variable show that the adoption of the innovation is more likely to occur in areas experiencing lower rainfall (0.20). It is important to note that the predicted adoption rates for the innovation for areas having fertile soils and those having moderately fertile soils are not significantly different. However, farms located in areas of poor soil fertility have the least likelihood of adoption of the innovation (0.03). Taking the total hectarage under drought resistant crops (sorghum, finger-millet, cassava and simsim) as an indicator of the land potential, the results show that a unit increase in the hectarage lowers the likelihood of adoption of the innovation. All these findings tend to suggest that the higher the agricultural potential of a given land, the greater the likelihood of adoption of a yield enhancing innovation.

Only two personal characteristics of farmers have been isolated as critical in the partial adoption of hybrid seed and commercial fertilizer. These are the farmers' educational level (GEDU) and gender (GSEX). In the case of the former, higher educational level has a positive influence on the likelihood of adoption of the innovation. Having primary level of education increases the likelihood of adoption from 0.08 to 0.28 compared to 0.20 for secondary education and above. In other words, about 28% of farmers with primary level of education are expected to adopt the innovation in comparison to a lower 20% for those with secondary education and above. Female farmers have a significantly higher likelihood of adoption of hybrid seed and commercial fertilizer (0.35) compared to their male counterparts (0.08). Both these results reinforce the earlier finding that basic education is necessary for increased farm productivity and the fact that female farmers are competent farmers who must be more explicitly involved in existing agricultural support programmes.

Two important variables isolated by the modelling procedure related to existing agricultural support programmes are utilisation of credit facilities and exposure to extension services. The parameter estimates confirm the important role extension services play in the adoption of farm innovations. Farmers who admitted having been visited by an extension officer at the farm have a greater likelihood of adopting the innovation (0.16). The physical accessibility of farmers to information centres measured by distance of farm to nearest major road (DSRK) is also an important variable in the adoption of the innovation. The more inaccessible a farmer is from the nearest road, the less the likelihood that one would adopt the innovation. However, the negative effect of use of credit facilities predicted by the model is unexpected and may be explained by the fact that much of the credit usually given to farmers is in most circumstances diverted to non-agricultural purposes.

Other factors which describe the position of the farmer in the socio-economic matrix isolated by the model are hectarage planted with maize (HMA), number of farm animals (ANI) and wheel-barrows (WLB) owned. A unit increase in the number of farm animals is expected to increase the probability that a farmer adopts the innovation by 0.08. The corresponding figure for number of wheel barrows is

0.16 while a unit increase in hectarage planted with maize increase the likelihood by 0.15. All these results suggest that the higher the socio-economic status of the farmer, the greater the likelihood that he would adopt both the planting of hybrid seed and the application of farm yard manure and or commercial fertilizer. It is therefore suggested that extension services tailored specifically for farmers in the lower socio-economic hierarchy be devised if universal adoption of the most important innovations in the production of maize has to occur within the small-scale farming sector.

5.4 SUMMARY OF FINDINGS AND CONCLUSIONS.

The main findings in this chapter are that partial adoption of recommended practices in maize cultivation is predominant in the study area with very few farmers adopting the complete package. The adoption of commercial fertilizer has the least rate (12.5%) followed by the planting of hybrid seed without mixing it with other seed varieties (53.5%). Very few farmers (55.5%) adopted the complete package of hybrid seed combined with either the application of commercial fertilizer or farm-yard manure. The model fitted predicts that only 8% of any given sample of farmers are likely to belong to this category of adopters. The application of farm-yard manure and/or commercial fertilizer is the most widely adopted innovation practiced in 76% of the farms covered during the survey.

The model fitted to this innovation category predicts that 55% of any given sample of small-scale farmers would be adopters. The planting of hybrid seed either singly or in combination with other seed varieties was reported by 66% of the farmers sampled while the model fitted predicts the adoption rate for this innovation to be 17%. Considering the actual adoption rates for the different innovation categories and the ones predicted by the models, it is apparent that the innovations are hierarchical with the most technologically complicated adopted by the least number of farmers. It is suggested from this that more extension efforts need to be shifted to the least adopted innovations, in this case, the planting of hybrid seed. There is need to stress to farmers that hybrid seed does best when it is given the greatest care so that they can be able to combine the planting of the seed and the application of farm-yard manure and or commercial fertilizer for those who can afford.

Different variables have been found to influence the likelihood of adoption of these different innovation categories. Besides explaining observed variations in adoption patterns amongst small-scale farmers, these variables can be used to isolate target groups for future extension improvement efforts. The educational level of the farmer, age and gender group are all important variables in the adoption of the three innovations considered in this chapter. Possession of basic primary education enhances the likelihood of adoption of all the innovations. In this respect, universal basic education aimed at self reliance being pursued through the 8:4:4 educational system in Kenya is a step in the right direction. Adult literacy campaigns must also be intensified for the future. Age is only significant in the adoption of hybrid seed where the younger farmers have a greater likelihood of adopting the innovation. Female farmers are more likely to be adopters of all the innovations except the planting of hybrid seed singly or in combination with other seed varieties. The rural exodus of younger population to towns should therefore be seen as a negative contribution to increased agricultural production. A more aggressive involvement of women in agricultural support programmes needs to be initiated in recognition of their competence as farmers.

It has been mentioned that the agricultural potential of a given land as perceived by the farmers is likely to influence their decision whether to adopt an innovation or not. For all the innovations considered in this chapter, only average annual rainfall experienced and general soil fertility status proved to be significant variables. The location of a farm in an area of low soil fertility has a negative effect in the likelihood of applying farm yard manure and/or commercial fertilizer as well as the partial adoption of both hybrid seed and farm-yard manure/or commercial fertilizer. However, it does not influence the adoption of hybrid seed. High average annual rainfall has a positive effect in the adoption of hybrid seed/fertilizer combination only. These results suggest that the greater the agricultural potential of a given land, the greater the likelihood of adoption of new agricultural innovations. This is further reaffirmed by the established negative effect of total hectarage under drought resistant crops on the partial adoption of hybrid seed/fertilizer combination.

Extension services provide a vital link between research institutions and farmers. Extension contact was found to have a positive influence on the likelihood of adoption of hybrid seed and hybrid seed/fertilizer combination. It is important to note that the variable was not critical in the application of farm-yard manure and/or commercial fertilizer. This can be explained by the fact that the practice is indigenous amongst small scale farmers, having a long history of existence in comparison with hybrid seed. In addition, there are few alternative practices which can compensate for the failure to apply fertilizer or farm-yard manure once the soil fertility is on the decline. Hybrid seed however, has its substitute in local seed varieties which have been observed in chapter four as having comparable yields. The farmers therefore need less persuasion from extension workers to apply farm-yard manure and or commercial fertilizer than would be the case for hybrid seed. The use of credit facilities is only significant in the partial adoption of hybrid seed/

fertilizer combination and not in the other two adoption categories. The negative effect it has on the likelihood of adopting the innovation is unexpected and can be because the farmers interviewed who admitted use of credit utilized such credit mainly in non-agricultural activities.

Use of casual labour, increasing hectarage planted with maize, number of wheel barrows and farm animals owned are all indicators of the socio-economic position of the farmer. Use of casual labour increases the likelihood of adopting hybrid seed and hybrid seed/fertilizer combination while number of wheel barrows positively affect the likelihood of adopting all the innovations. The two variables taken as surrogates for the socio-economic position of the farmer indicate that the more well-off small scale farmers are the most likely to adopt new farm innovations. This lends some credence to Johnsons' (1970) and Rundquist's (1984) observations that the introduction of hybrid seed in small-scale farming areas tend to intensify the socio-economic stratification of the communities. The number of farm animals positively affects the likelihood of adopting farm-yard manure and hybrid seed/fertilizer combination. Livestock development must therefore be pursued as an integral part of crop production.

The total acreage devoted to cane production depresses the probability of manure/fertilizer application. Sugar-cane production which is a recently introduced enterprise in the study area is therefore expected to have a negative impact on maize production since it has been found that it competes with maize not only for land (chapter four above) but also for farm inputs.

The role of physical infrastructure in the adoption of innovations is critical because it enhances the flow of information, goods and people. The results in this chapter suggests that increasing remoteness of a farm negatively affects the likelihood of adopting hybrid seed and hybrid seed/fertilizer combination. It should be noted that the two innovations require the purchase of physical inputs from the market centers. This is easier to occur in a case where a farmer is close to a nearby major road. The variable is not critical in the application of farm-yard manure and or commercial fertilizer probably because farm-yard manure is locally available so it does not involve travelling outside the farm. Distance of farm from the nearest market centre is expected to have a negative influence on the adoption of hybrid seed. However, the modelling procedure predicts a positive influence. This might signify that the major market centres considered in the data analysis are not important dissemination points of agricultural innovations nor major distribution points for hybrid seed.

Three main conclusions can be drawn from the major findings in this chapter. In the first instance, the adoption of the package of innovations recommended in maize production is partial in nature. Only very few farmers adopt the complete package. The adoption is also hierarchical in that the most technologically advanced innovations are adopted by fewer farmers. Secondly, socio-economic factors especially literacy tend to play a great role in the adoption of innovations with those farmers in the higher socio-economic hierarchy being the better adopters. Thirdly, environmental characteristics play a lesser role in the decision to adopt agricultural innovations although they are often taken into account in the decision making process of farmers.

CHAPTER SIX - MAIZE MARKETING SYSTEM

CHAPTER SIX: MAIZE MARKETING SYSTEM.

6:O INTRODUCTION.

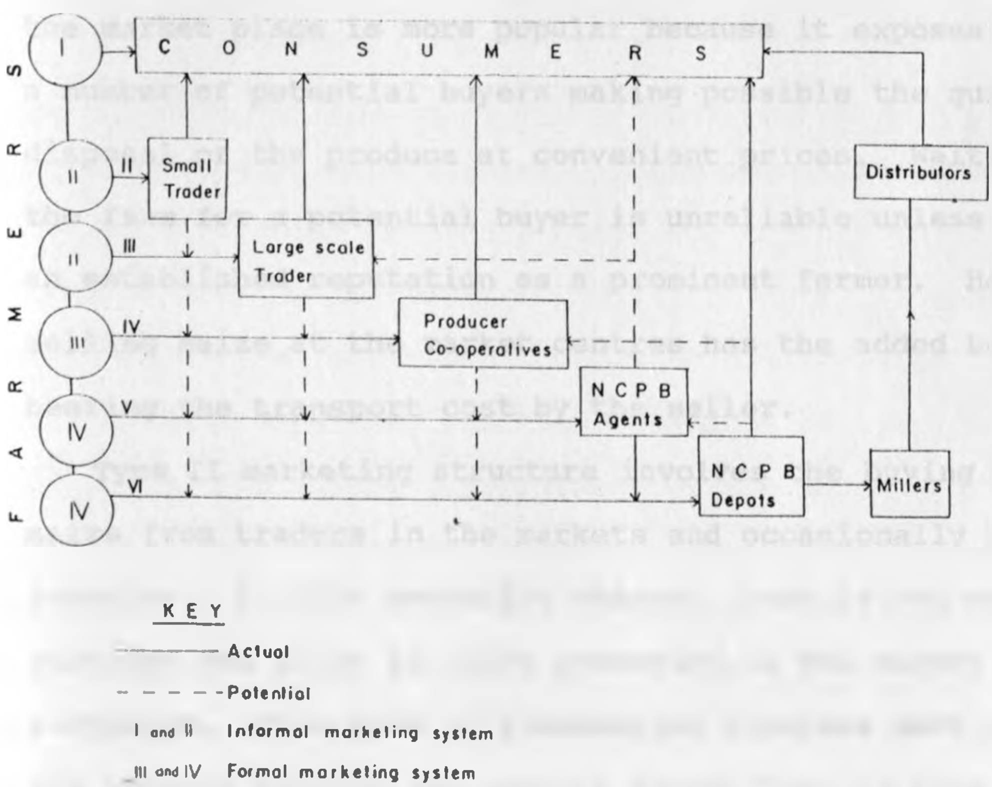
In this chapter, an attempt is made to characterise the marketing mechanisms available to the small-holder maize producers and the extent of their utilization. It should be realized that the accessibility of markets (for the buying and selling of produce) is an important factor in the farmer's decision making process, affecting the range and volume of crops one can produce. The maize marketing system is therefore considered to be closely related to the production aspects of the crop already considered in the previous chapters. Although the maize marketing system is built mainly around the National Cereals and Produce Board (NCPB), it is faced with several inadequacies. Such inadequacies may be the reason for the multiplicity of marketing strategies adopted by maize farmers. Section 1 of this chapter addresses itself to a classification of the major marketing mechanisms existing in the area. The extent of utilisation of the identified marketing structures and the factors influencing variations in quantities of maize sold are dealt with in section two. Section three examines solely the informal marketing sector with particular attention to characteristics of periodic markets and traders, organisational characteristics, variations in maize prices and quantities handled within the sector.

Farmers depend on the maize marketing system both for the disposal of surplus and the procurement of supplies to augment domestic shortfalls. Although it is a common assumption that small-scale farmers sell only their surplus produce, it is evident that a number of farmers sell their produce regardless of the existence of a surplus. This is mainly caused by the need to meet urgent cash requirements. Some farmers in the study area do sell their maize soon after harvest but later have to rely on the marketing system to buy maize. This group of farmers comprised 10% of all the farmers interviewed although only 2.5% of all farmers reportedly bought more maize than they sold. Farmers can buy maize to meet shortfalls in domestic supply including those caused by unexpected short term inflated demand (for example, during ceremonies) or for reasons of resale. The multiple marketing structures in the study area are partly the result of official government policy and are utilised in relation to the farmers' various needs.

6:1 MAIZE MARKETING STRUCTURES IN THE STUDY AREA

In the sample of farmers interviewed 23% (46 farmers) admitted having bought maize to augment their own supplies and meet their various needs compared to 40.5% (81) who sold maize during the same period. Considering these figures alone, it can be argued that the study area is mainly a maize surplus zone indicating self-sufficiency in maize. However, the figures must be used with caution since some farmers rely on other cereals like sorghum and other staples to meet their food needs. From the sample obtained, four major marketing structures can be identified, all used in the disposal and procurement of maize by farmers in the study area (Figure 6.1). These are differentiated on the basis of number of farmers involved and quantities of maize bought.

Fig 6 I MAIZE MARKETING STRUCTURE RONGO DIVISION



Type I marketing structure involves the procurement of maize by individual consumers (usually farmers) directly from other farmers. This kind of transaction is the simplest in organization and distances and amounts of maize involved are small. The transaction usually occurs at the farm-gate (and needs local knowledge of who possesses maize surplus for sale) but more frequently at the local market. If such occurs at the farm-gate the method of payment and the price is usually mutually agreed on and can involve payment in kind. To the buyer, the farm gate is more advantageous since prices tend to be lower. To the seller, the market place is more popular because it exposes one to a number of potential buyers making possible the quick disposal of the produce at convenient prices. Waiting at the farm for a potential buyer is unreliable unless one has an established reputation as a prominent farmer. However, selling maize at the market centres has the added burden of bearing the transport cost by the seller.

Type II marketing structure involves the buying of maize from traders in the markets and occasionally by the roadside. In this marketing channel, cash is the medium of exchange and price is fixed according to the market situation. This kind of transaction involves most farmers and amounts handled are usually higher than in type I above. Distances travelled are also longer, and is the most active because of the numerous periodic markets in the study area. It should be noted that there are also different types of traders (maize) as will become apparent below. The use of traders as outlets for produce is the most significant in terms of number of farmers involved. This kind of transaction is most popular at the market place although some traders may visit farms to buy maize for later resale (Fig. 6.2). This relieves the farmer of the transport problem. The only disadvantage this arrangement has to the farmer is that the traders tend to depress prices at the farm-gate in order to increase their profit margins once they sell the produce later in the periodic markets.

Type III marketing structure consists of local farmers' cooperatives selling maize directly to consumers at the same time buying from farmers. These cooperatives are not specifically meant to handle maize but can use their financial outlay and storage facilities in a few centres to order maize from different sources to satisfy local demand. On the other hand they can take advantage of the same to buy maize at a profit from farmers during periods of great surplus. This structure therefore represents only an occasional response to crisis situations and therefore plays a limited but crucial role in the marketing of maize. It normally involves longer distances and higher amounts than the two types already considered.

Type IV is the formal marketing system built around the National Cereals and Produce Board (NCPB). This system is operated through a network of depots and appointed agents.

FIGURE 6.2: MARKET TRADERS-INFORMAL MARKETING SYSTEM

The agents mainly participate in the buying of maize on behalf of the Board. The maize depots accept maize produce from farmers but since these are few and widely scattered, only a few farmers depend on them as major maize outlets. It is the highest in the hierarchy of marketing structures already considered since prices are government controlled and transactions are in cash. From the sample of farmers interviewed, the Board is more active in the buying of produce from farmers rather than selling because of the network of NCPB agents operating at the local level.

6:2:1 <u>EXTENT OF UTILISATION OF MARKETING STRUCTURES.</u>

Type I and II marketing structures form the informal marketing system. It is apparent that the informal marketing system is the most important in both the disposal and procurement of maize by farmers. 33% and 23% of the farmers who sold maize used the two marketing structures (type I and II) respectively compared to 54% and 53% of those who bought. The formal marketing system consisting of the producer cooperatives and NCPB are considerably less important considering the number of farmers utilising them (see Table 6.1).

Within the informal marketing system farmers play a lesser role than small-scale traders in the buying and selling of maize. In the formal marketing system, producer cooperatives and the NCPB have comparative significance in the selling of the produce to farmers. However, the NCPB plays a greater role in the buying of produce from farmers reflecting the fact that the cooperatives are not maize specific.

A comparative assessment of the role of individual market channels in the procurement and disposal of produce reveals further important variations. Local farmers are more important as suppliers rather than buyers. A greater proportion of farmers bought maize from fellow farmers than those who sold to the same.

The proportion of farmers who bought maize from small-scale traders also outstrips the number of farmers who sold to the same. The trend is however reversed when it comes to the formal marketing system. A greater proportion of farmers sold their maize to local cooperatives than those who bought from the same source. Similarly more farmers sold to the NCPB than bought from them. It can therefore be concluded that although the informal marketing system seems to be more important than the formal on the basis of number of users, this is particularly true in the maize supply to farmers. The formal marketing system is significant mainly in the buying of produce from farmers. This underlines the possibility that during periods of maize glut, the farmers are likely to face problems arising from the shortcomings facing the NCPB unless its appointed agents become more active in maize buying. The informal marketing system would be ill-disposed to assist the

TABLE 6.1 UTILISATION OF MAIZE MARKETING STRUCTURES

STRUCTURE	BUYERS	%	SELLERS	%
I-LOCAL FARMERS -	10	21.7	10	12.50
I-LOCAL TRADERS -	20	43.5	37	46.25
III-LOCAL COOPERATIVE -	3	6.5	7	8.75
IV-LOCAL NCPB -	3	6.5	14	17.50
I- LOCAL FARMERS/ TRADERS -	9	19.6	10	12.50
I&IV-LOCAL TRADERS /NCPB -	1	2.2	-	-
I&IV-LOCAL FARMERS /NCPB -	-	-	1	1.25
I&III-LOCAL FARMERS /TRADERS/ COOPERATIVES-	-	-	1	1.25
TOTAL	46	100	80	100

SOURCE: MARKET-SURVEY: RONGO DIVISION-1986/87

farmers because there are no formal price controls and the farmers are likely to sell their maize at low prices. Restrictions on maize movement beyond district boundaries is a further limitation which would reduce the utility of the sector as a major maize outlet. During periods of maize shortages, the formal marketing system would be more well placed to supply the farmers with maize due to its capacity to use its logistics to procure maize from outside sources and sell at subsidised prices. Despite this, the formal marketing system would not be able to effectively supply all the rural dwellers because of the lack of adequate outlets. The Board operates three main depots in South-Nyanza District namely Kihancha, Migori and Homa-Bay (Fig. 6.3). All these are located outside the study area. Farmers in need of maize would have to incur transport costs which can be beyond the reach of many. The possible outcome therefore would be the buying of maize from the NCPB by informal traders at controlled prices who later sell the same at inflated prices through the existing periodic markets. It is therefore suggested that the existing controls which hinder the full participation of the informal traders in the maize trade be lifted so that they can become more effective as suppliers of maize to rural consumers. On the other hand, the role of the NCPB should be restricted to the buying of maize from farmers with the main purpose of maintaining the strategic food reserve for the country.

The comparative importance of the different marketing channels can also be assessed on the basis of volumes handled. Although this is also possible with prices, data on this aspect was particularly lacking. Table 6.2 shows the average volumes of maize handled in the different marketing channels.

In terms of volumes handled (buying and selling) the significant role of small-scale traders is apparent for it

FIGURE 6.3. NATIONAL CEREALS AND PRODUCE BOARD DEPOT, HOMA-BAY

TABLE 6.2 VOLUME OF MAIZE (BAGS) HANDLED IN DIFFERENT MARKETING STRUCTURES.

STRUCTURE		NO. OF BUYERS	MEAN	TOTAL	NO. OF SELLERS	MEAN MEAN	TOTAL
I-LOCAL FARMERS	-	10	2.22	22.2	10	4.40	44.00
I-LOCAL TRADERS	-	20	1.98	39.6	37	15.65	579.05
III-LOCAL COOPERATIVE	-	3	9.67	29.01	7	13.31	93.27
IV-LOCAL NCPB	-	3	1.83	5.49	14	20.86	292.04
I- LOCAL FARMERS/ TRADERS	-	9	1.48	13.32	10	4.56	45.60
I&IV-LOCAL TRADERS /NCPB	-	1	0.20	0.20	-	-	-
I&IV-LOCAL FARMERS /NCPB	-	-	-	-	1	1.50	1.50
I&III-LOCAL FARMERS /TRADERS/ COOPERATIVES	-	-	-	-	1	12.00	12.00
TOTAL		46	2.38	109.82	80	13.34	1067.46

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87)

exceeds the rest. The lowest volume of maize recorded is for the local farmers themselves indicating that inter-farmer maize transactions are rather low. The second most important marketing channel is the local NCPB. These differences are aggregates which are also influenced by total number of farmers. If these volumes are weighted according to number of farmers then a distinct pattern emerges in which average volumes increase with relative sophistication of the market. The implication here is that the formal marketing is in general more tailored to the needs of large-scale farmers who deal in greater average volumes.

The table further implies the different roles the marketing channels play in the buying and selling of maize. On the basis of total quantities of maize supplied to farmers, local traders seem to be the dominant marketing channel followed by the local cooperatives. The average volume supplied to each farmer is however comparable for all the different categories except local cooperatives. The figure for local cooperatives is rather inflated by one farmer who reportedly bought maize from Kericho district. The next important channel of maize supply to farmers is through local farmers and lastly the NCPB. This suggests the negligible role the Board plays in maize supply to farmers. A possible reason for this is that the contact between farmers and the Board is through appointed agents who are more active in the buying rather than the selling of maize. With the exception of cooperatives for/reason [the already mentioned, the average amounts of maize bought by farmers from the three sources are comparable.

In terms of the provision of outlets for farmers produce small-scale traders are again the most important taking into account aggregate maize quantities handled. The channel however ranks last in terms of average volume reflecting the small-scale nature of the transactions. Second in importance is the National Cereals and Produce Board which also occupies first position in terms of average volume bought from farmers. This further underlines the fact that the Board is more important as a buyer (a function which is more beneficial to the larger scale farmers), and not a seller. This springs probably from the fact that they maintain agents operating closer to farmers but who participate more as buyers and not suppliers. All these trends suggest that the closer the market to the farmer, the greater the volume marketed. It is therefore important to understand the factors influencing variations in quantities of maize sold by farmers. Another important observation is that while local farmers play a significant role in the supply of produce, they rank last as consumers. This probably reflects the greater degree of self sufficiency in food already suggested. Local farmers as consumers make transactions in the smallest units since they only meet short term needs and may not have the necessary financial outlay to afford greater units. Local cooperatives are relatively more important as buyers than sellers although its position may be because of the inflated buying of one farmer. Their comparative position as buyers and sellers should be the same since they are not maize specific, participating in maize trade only intermittently.

The National Cereals and Produce Board is the parastatal body charged with the responsibility of handling grain trade in Kenya. It has monopoly powers over the buying of maize and its sale across district boundaries. These powers were given to the Board in order to control prices of maize for farmers and consumers. It is also charged with the responsibility of providing adequate outlets for farm produce and the custodian of the country's strategic food reserve. None of the depots the Board operates is located within the study area although they can be reached by road links. It is in these centres that the buying of maize from farmers is conducted. Farmers have to meet their transport costs. Although the prices offered for the grain supplied by the farmers may be higher than those offered by informal market traders, there are a number of factors which limit the use of the NCPB depots as maize disposal points. In the first instance, these are not easy to reach and thereby involve high costs of transportation. The financial problems facing the Board also limits the use of vehicles to buy maize directly from farmers. In addition, some farmers complained that sometimes personal influence is required for ones maize to be accepted by the Board especially if large amounts are involved.

The selling of maize to farmers is influenced by a number of factors. The head office usually determines where and what amounts of maize should be transferred and at what prices. The implication of this is that while the NCPB depots have maize from the study area, farmers from this area may not benefit from it during periods of maize shortages. The outlet points are very few so only farmers who buy in bulk are usually allowed. These are occasionally traders who later sell to consumers at exorbitant prices. This decreases the importance of the Board in controlling maize prices, allowing middlemen to reap undeserved profits to the disadvantage of producers and consumers alike. It is therefore apparent that while the NCPB is charged with several responsibilities, a number of limitations exist making it largely ineffective especially with regard to the supply of maize to consumers at controlled prices.

6:2:2 VARIATIONS IN AMOUNTS OF MAIZE SOLD

The major factors influencing amounts of maize sold by farmers is expected to be heavily dependent on the supply and demand of maize within the individual household level. Other factors such as accessibility to the existing marketing channels are also expected to be important explanatory variables. A multiple regression procedure is attempted here to determine the major factors influencing amounts of maize sold. The independent variables used in the regression procedure are listed in appendix 12 and can be divided into three major categories namely:

- those related to the demand of maize at the household level.
- those related to the supply of maize at the farm level.
- those related to the accessibility and utilisation

of marketing channels by farmers.

While the relationship between amounts of maize sold and personal characteristics of farmers is not obvious, there are priori expectations about the relationship between amounts sold and other variables included in the analysis. The receipt of remittances is expected to be negatively related to amounts of maize sold since it reduces the pressure for additional income which could accrue from maize sales. The same relationship is expected to hold for large household sizes on the assumption that rural farmers aim at domestic self-sufficiency and only sell their surplus maize. The other factors expected to exert a negative influence on amounts of maize sold are the total hectarage under cash-crops, increasing distance to the local periodic markets and major roads. The factors likely to have a positive relationship with amounts of maize sold include gross maize yield, total hectarage under alternative cereal crops, ownership of wheel-barrow and ox-cart. Environmental attributes such as soil fertility, agro-ecological zone and average annual rainfall are expected to be significant explanatory variables as they are closely related to maize yields and hectarages in the study area.

(a) MODELLING PROCEDURE

A total of four regression models were fitted on amounts of maize sold (Table 6.3) using all the variables listed in appendix 12. The first model fitted consisted of

TABLE 6.3 SUMMARY OF MODELS FITTED ON AMOUNT OF MAIZE SOLD

MODEL	DEVIANCE	D.F.	OBS.	R-SQ.	UNITS WEIGHTED OUT
NULL	47162	80	81	-	-
ONE	33150	48	81	0.40	-
TWO	2766.6	43	63	0.95	18
THREE	2809.9	48	63	0.95	18
FOUR	2875.9	52	63	0.95	18

D.F=DEGREES OF FREEDOM ; OBS=NUMBER OF OBSERVATIONS
R-SQ=R-SQUARED VALUE

the following terms (see appendix 12 for key to the acronyms):

MSOL=1+AAR+GSOT+GAGE+GSEX+GOCC+GREL+POP+GYL+MBOT+CASH+CER+FAR+HMA+OXP+WLB+MKCS+DSMK+DSRK+OXC+GST+GSM
- (6.2.1)

The model explained less than 40% of the total variation in the dependent variable. The residual plot revealed fifteen outliers and three influential points which were subsequently removed in the next model fitted. The parameter estimates for model 1 also showed that it contained a number of insignificant explanatory variables. These were also left out of the next model fitted. Model two fitted therefore contained the following terms (see appendix 12 for key to the acronyms):

MSOL=1+DSMK+POP+GREL+CASH+GSOT+AAR+GAGE+HMA+GSEX+
DSRK+GEDU+MKCS

- (6.2.2)

The model explained 95% of the total variation in the dependent variable. However, insignificant explanatory variables were still contained in the model. The residual and leverage plots revealed no ill fitting points.

The third model fitted excluded four insignificant explanatory variables identified in model two. Model three consisted of the following terms:

MSOL=1+GAGE+GSEX+DSMK+GEDU+MKCS+DSRK+AAR+GSOT

- (6.2.3)

The R-squared statistic remained stable at 0.95 showing that the excluded variables do not contribute significantly to the explanatory power of the model. Three more insignificant variables were removed from the model in the next modelling procedure. The fourth model fitted therefore contained the following terms:

MSOL=GAGE+GSEX+GEDU+DSMK+MKCS

- (6.2.4)

The parameter estimates of the model are displayed in table 6.4. The residual and leverage plots for the model are shown in appendix 13 and 14 respectively. For comparative purposes, the corresponding plots for model one are shown in appendix 15 and 16.

(b) INTERPRETATION OF RESULTS

The best model adopted to explain variations in amounts of maize sold is model four (Table 6.4). The model has isolated only five explanatory variables namely age of the farmer (GAGE), sex of the farmer (GSEX), educational level of the farmer (GEDU), distance from the farm to the nearest periodic market (DSMK) and the marketing channel used in selling maize produce (MKCS). Although the variables MKCS and DSMK are not statistically significant, they have been retained in the model because they are considered potentially important variables in the marketing of maize.

TABLE 6.4 REGRESSION RESULTS FOR MODEL FOUR-AMOUNTS OF MAIZE SOLD (MSOL)

**PARAMETER	ESTIMATE	STANDARD ERROR	T-VALUE
1***	-3.07	4.02	-0.76
GAGE (2)	3.64	2.22	1.64*
GAGE (3)	7.21	3.06	2.36*
GSEX (2)	5.37	2.40	2.24*
GEDU (2)	4.33	2.28	1.90*
GEDU (3)	1.19	4.68	0.25
DSMK	0.80	0.70	1.13
MKCS (2)	2.10	3.12	0.67
MKCS (3)	2.97	4.16	0.71
MKCS (4)	5.53	3.74	1.48
MKCS (5)	-1.36	3.64	-0.37
MKCS (6)	0.00	aliased	0.00
MKCS (7)	0.00	aliased	0.00
MKCS (8)	0.00	aliased	0.00

* SIGNIFICANT AT P=0.05
** FOR FULL PARAMETER NAMES SEE APPENDIX 12
*** ANCHOR CATEGORY REPRESENTING LEVEL 1 OF THE CATEGORICAL VARIABLES IN THE MODEL.

The parameter estimates indicate that older farmers (GAGE-2 and GAGE-3) and female ones (GSEX-2) tend to sell significantly higher quantities of maize. Farmers with primary level of education (GEDU-2) also sell significantly higher quantities than those without any educational background. These results seem to suggest that maize is increasingly used by farmers as their source of income. The older farmers and the female ones normally face restricted income earning opportunities outside farming. On the other hand, the significant regression coefficient between quantity of maize sold and farmers educational level suggests that farmers with higher maize yields sell more maize. In the analysis of maize yields, it was found that farmers with primary level of education had the highest maize yields. The regression coefficients between marketing channel used and quantity of maize sold indicate the earlier finding that greater volumes of maize are channelled in more sophisticated channels. The least amount of maize is channelled through fellow farmers while the highest is channeled through the National Cereals and Produce Board (MKCS-4). The main conclusions drawn from these findings are that farmers in the lower socio-economic hierarchy are dependent on maize as a major cash-crop. In addition, improved maize yields in the small-scale farming sector is likely to lead to greater amounts of maize marketed. Lastly, while the informal marketing system is the most important in maize marketing, it tends to deal in lesser units than the National Cereals and Produce Board. It is therefore recommended that improved maize yields should be pursued in the small-scale farming sector not only to maintain domestic self-sufficiency in food but also as a strategy for increasing rural incomes especially for farmers in the lower socio-economic hierarchy. The existing controls on informal marketing system need to be relaxed for it to handle greater volumes of maize. Complementary linkages should also be established between it and the National Cereals and Produce Board.

6:3: INFORMAL MARKETING SYSTEM:

From the foregoing account of the main marketing structures existing in the study area, its apparent that the informal marketing system (type I and type II structures) is the most important on the basis of the number of farmers involved and the quantity of produce channelled through the system. However, it should be realised that the formal marketing system also has a significant role to play and the two systems are interlinked mainly by middlemen.

This section therefore discusses the main aspects of the informal marketing system based on data obtained from a sample of 80 grain traders in eight different market centres. Figure 2.2 shows the location of the eight market centres. The main aspects discussed include:

- characteristics of the periodic markets where most of the transactions occur

- the characteristics of traders involved in the informal trade namely: age, sex, residence, years of experience.
- organisational characteristics of the informal trade including: sources of grain supply, number of periodic markets served per trader, number of other commodities handled by traders, and the utilisation of transport and storage facilities.
- factors influencing quantities of maize handled by individual traders and price variations.

6:3:1 NATURE OF MARKETS

The markets surveyed displayed variety in size although a common trait they shared is their periodicity, with each market having a major market day per week. Their sizes tended to be closely associated with their location in terms of communication network. The relatively isolated periodic markets tend to be smaller. These include Angaga, Otho, Mariwa, Dede and Riosir. The three large periodic markets (Rongo, Ranen and Awendo) are located on the main highway transversing the study area (Fig.2.2). There is less activity in the smaller markets reflecting perhaps the local nature of their operations and the inferior communication links they have in comparison with the larger ones. Maize supply to these smaller markets are done in smaller units conveniently transported through head porterage. However, quantities of maize traded is a function of multiple variables as will become apparent below. The bigger periodic markets showed greater quantities of maize offered for sale, probably because of the ease with which storage facilities can be found and the use of cheap and quicker means of grain transport to the markets.

6:3:2 CHARACTERISTICS OF TRADERS

The informal maize trade is dominated by females. Out of the 80 traders sampled, only two were men. The main reason cited for participation in the trade is to earn a living. This not only signifies the important role women play in the rural economy but also the fact that compared to their male counterparts, women have limited income earning opportunities outside the informal rural sector. Attempts to streamline the maize marketing system in order to encourage a greater participation of the private sector must therefore take this into account. Such a restructuring should not be done in a way that leads to the displacement of women from this important source of their livelihood.

Table 6.5 below shows that the majority of traders are in their middle age (54%). Those below 30 years of age constitute 39% of the total sample in contrast to 7% who are over 50 years of age. A possible explanation for this pattern is that middle aged women are the ones who are most likely to have family commitments and fewer income earning opportunities in contrast to their male or younger counterparts. These commitments prompt them to look for income earning opportunities close to their residences to augment the incomes of their spouses.

TABLE 6.5 INFORMAL MAIZE TRADERS BY AGE GROUPS

AGE GROUPS (YEARS)	<30	30-49	50&ABOVE	TOTAL
NUMBER OF TRADERS	31	43	6	80
%	39	54	7	100

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87).

Maize trade within the informal marketing system involves a great expenditure of energy in transporting the grain to the scattered periodic markets and sitting long hours selling the goods. This is obviously cannot encourage the participation of people in their old age. Younger people on the other hand are normally involved in other activities such as educational pursuits which reduce their usefulness as grain traders. They are also likely to make poorer traders because of lack of experience. Success in the informal marketing system requires a thorough knowledge of the prevailing market conditions (maize demand and prices) in the different periodic markets.

Many of the transactions further require personal special skills to attract customers and negotiate prices according to changing market conditions. Temporal price variations even within one day is a common feature of the informal marketing system, in complete contrast to the formal marketing system. As more and more maize is channelled through the informal marketing system, the price regulatory function of the NCPB is bound to become largely ineffective.

It is interesting to note that as many as 29% of the traders interviewed were only intermittent traders (Table 6.6). Such traders usually handle smaller quantities of grain to meet immediate cash needs for the purchase of other food items or general household requirements at the same periodic market. Traders with long years of experience are fewer in number. Their significant contribution to grain trade is reflected by the comparatively high average quantities of maize they handle. This group of traders exhibit a high degree of flexibility switching between products handled and markets served according to changing market conditions.

The residential areas of traders interviewed roughly indicate the threshold of particular periodic markets. In addition, they show a close relationship with the locational and size characteristics of the markets. Table 6.7 shows the distribution of traders by their residence.

TABLE 6.6 INFORMAL MAIZE TRADERS BY YEARS OF EXPERIENCE

CATEGORY	NO.	%	AVERAGE QUANTITY OF MAIZE HANDLED (BAGS)
IRREGULAR TRADERS	23	29	0.24
<I YEAR	16	20	0.32
1-3 YEARS	16	20	0.78
4-6 YEARS	10	12	0.69
7-9 YEARS	4	5	1.91
> 9 YEARS	6	8	0.25
NON RESPONDENTS	5	6	0.17

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87)

The emerging pattern indicates the local nature of informal maize marketing. Most of the informal traders usually come from the same sub-location where the periodic market is situated. The high figure of traders coming from outside districts in the case of Riosir should be interpreted with caution since the periodic market is located at the border between Kisii and South-Nyanza Districts. Traders hailing from outside locations, divisions, districts and provinces are relatively few although they tend to be greater in number in the larger periodic markets (see Table 6.8).

TABLE 6.7 INFORMAL MAIZE TRADERS BY RESIDENCE

RESIDENCE	NUMBER	%
SUB-LOCATION	35	44
LOCATION	23	29
DIVISION	9	11
DISTRICT	7	9
PROVINCE	6	7
TOTAL	80	100

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87)

TABLE 6.8 RESIDENCE OF TRADERS BY SIZE OF PERIODIC MARKET

CATEGORY	SUB-LOCATION	LOCATION	DIVISION	DISTRICT	PROVINCE	TOTAL
SMALL: -ANGAGA -OTHO	11	8	1	-	-	20
MEDIUM: -MARIWA -DEDE -RIOSIR	14	6	3	1	6	30
LARGE: -RONGO -RANEN -AWENDO	10	9	5	6	-	30
TOTAL	35	23	9	7	6	80
%	43.75	28.75	11.25	8.75	7.5	100

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87)

6:3:3 ORGANIZATION OF TRADE

Just as there exists variation in the nature of markets, and characteristics of traders, there is considerable variation in the manner in which the maize trade is organised within the informal marketing system.

(a) SOURCES OF SUPPLY

The sources of maize supply utilised by informal traders include local farmers, own farms, other traders within the same market and traders in other markets. Although none reported having bought their maize from the National Cereals and Produce Board, it is a possible source. Table 6.9 and 6.10 gives a classification of the informal traders on the basis of source of supply utilised and use of the sources in different size categories of periodic markets.

On the basis of number of traders utilising each source of supply, the procurement of maize from own farms is the most important. This source of supply ranks second after "other markets" in terms of total maize offered for sale in the eight periodic markets. These trends suggest the local nature of the informal trade and the significant role informal traders play in the marketing of maize. Traders depending on other traders within the same periodic market for their supplies form the lowest in the hierarchy of maize traders. These deal in smaller amounts which can be sold within the same day saving them the expenses involved

TABLE 6.9 INFORMAL MAIZE TRADERS BY SOURCE OF SUPPLY

SOURCE	NO.OF TRADERS	AVERAGE QUANTITY	TOTAL	%
OWN FARM	32	0.23	7.36	40
OTHER FARMS	3	1.75	5.25	4
TRADERS IN SAME MARKET	26	0.43	11.18	32
OTHER MARKETS	19	0.85	16.15	24
TOTAL	80	0.50	39.94	100

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87)

TABLE 6.10 UTILISATION OF SOURCES OF SUPPLY BY MARKET SIZE CATEGORIES.

	OWN FARM	OTHER FARMS	OTHER TRADERS	OTHER MARKETS	TOTAL
SMALL: -OTHO -ANGAGA	9	-	2	9	20
MEDIUM: -DEDE -MARIWA -RIOSIR	12	1	13	4	30
LARGE: -RONGO -RANEN -AWENDO	11	2	11	6	30
TOTAL	32	3	26	19	80
%	40	4	32	24	100

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87).

in maize transport and storage. There dependence on other traders as sources of maize supply tend to be more typical of the larger markets while dependence on other markets is more prevalent in the smaller isolated periodic markets. This suggests that the larger traders from whom maize can be bought for resale in the same market or in the smaller ones tend to frequent the larger markets. Larger quantities of maize are more easily transported to the larger periodic markets. The low numbers of traders reported to have obtained their supplies from local farms shows that informal maize traders would rather wait for the farmers to bring their produce to the periodic markets rather than seek them out. This relieves them of the burden of transporting the maize to the markets. Traders who rely on other markets for maize supplies are the highest in the hierarchy of informal traders. These traders are almost evenly spread across the different size categories of markets. They handle comparatively larger quantities of maize and/well placed to play a significant [are role in interregional trade of maize should the existing controls be liberalised. In addition, they are invaluable to the local authorities which benefit from the market levies imposed on such traders. They potentially represent an important linkage between the informal and the formal marketing systems.

(b) NUMBER OF MARKETS SERVED

The number of markets served by a particular trader indicates the degrees of sophistication of the trader in question. It is assumed that the more markets served by a trader, the higher the position of the trader in the hierarchy of traders. Most of the traders serve between one to three periodic centres regularly (Table 6.11). This trend reflects the local nature of the informal trade and is characteristic of all the periodic markets regardless of size. The traders serving between four and five different

TABLE 6.11 TRADERS BY NUMBER OF MARKETS SERVED AND SIZE CATEGORIES OF MARKETS

NO. OF MARKETS/ SIZE OF MARKETS	1	2-3	4-5	6&ABOVE	TOTAL
SMALL:	5	9	5	1	20
-ANGAGA	2	5	2	1	10
-OTHO	3	4	3	0	10
MEDIUM:	13	16	-	1	30
-DEDE	4	5	-	1	10
-RIOSIR	4	6	-	0	10
-MARIWA	5	5	-	0	10
LARGE:	11	12	6	1	30
RONGO	1	5	4	0	10
AWENDO	6	2	1	1	10
RANEN	4	5	1	0	10
TOTAL	29	37	11	3	80
%	36.25	46.25	13.75	3.75	100

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87) market centres are not represented in the medium sized periodic markets. It should be noted these markets are all far removed from the main road system in the study area. Traders serving six markets and above are represented in all the three size categories of markets.

(c) COMMODITIES HANDLED TOGETHER WITH MAIZE

The presence of other commodities sold reflects the degree of specialisation of the traders. Those selling maize alone are therefore expected to be either farmers (intermittent traders) or "within-market" traders. This group are expected to handle larger quantities of maize

TABLE 6.12 TRADERS BY NUMBER OF COMMODITIES HANDLED AND MARKET SIZE:

NO. OF COMMODITIES/ MARKET RANK	1	2	3	4	5	TOTAL
SMALL:	10	6	2	1	1	20
-OTHO	2	4	2	1	1	10
-ANGAGA	8	2	0	0	0	10
MEDIUM:	21	7	0	2	0	30
-MARIWA	10	0	0	0	0	10
-DEDE	6	2	0	2	0	10
-RIOSIR	5	5	0	0	0	10
LARGE:	13	11	8	0	0	30
-RANEN	5	5	0	0	0	10
-RONGO	0	6	4	0	0	10
-AWENDO	8	0	2	0	0	10
TOTAL	44	24	8	3	1	80
%	55	30	10	3.75	1.25	100

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87).

due to their specialisation. Table 6.12 indicates that the majority of maize traders tend to handle the crop alone without any other commodities (55%). The rest of the traders handle between two and five commodities together with maize. However, the number of such traders decline with increasing number of other commodities sold together with maize.

Commodities handled together with maize show a great variety. These include beans, finger-millet, cassava, groundnuts, fish, sugar-cane, sorghum, onions, sweet potatoes, rice, tomatoes, tobacco and a variety of vegetables.

In aggregate, the commodities can be divided into four major groups on the basis of prevailing dietary preferences in the study area. The first group consists of beans, cassava and fish and is the dominant category in terms of number of traders involved. Beans is normally mixed with maize in one of the major recipes in Rongo Division while cassava is a substitute staple for maize. Fish is popular amongst most of the inhabitants of the area who can afford it. The second in importance is a group comprising tomatoes, sorghum and finger millet. Tomatoes are utilised in almost all the major food preparations while sorghum and finger millet are more important than maize in making uji. Category three consists of groundnuts, vegetables and onions. Groundnuts serve the same purpose as beans but can also be prepared in a variety of ways to satisfy dietary requirements. The last category include bananas, tobacco, sweet potatoes, rice and sugar-cane. This group represents the least popular of the foods consumed in the study area. From all the above, it is suggested that attempts to reorganise the informal maize trade to serve the dietary needs of rural consumers should take into consideration the variety displayed in their dietary preferences.

(d) MODE OF TRANSPORT

Different modes of transport utilised by traders in the informal marketing system show a great variety depending upon distances travelled, accessibility of markets, and quantities of maize handled. These include road (vehicle) transport, head porterage and animal transport (donkeys and oxen). Those traders who simply walk to the respective periodic markets are mainly "within-market" traders living close to the market and do not need to deliver any amount of maize to the market.

Human poterage of maize to the periodic markets is the most prevalent means of transport (Table 6.13) reflecting the short distances travelled by the traders and the small quantities of grain handled. This transport means was utilised by 65% of traders who visited the small periodic markets compared to 36% and 63% for the medium and large sized ones respectively. This suggests the small and localised nature of transactions in the small sized periodic markets. Road transport is the next in importance utilised by 31.25% of all the traders interviewed. Most of these traders were reported in the medium sized periodic markets which are also remotely located. Animal transport is the least in importance utilised by only 4% of the traders. This mode of transport is quite cumbersome especially when oxen are used and is more convenient for farmers living close to the markets and have large quantities of maize to be sold. The category of traders who simply walked to the markets were few in number and were mainly found in Riosir and Awendo. These two

TABLE 6.13 MODES OF TRANSPORT UTILISED BY MARKET CENTRES.

MODE OF TRANSPORT/ MARKET SIZE	ROAD	HUMAN	ANIMAL	NONE	TOTAL
SMALL:	6(30)	13(65)	1	0	20
-ANGAGA	5	5	0	0	10
-OTHO	1	8	1	0	10
MEDIUM:	14(46.7)	11(36)	0	5	30
-MARIWA	1	8	0	1	10
-DEDE	10	0	0	0	10
-RIOSIR	3	3	0	4	10
LARGE:	5(16.7)	19(63)	2	4	30
-RONGO	5	5	0	0	10
-RANEN	0	8	2	0	10
-AWENDO	0	6	0	4	10
TOTAL	25	43	3	9	80
%	31.25	53.75	3.75	11.25	100

SOURCE: MARKET-SURVEY-RONGO DIVISION (1986/87).
NOTE: PERCENTAGE FIGURES ARE ENCLOSED IN PARENTHESIS

markets had the largest number of "within-market" traders.

(e) STORAGE FACILITIES

The utilisation of storage facilities is related to the size of market, type of trader and quantities of maize involved. The bigger the size of the market, the greater the availability of storage facilities. Long distance and permanent traders serving multiple markets are the ones most likely to store their maize. This is also true of those traders handling large amounts of maize which can not be sold all in a single day.

Table 6.14 shows that over 80% of the traders do not store any of their maize at the end of business in a given day. The use of storage facilities for maize was particularly marked in Riosir. In this market, a large number of traders bring large quantities of maize from the neighbouring Kisii District and keep them with their relatives who own most of the small shops found in the periodic market. The most popular storage facility is that provided free by friends and relatives residing within particular market centres although cases of persons using their own premises also exist. Storage facilities which are paid for are less popular and these range from rooms rented specifically for the purpose or living dwellings of acquaintances.

TABLE 6.14 STORAGE UTILISATION BY TRADERS IN THE INFORMAL MARKETING SYSTEM

MARKET SIZE	USERS	%	NON-USERS	%	TOTAL
SMALL:	1	5	19	95	20
-OTHO	1	10	9	90	10
-ANGAGA	0	0	10	100	10
MEDIUM:	8	26.7	22	73.3	30
-RIOSIR	6	60	4	40	10
-DEDE	2	20	8	80	10
-MARIWA	0	0	10	100	10
LARGE:	4	13.3	26	86.7	30
-AWENDO	1	10	9	90	10
-RONGO	2	20	8	80	10
-RANEN	1	10	9	90	10
TOTAL	13	16.2	67	83.75	80

SOURCE: MARKET-SURVEY-RONGO DIVISION (1986/87)

6:3:4 VARIATIONS IN QUANTITIES OF MAIZE HANDLED

It is expected that quantities of maize handled by individual traders would depend on their characteristics and those of the periodic markets frequented. Organisational characteristics of the informal trade and their expression at the individual level is also likely to influence the amount of maize handled by informal traders.

Table 6.15 shows that most traders deal with quantities greater than 1 tin but less than 1 sack. Denominations of less than one tin is the second most important. Traders with 1 sack and above for sale were quite few (12.5%) and were mainly found in the larger periodic markets. The smallest denomination(less than 1 tin) is common in the smaller periodic markets amongst within market traders who buy from bigger traders or farmers and later sell at a small profit. This group of traders do not have a large financial outlay and do not want to risk remaining with unsold maize at the end of the day. The traders handling more than 1 tin but less than 1 sack are the most numerous and are mainly found in the larger market centres. These are mainly larger scale traders or farmers who can expend some money on transport and storage. The last quantity category is the bulk and its clear that this is mostly related to the larger sized markets and those

TABLE 6.15 TRADERS BY QUANTITIES OF MAIZE OFFERED FOR SALE

QUANTITY CATEGORY/ MARKET	>1 TIN	>1 SACK	1 SACK & ABOVE	TOTAL
SMALL:	8 (40%)	9 (45%)	3 (15%)	20
-ANGAGA	4	5	1	10
-OTHO	4	4	2	10
MEDIUM:	6 (20%)	23 (77%)	1 (3%)	30
-MARIWA	0	10	0	10
-RIOSIR	1	8	1	10
-DEDE	5	5	0	10
LARGE:	8 (27%)	16 (53%)	6 (20%)	30
-RANEN	3	5	2	10
-RONGO	2	5	3	10
-AWENDO	3	6	1	10
TOTAL	22	48	10	80
%	27.5	60	12.5	100

SOURCE: MARKET SURVEY-RONGO DIVISION (1986/87).

located in major maize growing areas. It is least popular in those market centres not properly served by efficient transport systems. However, smaller sized markets located in areas of maize deficiency as well as served with good transport network are a major exception.

(a) MODELLING PROCEDURE

In order to explain observed variations in amounts of maize handled by informal traders across the eight markets surveyed, a multiple regression procedure has been used beginning with the highest possible number of explanatory variables (see appendix 17).

The null model fitted to amount of maize handled (MAI) had a deviance of 36.170 from 79 degrees of freedom. The first regression model entered had the following variables (see appendix 17 for the key to the acronyms):

$$MAI=1+SEX+GAGE+EXP+RES+TYP+MAK+COM+SIZ+DSMK+SSP+TRA+NMK+NCO+STO+BUY+SEL+TCO+DSSK+PROF \quad - (6.3.1)$$

The model reduced the deviance by 33.21 (2.9577) from 46 degrees of freedom. The R-square value which indicates the goodness-of -fit of the model was 0.9182. An examination of the plot of leverage values revealed no influential points. Six outliers were however detected from the residual plot. These were 1,5,6,9 and 10. These suspicious points were subsequently weighted out. The following variables were reported as aliased: TYP, COM, SIZ, DSMK and DSSK. All these variables describe the characteristics of the individual markets in the model represented by the variable MAK (name of market). The second model fitted therefore excluded the variables MAK and PROF (profit margins).

Model two fitted on amount of maize handled therefore consisted of the following terms:

$$MAI=1+SEX+GAGE+EXP+RES+TYP+COM+SIZ+DSMK+SSP+NMK+NCO+STO+BUY+SEL+TCO+DSSK \quad - (6.3.2)$$

This model reduced the deviance to 1.0753 from 74 observations (d.f=44, r-squared=0.9703). Both the residual and leverage plots revealed no suspicious points. The parameter estimates and the corresponding t-values revealed a number of insignificant variables which could be excluded from the model without loss in its explanatory power. Using a minimum t-value of 1.645 as the cut-off point for the inclusion of variables in subsequent models, the third model fitted consisted of the following terms:

$$MAI=1+BUY+SSP+NMK+TCO+SEX+EXP+TRA+DSMK+RES+NCO \quad - (6.3.3)$$

Model three reduced the deviance to 1.252 (d.f=51). The R-squared value of 0.9654 for the model suggest that the exclusion of the insignificant variables did not significantly affect the model. An examination of the plot of leverage values identified 40 and 48 as influential points. These were subsequently excluded from the modelling procedure.

The fourth model fitted was therefore basically the same as model three except that the influential points were left out. The model explained 96% of the total variation in quantities of maize sold. The residual plot and the plot of leverage values (see appendix 18 and 19) revealed no ill fitting points. The model was therefore adopted to explain variations in quantities of maize handled by informal maize traders. The results of the model are displayed in table 6.16.

(b) INTERPRETATION AND DISCUSSION OF RESULTS

Only three personal characteristics of traders have been isolated as related to quantities of maize handled by informal maize traders namely sex (SEX), years of experience (EXP) and residence (RES). Male farmers tend to handle less quantities than their female counterparts although this difference is not statistically significant. The amounts handled increase significantly with years of experience while farmers living in the same division but outside the administrative location where the periodic market is found handle significantly more maize.

Organizational characteristics of the informal trade found to be significantly related to the amounts of maize handled include the purchase price of maize (BUY), source of maize supply used (SSP), number of markets served (NMK), transport cost (TCO), and number of commodities sold by traders (NCO). As is expected, the higher the purchase

TABLE 6.16 REGRESSION RESULTS FOR MODEL FOUR QUANTITY OF MAIZE HANDLED BY TRADERS

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE
1	0.11	0.11	0.97
BUY	-0.10	0.02	-5.27*
SSP(2)	0.28	0.19	1.51
SSP)3)	0.35	0.09	3.71*
SSP(4)	0.42	0.10	4.25*
NMK	0.09	0.02	4.71*
TCO	0.01	0.01	2.35*
SEX	-0.23	0.37	-0.62
EXP(2)	0.05	0.06	0.82
EXP(3)	0.21	0.08	2.73*
EXP(4)	0.13	0.10	1.37
EXP(5)	0.27	0.16	1.71*
EXP(6)	0.08	0.09	0.90
EXP(7)	0.09	0.08	1.17
TRA(2)	-0.16	0.07	-2.25*
TRA(3)	0.00	aliased	0.00
TRA(4)	-0.21	0.11	-1.83*
DSMK	0.01	0.01	1.42
RES(2)	-0.05	0.05	-1.08
RES(3)	0.15	0.07	2.04*
RES(4)	0.12	0.08	1.56
RES(5)	0.1384	0.10	1.41
NCO	-0.04171	0.02	-1.66*

* SIGNIFICANT AT P=0.05
** SEE APPENDIX 17 FOR FULL PARAMETER NAMES

price, the less maize handled. Those traders who obtain their maize from the same markets as well as other markets tend to handle significantly greater quantities of maize. Transport costs and number of markets served have positive relationships with quantities handled. As number of other commodities handled together with maize increase, less maize quantities are handled. This shows that the more specialised maize traders handle more of the produce.

The main conclusion emanating from these findings is that there exists a hierarchy of maize traders. The most important informal traders in terms of quantities of the produce handled are regular ones with long years of experience. These traders utilise the periodic markets to obtain maize supplies. They therefore serve multiple markets while specialising in maize trade.

6:3:5 VARIATIONS IN MAIZE PRICES

There are considerable variations in the selling and buying price of maize within the informal marketing sector. This is in contrast to the formal marketing system where prices are fixed and stable.

Amongst the eight market centers surveyed, the average price per tin amounted to Kshs. 30.85. However, there was a wide margin between the maximum and minimum recorded. The former amounted to Kshs. 42.60 recorded in Rongo while the latter was Kshs. 25/90 recorded in Rongo giving a margin of Kshs. 16/70. This wide variation in price suggests the unstable prices over time and space. The highest average buying price occurred in three markets which are relatively close to each other (Ranen, Rongo, Riosir) and are all connected by a good road. The lowest buying prices are found in a group of markets in the southern parts of the study area (Awendo, Mariwa, Angaga, Otho, and Dede). These are relatively smaller in sizes than the first group except for Awendo whose low prices could be attributed to the many within-market-traders operating there. The difference between the highest and the lowest buying price reportedly paid by traders was highest in Otho (ksh.20/80), while the lowest occurred in both Angaga and Mariwa (Kshs. 4/00). A general trend observed about prices is that the selling price for maize tend to be higher than the buying price. This is, however, an expected trend since traders must have some profit to stay in business. In addition, there are notable variations in minimum and maximum selling prices across the periodic markets surveyed and within each market. Low prices for maize offered for sale seem to be associated with the number of category 1 traders found within each individual market. Across the markets surveyed, the maximum selling price was recorded in Ranen, while the lowest was in Mariwa. A classification of the eight markets on the basis of recorded average selling prices groups Ranen, Rongo, Dede and Otho in one category having higher than average selling prices. The second group consisting of markets with lower than average selling prices consist of Awendo, Angaga, Riosir and Mariwa. No particular pattern emerges from this grouping because the two groups share more similarities than contrasts. Within individual markets, the greatest price range was recorded in Angaga and Mariwa while the lowest was recorded in Riosir. The former are in close proximity to each other, relatively isolated from the rest of the markets and are located in areas where maize production is not very extensive. Riosir is dominated by traders who get their maize supply from their own farms in the nearby Kisii District (where maize output is quite high) and within - market-traders who buy and sell their produce on the same day in the same market. Overall, higher than average price ranges were recorded in Otho, Riosir and Ranen; lower than average price ranges in Dede, Rongo, Awendo, Angaga and Mariwa. Again there is no common denominator differentiating the two groups. However, for the latter group, price ranges tend to diminish with increasing isolation of particular markets.

(a) MODELLING PROCEDURE

In order to explain the observed variations in the sale price for maize across the eight periodic markets, a multiple regression procedure has been attempted utilising the variables listed in appendix 17. The null model fitted to the variable maize prices (SEL) had a deviance of 151.62 (d.f=79). The first model fitted was of the following form (see appendix 17 for key to the acronyms):

SEL=1+SEX+GAGE+EXP+RES+TYP+MAK+COM+SIZ+DSMK+SSP+
TRA+NMK+NCO+STO+BUY+MAI+TCO+DSSK
- (6.4.1)

The model reduced the deviance to 27.795 (change=123.8) from 47 degrees of freedom (change=32) giving an R-squared value of 0.8167. One outlier was detected from the residual plot (68) and was subsequently left out of the modelling procedure. The plot of leverage values however revealed no influential points. The parameter estimates showed the following as aliased: TYP, COM, SIZ, DSMK, DSSK. The second model was therefore refitted with the variable MAK excluded on suspicion that it represented the same measurement as the aliased variables. Model two fitted consisted of the following variables:

SEL=1+SEX+GAGE+EXP+RES+TYP+COM+SIZ+DSMK+SSP+TRA+
NMK+NCO+STO+BUY+MAI+TCO+DSSK
- (6.4.2)

The model reduced the deviance to 18.729 from 79 observations (d.f=49) with the R-squared values of 0.8765. The plot of leverage values revealed one influential point (48) which was left out in subsequent models. Using a t-value of 1.645 as the minimum below which terms are excluded from the modelling procedure, the third model fitted consisted of the following terms:

SEL=1+RES+COM+BUY+DSSK+EXP+DSMK+SSP+NMK+TRA
- (6.4.3)

This model increased the deviance negligibly to 19.763 (d.f=55, 78 observations) suggesting that the excluded variables are insignificant. This is confirmed by the R-squared value which reduced insignificantly to 0.8697. Both the residual and the leverage plots for this model revealed no suspicious points (see appendix 20 and 21).

The fourth model fitted introduced the interaction effect between source of supply (SSP) and mode of transport utilised by traders (TRA) as an extra term. The model was of the following form:

SEL=1+RES+COM+BUY+DSSK+EXP+DSMK+SSP+NMK+TRA+
SSP.TRA
- (6.4.4)

This model reduced the deviance insignificantly to 18.665 (d.f=51, F-value=0.75) showing that the interaction effect does not significantly improve the explanatory power of the model and could therefore be left out. The fifth model fitted explored the possible effect of introducing the interaction term between years of experience (EXP) of traders and their residence (RES). This model consisted of the following terms:

SEL=1+RES+COM+BUY+DSSK+EXP+DSMK+SSP+NMK+TRA+
RES.EXP
- (6.4.5)

This model increased the deviance to 22.258 from 48 degrees of freedom indicating that the addition of the interaction term RES.EXP significantly decreased the explanatory power of the model. The model finally adopted to explain the observed variations in sale price of maize within the informal marketing system was therefore model three whose parameter estimates, standard errors and correponding t-values are displayed in table 6.17.

(b) <u>INTERPRETATION AND DISCUSSION OF RESULTS</u>

The significant explanatory variables in model three (Table 6.17) can be conveniently divided into three subgroups namely:

- those relating to the personal characteristics of informal traders. These include residence of traders (RES), years of experience in informal maize trade (EXP) and number of markets regularly visited by the traders (NMK).
- those relating to the characteristics of the periodic markets within which transactions occur. These include the location of the periodic market with respect to existing communication links (COM), distance of the market from the nucleus sugar-cane plantation in the study area (DSSK) and distance to the nearest market centre (DSMK).
- those relating to the general organisation of the informal maize trade namely purchase price of maize being sold, source of supply of maize offered for sale (SSP) and the means of transport utilised by the informal traders for both self and produce (TRA).

(b.i) MAIZE PRICES AND CHARACTERISTICS OF TRADERS

The model adopted predicts that the average selling price for maize in the study area is Kshs. 5.05 per small tin. The residence of the traders contribute significantly

TABLE 6.17 RESULTS OF MODEL THREE - SALE PRICE OF MAIZE WITHIN THE INFORMAL MARKETING SYSTEM

PARAMETER**	ESTIMATE	STANDARD ERROR	T-VALUE
1	5.05	0.50	10.03*
RES(2)	-0.17	0.17	-0.97
RES(3)	-0.39	0.29	-1.34
RES(4)	-0.20	0.32	-0.62
RES(5)	-1.84	0.42	-4.35*
COM(2)	-0.61	0.22	-2.87*
COM(3)	-0.90	0.22	-4.08*
BUY	0.30	0.08	3.64*
DSSK	0.03	0.01	3.58*
EXP(2)	-0.35	0.25	-1.39
EXP(3)	-0.58	0.30	-1.91*
EXP(4)	-1.18	0.35	-3.37*
EXP(5)	-1.04	0.48	-2.18*
EXP(6)	-0.55	0.36	-1.52
EXP(7)	0.67	0.33	2.05*
DSMK	-0.08	0.03	-2.62*
SSP(2)	-0.90	0.55	-1.62
SSP(3)	-1.01	0.39	-2.58*
SSP(4)	-0.64	0.43	-1.48
NMK	0.20	0.08	2.61*
TRA(2)	0.57	0.30	1.91*
TRA(3)	1.50	0.53	2.82*
TRA(4)	0.54	0.41	1.30

* SIGNIFICANT AT P=0.05
** SEE APPENDIX 17 FOR FULL NAMES OF PARAMETERS

to variations in price. Those traders whose homes are located in the same sub-locations as the market centre are predicted by the model to sell at the average price of Kshs.5.05. Those traders coming from outside the sub-location but from the same location where the market is situated sell at a lower but insignificant price of Kshs. 4.90. The corresponding figure for those living in the same division is Kshs. 4.65. These predicted variations in price with residence of traders seem to suggest that the further the home of the trader from the market, the lower the price one would charge for maize offered for sale. However, these variations are not significant. Traders hailing from the same province but outside the district where the market is located sell at significantly lower prices averaging Kshs. 3/20 per tin. It is important to note that most of the traders from this category came from the neighbouring Kisii District where maize production and yields are much higher compared to the study area.

Irregular informal traders sell their maize at higher prices than those with less than one year experience in the trade. However, this difference is insignificant. The results indicate that as years of experience increase, the traders tend to sell their maize at lower prices. Those with 1-3 years of experience sell at approximately Kshs. 4.50 per tin. The corresponding figures for those with 4-6 and 7-9 years experience are Kshs.3.90 and Kshs. 6.10. The results for the latter is significant. Traders with over 9 years sell at about Kshs. 4.50 while non-respondents sell at significantly higher prices of Kshs.5.70 per tin.

Traders who regularly visit multiple periodic markets sell their maize at significantly higher prices than those who do not. A unit increase in number of periodic markets visited by a trader increases the price of maize by 20 cents per tin.

(b.ii) <u>MAIZE PRICES AND CHARACTERISTICS OF MARKETS</u>

All the markets investigated were categorised into three groups on the basis of their communication links with other markets. Category 1 consisted of those with good communication links with the others. These included Rongo, Awendo and Ranen. Category II periodic markets are those with moderately good communication links namely Mariwa, Riosir and Dede. The last category are those with poor communication links with the rest namely Angaga and Otho. It should be realised that this categorisation also reflects the size characteristics of the markets. Category I are the largest in the group and Category III the smallest in size. The parameter estimates indicate that the prices are significantly lower in the medium sized markets by 60 cents and in the smaller ones by 90 cents.

The distance of a particular periodic market from the nucleus sugar plantation at Awendo is an important variable explaining variations in prices of maize in the periodic markets. A unit increase in the distance increases the price significantly but negligibly by 0.02 cents. As distance to the nearest market increases, the price decreases by 0.08 cents. This reinforces the earlier finding that prices tend to be lower in the small sized and remotely located markets.

(b. iii) MAIZE PRICES AND ORGANISATIONAL CHARACTERISTICS

As is expected, a unit increase in the price a trader is charged for maize increases the selling price charged by that particular trader by 30 cents. The source from which the trader obtains the maize also influences the maize prices charged in the periodic markets. Those traders who buy from local farmers sell at significantly lower prices than those who obtain what they sell from their own farms. Those who buy and sell within the same market and those bringing from other markets all sell at lower but insignificant prices than those bringing maize from their own farms. What this result tend to suggest is that traders sell at lower prices than those who are not full time ones. It is important to note that the traders who obtain their maize supplies from home are actually farmers who have chosen not to sell their maize through intermediaries. They therefore lack the experience full time traders have. The cost of transporting grain to the periodic market is normally passed on to consumers. This is suggested by the parameter estimates which indicate that those traders who never transported their maize to the periodic markets sell at significantly lower prices than those who used human or animal transport. The prices for those who used motor transport are also higher although not statistically significant.

6.4 SUMMARY AND CONCLUSIONS

Four maize marketing structures have been identified in this chapter. These are the sale of maize directly to fellow farmers (consumers), informal traders, local cooperatives and the National Cereals and Produce Board. The first two constitute the informal marketing system and the other form the formal maize marketing system. The NCPB is more active in the buying of maize from farmers while the majority of farmers depend on the informal sector for the selling and procurement of maize. However, the average quantities of maize per farmer tend to be lower in the informal sector. The quantities of maize sold by farmers vary according to the farmers' age, sex and educational level. The variations are also dependent on the marketing channel utilised. The average volumes of maize increase with the ranking of the channel used in the hierarchy of maize marketing structures identified.

The informal marketing system consists of transactions involving both farmers and traders mostly in the periodic markets which vary in size and locational characteristics. The informal maize trade is undertaken as an income earning business and is dominated by females. Most of the traders are in their middle age and having several years of experience. These traders tend to operate in multiple periodic markets and depend greatly on their own farms for the maize sold. Maize traders tend to specialise in the produce and rarely sell other commodities besides maize. The trade is highly localised with most traders hailing from the administrative locations where the periodic markets are located. Storage utilisation for produce sold is quite rare and motor transport play a negligible role.

The quantities of maize handled by the informal traders vary according to purchase price, source of supply, transport cost, mode of transport used, number of other commodities sold, years of experience and residence of the traders. The further the residence of traders from the periodic market, the lower the prices of maize sold. This is also true with increase in years of experience. The number of periodic markets visited tend to increase the price of maize. Higher prices of maize are also found in the larger periodic markets. Prices tend to increase with increasing distance from the nucleus sugar-cane plantation in the study area. Periodic markets which are isolated and smaller in sizes tend to have lower prices of maize.

The main conclusions drawn from the findings are that the prevailing organisation of the maize marketing makes the formal marketing system more suitable as a buyer of maize. In addition, the informal marketing is performing a significant role in maize marketing especially to meet the needs of small-scale sellers and consumers despite existing controls. The informal trade also offers employment to those with restricted income earning opportunities who are basically the aged and members of the female sex. With less restrictions on the informal marketing system and better organisation, the sector can perform a complementary role in the marketing of maize in order to solve the shortcomings currently facing the formal marketing system.

CHAPTER SEVEN - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.

CHAPTER SEVEN - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.

7.0 INTRODUCTION

This study set out to investigate the factors responsible for spatial variations in maize production and marketing in Rongo Division, South-Nyanza District in Western Kenya. The variations in maize yields, hectarages and the adoption of technological innovations were analysed. Furthermore, the maize marketing system in the study area was investigated. The overall aim of the study was to arrive at useful findings and recommendations which could lead to increased maize production and effective maize marketing within a small-scale setting. This is in line with Kenya's food policy which places great emphasis on intensified food production within the small-scale farming sector to achieve food self-sufficiency.

Maize has become an important staple food crop in the study area and elsewhere in the country. However, its production is beset with a number of problems which must be identified and appropriate solutions found. The study area is a small-scale farming area presently witnessing a rapid transition towards commercial farming based on the production of cash-crops. In addition, it is facing an increasing population and diminishing land. All these characteristics offered a useful scenario within which the problems of small-scale maize production were analysed.

This chapter gives a summary of the major findings and conclusions of the study. In addition, the major policy recommendations and suggestions for further research are given.

7.1 SUMMARY OF FINDINGS

It was established that maize yields in the study area were below the potential despite the prevailing suitable environmental attributes. The average maize yield per hectare was found to be 28 (90kgs.) bags of unshelled maize. This was far below the potential for the area which was estimated to lie between 70-100 bags of shelled maize at maximum efficiency (Republic of Kenya, 1985). Against this background, it was found that most of the farmers (69%) solely relied on farming as their main source of livelihood. They will therefore continue to count on their own production to meet increasing food needs. Generally, maize production in the study area was found to be characterised by low technology based on the use of simple implements with a great expenditure of raw human labour.

Spatial variations in maize yields were found to vary according to established crop combinations in the study area. Four different crop combinations were established in the study area. They suggested a negative impact of cash-crop production especially sugar-cane on maize yields. The combinations also indicated the growing importance of cash-crop production and declining production of maize, and alternative drought resistant food crops such as sorghum, cassava and millet in the study area.

Further analyses revealed that maize yield variations are closely associated with variations in environmental attributes, agronomic practices and socio-economic attributes. The regression analysis done predicted lower maize yields in areas of lower rainfall (1400-1600mm), lower soil fertility and those located within the sugar-cane and the coffee-tea zones. Inappropriate agronomic factors were also found to contribute to lower maize yields especially intercropping, the planting of hybrid seed and late weeding. Other factors found to be negatively related to maize yields included area under sugar-cane cultivation and total area under maize.

The average hectarage devoted to maize per farmer was found to be 1.06 hectares with a standard deviation of 0.83 hectares. Variations in this variable was found to be associated with differences in soil fertility and agro-ecological zones. It was established that the observation of long fallow periods, lack of ploughing implements and absentee land ownership all contributed significantly to lower areas under maize cultivation.

The analysis of adoption of innovations revealed that packages of inseparable innovations were rarely adopted. The planting of hybrid seed either alone or in combination with other seed varieties was observed in 66% of the total sampled farms. The corresponding figure for the application of farm-manure/fertilizer was 76%. However, fewer farmers adopted the two innovations combined (55.5%). The logit regression model fitted on these innovations suggested that the likelihood of their adoption were closely related to the environmental attributes and individual traits of farmers, particularly age, sex and educational level. The accessibility to extension and credit facilities, the possession of relevant farm inputs (farm animals, wheel-barrows, casual labour) and types of crops planted were also found to be significant explanatory variables.

The analysis of the maize marketing system established that farmers in the study area employ multiple marketing strategies. The utilization of any given marketing channel was found to be related to the individual needs of the farmer and the specific characteristics of a given channel. The informal marketing system emerged as the most important marketing channel. The majority of farmers (87%)who bought maize to supplement their domestic supplies relied on the informal marketing system. In addition, out of the farmers who sold maize, 72% utilised the informal marketing system. The amount of maize sold by farmers were found to be related to their individual attributes and the type of marketing channel used. Within the informal sector, variations in the amount of maize handled by traders and maize prices were found to be significantly related to the individual attributes of traders and the organisational aspects of the informal trade.

7.2 CONCLUSIONS.

In the light of the findings presented above, the following conclusions have been drawn. In the first instance, it is certain that food production in the study area will decline as a result of the unfavourable competition (for land and inputs) from cash-crops especially sugar-cane. This conflict must be resolved not only in the study area but also elsewhere in the country for self-sufficiency in food.

While environmental considerations must be taken into account, it is obvious from the study that the major limitation to increased maize yields is the prevalence of inappropriate agronomic practices in the study area. These must be improved since it is inevitable that the increasing food needs of the study area will have to be met from diminishing land.

It is evident that the expansion of the total area under maize in the study area is only feasible in the short run. However, even such a strategy would require an increased accessibility of farmers to adequate land preparation implements.

The adoption of relevant technological innovations will greatly determine the future of maize production in the study area and elsewhere in the country. It is also definite that the adoption of these innovations are closely governed by the position of the farmer in the existing socio-economic hierarchy. A general improvement in the living standards of the rural population will therefore undoubtedly lead to greater production of maize through the application of appropriate technological innovations.

Finally, the informal marketing system will definitely continue to play a significant role in the disposal of maize surplus from small-scale farmers and in the supply of maize especially to rural consumers. There is therefore a need to integrate it with the statutory marketing board.

7.3 POLICY RECOMMENDATIONS

From the findings of this study, the following recommendations have been put forward to guide policy making and implementation with respect to improved maize production and marketing in the study area. These recommendations can also be applicable elsewhere in the country where similar conditions exist:

(i) It is highly necessary to resolve the conflict between cash-crop and food-crop production in the country. With specific reference to the study area, sugar-cane farmers should be required to devote an appropriate minimum land specifically for maize in every growing season. This should be accompanied by a vigorous promotion of alternative food crops such as sorghum, millet, cassava, beans and groundnuts.

(ii) The main thrust of extension services in the study area should be the encouragement of farmers to aim at attaining maximum yields through the adoption of technological innovations as inseparable packages. The extension advice must also reflect local variations in environmental conditions. In areas of low soil fertility for example, appropriate soil management practices should be emphasised.

(iii) Prevalent inappropriate husbandry methods sometimes practiced out of lack of information must be eradicated. Specifically, the planting of second generation hybrid should be discouraged while intercropping should be based on a careful selection of crops. In this respect, crops such as beans and groundnuts whose nutritional requirements are complimentary to maize should be encouraged. Those crops which compete adversely with maize for soil nutrients, such as sorghum and sugar-cane should not be intercropped with maize.

(iv) Farmers' accessibility to credit, seeds, and farm implements should be increased. Tractor hire services, for example, should be made available to farmers at reasonable rates and at appropriate periods for timely land preparation. The distribution of hybrid maize seeds should be improved in the study area backed by intensified extension services. Overall, agricultural services should show a determined effort to integrate women in agricultural development.

(v) To supplement government support programmes within the small-scale farming sector, communal groupings should be encouraged based on the pooling together and sharing of agricultural inputs especially labour and land preparation implements. These could take the form of church, women and youth groups sharing resources in land preparation, weeding and even harvesting of maize. This could alleviate the shortage of implements and labour in the study area. Furthermore, such groups could be useful targets for extension services.

(vi) Livestock development should be vigorously pursued in the study/as an integrated part of general /area improvement in agriculture. The use of maize stalks as livestock feed, cattle-shed manure in maize farms, and the use of oxen and donkeys in both land preparation and transport of farm produce should be encouraged.

(vii) The supply of maize to consumers within the rural areas should be left solely to private maize traders. These should be licensed to operate beyond district boundaries.

(viii) The functions of the National Cereals and Produce Board should be restricted to the buying of surplus maize from farmers with the express purpose of keeping the strategic food reserve the country needs.

7.4 RECOMMENDATIONS FOR FURTHER RESEARCH.

Given below are a set of recommendations put forward for further research work given the fact that they could not be reasonably investigated in this study. However, it is apparent that they are important aspects of maize production and marketing.

(i) It is evident that increasing use of improved maize varieties will have to be intensified for higher maize production. However, the widespread use of improved seeds will contribute to decreased genetic diversity which will increase the vulnerability of maize to pests and diseases. It is therefore recommended that the influence of pests and diseases on maize be thoroughly investigated to reduce pre- and post-harvest grain losses.

(ii) Given the high prices of fertilizers and possible environmental consequences of their use, it is recommended that biological alternatives to commercial fertilizers be investigated. This should be based on nutrient deficiencies in specific soil types. In connection with this, rapid soil assessment methods need to be found to help farmers in their decisions to apply farm-yard manure/fertilizers when necessary.

(iii) The suitability of different crops to intercrop with maize require further investigation.

(iv) Urgent research is required on the efficiency, durability and costs of existing farm implements with a view to widening the scope of their application in major farm operations. This should focus particularly on ox-drawn implements such as the ox-plough and ox-cart.

(v) The decision-making process in rural households needs further study particularly to isolate target groups for extension services within the small-holder farming sector.

(vi) The organizational structure of the informal marketing system and its potential role in grain marketing require further analysis with the objective of establishing appropriate complementary linkages between it and the statutory marketing board.

BIBLIOGRAPHY

BIBLIOGRAPHY

Acland, J.D. (1971) East African crops: an introduction to the production of field and plantation crops in Kenya, Uganda and Tanzania. Longman, London.

Agresti, A. & Finlay, B. (1986) Statistical methods for the social sciences. Dellen Publishing Co. San Francisco.

Atherley, K. (1986) The application of tourist-based research to coastal management in Barbados. M.A. thesis, Department of Geography, McGill University.

Akech, S.O. (1985) Small-scale cotton production: a case study in the Lambwe Valley. B.A dissertation, Department of Geography, University of Nairobi.

Allan, A.Y. (1971) The influence of agronomic factors on maize yields in Western Kenya with special reference to time of planting. Ph.D thesis, University of Nairobi.

Blaut, J.M. (1959) "Micro-geographic sampling: a quantitative approach to regional agricultural geography." Economic Geography, Vol. 35, 1959.

Cattell, R.B. (1978) The scientific use of factor analysis. Plenum Press, New-York.

Chisholm, M. (1962) Rural settlement and land-use: an essay in location. Hutchinson & Co. Ltd., London.

Clark, D., Davies, W.K.D., & Johnston, R.J. (1974) "The application of factor analysis in human geography." The Statistician, vol. 23, 259-281.

Clark, W.A.V. & Hosking, P.L. (1986) Statistical methods for geographers. John Wiley & sons, New York.

Clayton, E.S. (1956) "Research methodology and peasant agriculture." Farm Economist, vol.8 no. 6.

Cliff, A.D. & Ord, J.K. (1973) Spatial autocorrelation. Pion, London.

------------ (1981) Spatial processes: models and applications. Pion, London.

Coppock, J.T. (1964) "Crop, livestock and enterprise combinations in England and Wales." Economic Geography, Vol. 40, 1964.

De'Wilde, J.C (1967) Experiences with agricultural development in tropical Africa Vols. 1 & 2. John Hopkins Press, Baltimore.

Dowker, R.A. (1971) "A note on the reduction of Taboran maize by late planting." East African Agricultural and Forestry Journal vol. 30: 33-34.

Draper, N.R. & Smith, H. (1966) Applied regression analysis. John Wiley and sons, New York.

Enyi, B.A.C. & Kuyembeh, N.G (1980) "Appropriate mechanization of small farms in Africa: the role of traditional equipment and improved tools." In Mati, J.K.G. edit. (1980) Appropriate mechanization of small-scale farms in Africa. City Printing Works (K) Ltd., Nairobi.

Fearn, H. (1961) An African economy: A study of Economic Development of the Nyanza Province of Kenya, 1930-53. Oxford University Press, Nairobi.

F.A.O. (1980) Improvement and production of maize, sorghum and millet, Vols. 1 & 2. F.A.O., Rome.

Garst, R.D (1972) The spatial diffusion of agricultural innovations in Kisii District, Kenya. Phd Thesis, Department of Geography, Michigan State University.

----------- (1974) "Innovation diffusion among the Gusii of Kenya." Economic Geography, vol.50, no.4.

Gerhart, J.D. (1974) The diffusion of hybrid maize in Western Kenya. Ph.D. thesis, Princeton University.

------------- (1975) "The diffusion of hybrid maize in Western Kenya." CIMMYT, Mexico City.

Glover, J. (1957) "The relationship between seasonal rainfall and yield of maize in the Kenya Highlands." Journal of Agricultural Science, vol.49: 171-180.

Greenway, P.J. (1945) "Origins of some East African food plants, part V. The East African Agricultural Journal of Kenya, Tanganyika, Uganda and Zanzibar, vol. XI no. 1: 56-63.

Gsaenger, H.G. & Schmidt, G. (1977) "Decontrolling the maize marketing system in Kenya." I.D.S. Discussion Paper no. 254, March, 1977. Institute of Development studies, University of Nairobi.

Haring L.L. & Lounsbury, J.F. (1978) Introduction to scientific geographic research. WMC. Brown Company Publishers, Iowa.

Harman, M.H. (1967) Modern factor analysis. Chicago University Press, Chicago.

Harvey, D.W. (1966) "Theoretical concepts and analysis of agricultural land-use patterns in geography." Annals of the Association of American Geographers, Vol. 56, 1966.

Harrison, M.N. (1970) "Maize improvement in East Africa" in Leakey, C.L.A.-edit- (1970) Crop improvement in East Africa. Commonwealth Agricultural Bureaux, Farnham Royal.

Hazelden, E.J.R. (1976) "Maize production in Lake Shore Nyanza". Mimeographed report from Kenya Seed Company, Kitale.

Henshall, J.D. (1966) "The demographic factor in the structure of agriculture in Barbados." <u>Transactions of the Institute of British Geographers, No. 38, 1966.</u>

------------- (1967) "Models of agricultural activity" In Chorley, E.J. & Haggett, P. -edits.- (1967) <u>Models in Geography,</u> Methuen & Co. Ltd., London.

------------- & King, L.J. (1966) "Some structural characteristics of peasant agriculture in Barbados." <u>Economic Geography, Vol. 41(1), 1966.</u>

Hesselmark, O. (1976) <u>Maize yields in Kenya.</u> Maize and Produce Board, Nairobi.

------------- (1977) "Marketing of maize and beans in Kenya: a proposal for improved effectiveness. <u>Discussion Paper no. 255</u>, Institute of Development Studies, University of Nairobi.

Heyer, J. (1975) "The origins of regional inequalities in small-holder agriculture in Kenya: 1920-73." <u>East African Journal of Rural Development, vol. 8 (1-2): 142-181.</u>

-----------, Maitha, J.K., & Senga, W.M. -edits.- (1976) <u>Agricultural development in Kenya: an economic assessment.</u> O.U.P., New-York.

Jaetzold, R. & Schmidt, H. (1982) <u>Farm management handbook: natural conditions and farm management information Vol. 2/A: West kenya.</u> Ministry of Agriculture & German Agricultural Team, Nairobi.

Johnson, S.L. (1970) Changing patterns of maize utilization in Western Kenya." Studies in Third World societies, no. 8, July, 1970.

Johnston, R.J. (1978) Multivariate statistical analysis in geography: a primer on the general linear model. Longman, London.

Jones, G.E. (1963) "The diffusion of agricultural innovations." Journal of Agricultural Economics, vol.16, no.3.

Jones, M.J. (1974) Effects of previous crops on maize yields and nitrogen response at Samaru, Nigeria. Institute of Agricultural Research, Samaru.

Kariungi, F.T.(1976) Structure, conduct and performance of Kitui local maize markets. Msc. Thesis, University of Nairobi.

Kenya Seed Company (undated) Recommendations for planting Hybrid seed. Information leaflet available with major seed distributors.

Kyesimira, Y.Z. (1966) "Some aspects of the Report of the Kenya Maize Commission of Inquiry 1966 (1)." Rural Development Research Paper no.36. Makerere University, Kampala.

Lloyd, P.E. & Dicken, P. (1972) Location in space: a theoretical approach to economic geography. Harper & Row, New York.

Lukando, M.F. (1980) Towards maize yield prediction in the Katumani area of Kenya. Msc. Thesis, University of Nairobi.

Massel, B.F. (1965) "Maize policy in Kenya." I.D.S. Discussion Paper no. 20, 1965. Institute of Development Studies, University of Nairobi.

Mather, P.M & Openshaw, S. (1974) "Multivariate methods and geographical data." The statistician, vol. 23, 283-308.

Mather, P.M. (1976) Computational methods of multivariate analysis in physical geography. John Wiley & sons., New-York.

Matovu, J.M.K. (1979) Efficiency of resource utilization in small-scale farming: a case study of maize and cotton production in Machakos and Meru Districts, Kenya. Msc. thesis, University of Nairobi.

Matson, J.E. (1975) Normative supply response in a mixed farming system: a study of dairying and maize production in Nandi District, Kenya. Phd. Thesis, University Of East Anglia.

Miracle, M.P. (1966) Maize in tropical Africa. University of Wisconsin Press, London.

Mohammed, N. -edit.- (1983) Perspectives in agricultural geography. Vol. 1. Concept Publishing House, New Delhi.

Moock, P.R. (1973) Managerial ability in small farm production: an analysis of maize yields in Vihiga Division of Kenya. Ph.D Thesis, Columbia University.

Morgan, W.B. (1969) "The zoning of land-use around rural settlements in tropical Africa." in Thomas, M.F. & Whittington, G.W. -edits- (1969) Environment and Land-use in tropical Africa. Methuen & Co. Ltd., London.

Mothender, B., Kjaerby, F., & Havenerick, K. (1986) Farm implements for small-scale farmers in Tanzania. Scandinavian Institute of African Studies, Uppsala.

Mugerwa, H.S. (1983) The impact of farmer training on farm output in Homa-Bay, South-Nyanza, Kenya. Msc. Thesis, University of Nairobi.

Mungai, D.N. (1984) Analysis of some seasonal rainfall characteristics in the Lake Victoria Basin of Kenya. M.A Thesis, Department of Geography, University of Nairobi.

Munro, W.H. (1973) An economic study of maize marketing in Kenya: 1952-1966. Phd. Thesis, University of Michigan.

Nijkamp,P., Leitner, H. & Wrigley, N. (1985) Measuring the unmeasurables. NATO ASI series, Martinus Nijhoff Publishers, Dordrecht.

Ogutu, M.A. (1973) "The economic history of maize in Nyanza Province, 1936-60: outline." A paper presented at the Historical Association of Kenya, Annual conference, 1973, Nairobi.

Obara, D.A. (1983) "Environmental and agronomic factors influencing variations in small-holder cotton yields in the Kano plains, Kisumu district, western Kenya." Phd. thesis, University of Nairobi.

------------ (1987) "Forces of Change: an analysis of factors shaping food security and agricultural development among resource-poor farmers in Western Kenya." Social Science Interface Research Series. International Centre of Insect Physiology and Ecology (ICIPE), Nairobi.

------------- (1988) Geography: East African Environments. College of Adult and Distance Education, Faculty of External Degrees Studies, University of Nairobi.

Odingo, R.A. (1977) Decision making in food marketing in Kenya with special reference to maize and sugar. M.B.A. Thesis, University of Nairobi.

Odingo, R.S. (1971) The Kenya Highlands: land-use and agricultural development. East African Publishing House, Nairobi.

----------- (1985) "The dynamics of land tenure and of agrarian systems in Africa: land tenure study in the Nakuru, Kericho and Machakos areas of Kenya Highlands. A study specially prepared for the Food and Agriculture Organization (F.A.O). Rome.

Prewitt, K. (1975) "Introductory research methodology: East African applications." Occasional Paper no. 10, Institute of Development Studies, University of Nairobi.

Poole, M.A & Farrell, P.O. (1971) "The assumptions of the linear regression model." Transactions of the Institute of British Geographers vol. 52, 145-158.

Republic of Kenya (1966) Report of the maize commission of inquiry. Government Printer, Nairobi.

------------- (1970) South-Nyanza District annual report, Ministry of Agriculture.

------------- (1973) Report of the Select Committee on the maize industry. Government Printer, Nairobi.

------------- (1978) Nyanza Province annual report, Ministry of agriculture.

------------- (1978) Estimate of maize production in kenya, 1978. Central Bureau of Statistics, Ministry of Finance and Planning, Nairobi.

------------- (1981) Sessional paper no. 4 of 1981 on National Food Policy. Government Printer, Nairobi.

------------- (1983) Development Plan 1984-88. Government Printer, Nairobi.

------------- (1984a) South-Nyanza District Development Plan, 1984-88. Government printer, Nairobi.

------------- (1984b) Statistical Abstract, 1984. Central Bureau of Statistics, Ministry of Finance and Planning, Nairobi.

------------- (1985) Economic Survey, 1985. Central Bureau of Statistics, Ministry of Finance and Planning, Nairobi.

------------- (1986) Sessional Paper no. 1 of 1986 on economic management for renewed growth. Government Printer, Nairobi.

Rummel, R.J. (1967) "Understanding factor analysis." in Journal of conflict resolution, Vol. 11 no.4 pp. 440-80.

Rundquist, F.M. (1984) Hybrid maize diffusion in Kenya. CWK Gleerup, Lund.

Schmidt, C. (1979) "Maize and beans marketing in Kenya: the interaction and effectiveness of the informal and formal marketing systems." Occasional Paper no. 31, Institute of Development studies, University of Nairobi.

Shah, M.M., Fisher, G., Kromer, G. & Parikh, K.S. (1984) "Africa's growing dependence on imported wheat: some implications for agricultural policies in Africa." International Institute for Applied Systems Analysis, Laxenburg.

Shaw, G. & Wheeler, D. (1985) Statistical techniques in geographical analysis. John Wiley and Sons, Chichester.

Simango, V.A. (1976) Maize yield in relation to rainfall and solar energy in Kenya. Msc. Thesis, University of Nairobi.

Staudt, K.A. (1976) Agricultural policy,political power and women farmers in Western kenya. Phd. thesis, University of Wisconsin, Madison.

Swynnerton, R.J.M. (1954) A plan to intensify the development of african agriculture in Kenya. Government Printer, Nairobi.

Townsend, W.W. (1973) An introduction to the study of the soil. Edward Arnold, London.

Velleman, P.F. & Welsch, R.E. (1981) "Efficient computing of regression diagnostics." The American Statistician Vol.35, No.4, 234-42.

Von Pischke, J.D. (1974) "Small-holder agricultural credit programmes in Kenya." Report prepared for the Development Economics Department of the International Bank for Reconstruction and Development. Institute of Development Studies, University of Nairobi.

------------- (1976) "A critical survey of approaches to the role of credit in small-holder development." Discussion Paper no. 233. Institute of Development Studies, University of Nairobi.

Weaver, J.C. (1955) "Changing patterns of cropland use in Middle West." Economic Geography, vol. 30, 1955.

Weaver, J.C., Hoag, L.P., & Fenton, B.L. (1956) "Livestock units and combination regions in the Middle West." Economic Geography, vol. 32, 1956.

Wrigley, N. (1979) "Developments in the statistical analysis of categorical data." Progress in human geography, vol.3, 315-55.

------------ (1983) "Quantitative methods: on data and diagnostics." Progress in human geography, vol.7, 565-75.

------------ (1984) "Quantitative methods: diagnostics revisited." Progress in human geography, vol.8, 525-35.

------------ (1984) Categorical data analysis for geographers and environmental scientists. Longman, London.

------------ & Dunn, R. (1986) "Graphical diagnostics for logistic oil exploration models." Mathematical geology, vol.18, no.4, 355-74.

Wilson, R.J.A.(1972) "Land control in Kenya's small-holder farming areas." East African Journal of Rural Development, vol. 5 (1-2): 123-146.

Yappa, L.S. & Mayfield, R.C. (1978) "Non-adoption of innovations: evidence from discriminant analysis." Economic Geography, vol. 54, no.2.

Yotopoules, P.A. (1968) "On the efficiency of resource utilization in subsistence agriculture." Food Research Institute Studies vol.8, no.2: 125-135.

Zarkovich, S.S. -edit.- (1965) Estimation of areas in agricultural statistics. Food and Agriculture Organization (F.A.O.), Rome.

Ziwa, E. (1977) Economics of crop protection with particular emphasis on the productivity of pesticides on cotton and maize in Machakos and Meru Districts of Kenya. Msc. Thesis, university of Nairobi.

APPENDICES

APPENDIX 1

CONFIDENTIAL

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PERSONAL QUESTIONNAIRE FOR SMALL-HOLDER MAIZE PRODUCTION IN RONGO DIVISION, SOUTH NYANZA DISTRICT: SEPTEMBER,1986.

A. GENERAL INFORMATION

(i) Sample number --
(ii) Date of interview -------------------------------------
(iii) Sub-location --
(iv) Location ---

B. PERSONAL DATA

(i) Name: ---
(ii) Age: ---
(iii) Sex*: ---
(iv) Relationship with farm-owner** -------------------------
(v) Educational level*** ------------------------------------
(vi) Religion/Church --
(vii) Technical training ------------------------------------
(viii) Occupation apart from farming ------------------------

C.1 FARM POPULATION PRESENT ON THE FARM (FOR AT MOST TWO MONTHS PRECEDING DATE OF INTERVIEW)

Name	----------	----------	----------
Age	----------	----------	----------
Sex*	----------	----------	----------
Relationship with farm-owner**	----------	----------	----------
Educational level***	----------	----------	----------
Occupation****	----------	----------	----------

NOTE: USE SEPARATE SHEET IF NECESSARY.

CODE: *1-MALE 2-FEMALE
**1-FARM OWNER 2-SPOUSE 3-CHILD 4-PARENT 5-GRANDCHILD 6-RELATIVE 7-EMPLOYEE 8-OTHER
*** 1-NONE 2-PRIMARY 1-4 YEARS 3-PRIMARY 5-8 YEARS 4-SECONDARY 1-4 YEARS 5-HIGHER
****1-GOVERNMENT EMPLOYMENT 2-SELF EMPLOYMENT OUTSIDE FARM 3-OTHER EMPLOYMENT OUTSIDE FARM 4-FARMING 5-NOT ECONOMICALLY ACTIVE

C.2 HOUSEHOLD MEMBERS ABSENT FROM FARM FOR AT LEAST TWO MONTHS PRECEDING DATE OF INTERVIEW

Name:	--------	--------	--------	--------
Age:	--------	--------	--------	--------
Sex*:	--------	--------	--------	--------
Relationship with farm owner**:	--------	--------	--------	--------
Educational level***:	--------	--------	--------	--------
Reason for absence$:	--------	--------	--------	--------
Contribution to household income$$:	--------	--------	--------	--------
Residence$$$:	--------	--------	--------	--------
Frequency of visit	--------	--------	--------	--------

NOTE: USE SEPARATE SHEET IF NECESSARY.

D.1 FARM RESOURCES: LAND

Separate plots of land	-----------	-----------	---------
Plot size (acres/ha.)	-----------	-----------	---------
Distance from homestead	-----------	-----------	---------
Mode of acquisition@	-----------	-----------	---------
Adjudicated@@	-----------	-----------	---------
Surveyed@@	-----------	-----------	---------
Registered(title)@@	-----------	-----------	---------

D.2 OTHER FARM RESOURCES

ITEM	QUANTITY	ITEM	QUANTITY
Draught animals	--------	Modern grain store	--------
Ox-plough	--------	Traditional grain store	--------
Ox-cart	--------	Cattle	--------
Wheel-barrow	--------	Goats	--------
Tractor	--------	Poultry	--------
Sheep	--------		

CODE: * 1-MALE 2-FEMALE **1-FARM OWNER 2-SPOUSE 3-CHILD 4-PARENT 5-GRANDCHILD 6-OTHER RELATIVE 7-EMPLOYEE 8-OTHER
***1-NONE 2-PRIMARY 3-SECONDARY AND ABOVE
$ 1-EMPLOYMENT 2-EDUCATION/TRAINING 3-OTHER(SPECIFY)
$$1-YES 2-NO
$$$1-OUTSIDE DISTRICT 2-WITHIN DISTRICT 3-OUTSIDE PROVINCE
@ 1-INHERITANCE 2-PURCHASE 3-TENANCY 4-LEASE 5-OTHER(SPECIFY)
@@ 1-YES 2-NO

D.3 LABOUR USE IN MAIZE CULTIVATION, LONG RAINS-1986

TASK	TYPE OF LABOUR*	LABOUR-SIZE	NO. OF DAYS WORKED
LAND PREPARATION	---------------	------------	-----------
SOWING	---------------	------------	-----------
FERTILIZER APPLICATION	---------------	------------	-----------
WEEDING	---------------	------------	-----------
HARVESTING	---------------	------------	-----------

CODE: * 1-FAMILY LABOUR 2-CASUAL LABOUR 3-PERMANENT LABOUR 4-COMMUNAL LABOUR

D4. TECHNOLOGY AND DATE OF FIELD OPERATIONS IN MAIZE CULTIVATION (LONG RAINS 1986)

1. How many separate fields of maize did you cultivate during the long rains this year?

2. For each of the maize fields, would you provide the following information:

FIELDS	FIELD SIZE	DISTANCE FROM HOME	*IMPLEMENT USED AND HOW ACQUIRED IN: LAND PREPARATION	SOWING	WEEDING
1					
2					
3					
4					

(USE AN EXTRA SHEET IF NECESSARY)

CODE: * 1-HAND IMPLEMENTS 2-OX-PLOUGH (A-OWN B-HIRED C-HELP) 3-TRACTOR (A-OWN B-HIRED C-HELP)

FIELDS	DATE OF LAND PREPARATION	1ST WEEDING	HARVESTING	TOTAL YIELD**
1				
2				
3				
4				

CODE: ** BAGS OF UNSHELLED MAIZE.

3. What mode of transport did you use in:
   (a) transporting farm-yard manure/fertilizer to farm--------
   (b) Transporting maize harvested to farm-------------------

E1. MAIZE FIELD CHARACTERISTICS AND AGRONOMIC PRACTICES

For each of the maize fields you planted during the long rains, would you provide the following additional information:

FIELDS	SEED TYPE PLANTED*	**DATE OF PLANTING	FERTILIZER APPLIED***	INTERCROPPING ****
1				
2				
3				
4				

CODE: * 1-HYBRID 2-LOCAL 3-SECOND GENERATION HYBRID
** ACTUAL/WEEKS AFTER BEGINNING OF FIRST RAINS
*** 1-NONE 2-FARM YARD MANURE 3-COMMERCIAL FERTILIZER
**** 1-PURE STAND 2-INTERCROPPED (specify crops)

E.2* CROPPING HISTORY OF MAIZE FIELDS CULTIVATED-LONG RAINS,1986

FIELDS/ SEASON	1	2	3	4
SHORT RAINS 1985	-------	---------	---------	-------------
LONG RAINS 1985	-------	---------	---------	-------------
SHORT RAINS 1984	-------	---------	---------	-------------
LONG RAINS 1984	-------	---------	---------	-------------

CODE: *1-FALLOW 2-CROPPED (SPECIFY CROP)

E.3 LAND-USE: LONG RAINS 1986.

CROPS OTHER THAN MAIZE	HECTARAGE	PURPOSE*
UNCROPPED LAND		

CODE: * 1-MAINLY FOR SALE
2-MAINLY FOR HOME CONSUMPTION
3-OTHER (SPECIFY)

E.4 FURTHER INFORMATION ON MAIZE CULTIVATION AND LAND-USE - LONG-RAINS 1986.

a. What particular problems did you face during the land preparation period for maize?

b. What reasons do you have for not planting hybrid seed?

c. What reasons do you have for planting maize late after the onset of the first rains?

d. What reasons do you have for not applying fertilizer/manure in your maize fields?

e. Why did you intercrop maize with other crops?

f. Why haven't you put the uncultivated part of your farm to agricultural use?

g. Which specific reasons do you have for locating your maize field(s) where it is/they are?

F.1.A **MAIZE MARKETING 1985**

	LONG RAINS	SHORT RAINS
AMOUNT HARVESTED	----------	-----------
AMOUNT SOLD	----------	-----------
WHERE SOLD	----------	-----------
MODE OF TRANSPORT	----------	-----------
PRICE OFFERED	----------	-----------
TYPE OF BUYER*	----------	-----------
REASON FOR SALE	----------	-----------
AMOUNT BOUGHT	----------	-----------
WHERE BOUGHT	----------	-----------
PRICES PAID	----------	-----------
TYPE OF SELLER*	----------	-----------
REASON FOR PURCHASE	----------	-----------

CODE: * 1-LOCAL COOPERATIVE 2-LOCAL NCPB DEPOT/AGENT 3-FELLOW FARMER 4-TRADER 5-OTHER (SPECIFY)

F.1.B Specify the location and distance from farm of the following:

	LOCATION	DISTANCE FROM FARM (measured in km from base map)
NCPB depot		
NCPB agent		
Cooperative store		
Major local market		
Major motorable road		

F.2 **SERVICES**

(i) From where did you purchase the following:

maize seed ---------------------------

fertilizer ---------------------------
farm implements/
spare parts ---------------------------

(ii) Have you received any credit in the last two years? If yes, specify the following: (IF NO, MOVE TO Q.(iii) BELOW)

Date received	-----------	------------	---------
Amount received	-----------	------------	---------
Source	-----------	------------	---------
Purpose used	-----------	------------	---------

(iii) a. Do you know of any credit institution? Yes/No
b. Have you applied for credit in any institution? Yes/No
c. If no, do you have any reasons for not applying?

Specify---.

(iv) How many times have you been visited by an extension officer this year?------------ What was the purpose for each visit?

DATE	PURPOSE
-----	------------------------------
-----	------------------------------
-----	------------------------------
-----	------------------------------
-----	------------------------------

(v) Which of the following do you rely on mostly for new agricultural information? (Check appropriately)

Neighboring farmers --------------
Local extension Officers' visits --------------
Local chief's baraza --------------
Local F.T.C --------------
Newspapers/magazines --------------
Radio/T.V --------------
Other (specify) --------------

G. MISCELLANEOUS INFORMATION

(i) What are the main problems facing maize farmers in this area?

(ii) What measures do you think should be taken to improve maize production and marketing in this area?

(iii) Would you give a brief history of maize cultivation in this area (date of introduction/who introduced it/when and how it became a major food.)

H. INTERVIEWER' GENERAL COMMENTS

-END-

APPENDIX 2

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MARKET-SURVEY QUESTIONNAIRE

SMALL-HOLDER MAIZE PRODUCTION IN RONGO DIVISION, SOUTH NYANZA DISTRICT.

MARKET/TRADING CENTRE: ------------------------------------
DATE OF INTERVIEW: ------------------------------------

1. Name of trader --
   Sex of trader --
   Age of trader --
2. Residence: same sub-location----------------------
   same location----------------------------
   same division----------------------------
   same district----------------------------
   same province----------------------------
   outside province-------------------------
3. For how many years have you been in the grain trade?-------

4. How much maize did you bring to the market today?----------

5. From where did you get the maize you are selling here?-----

   ----

   ----

5. How much did you pay for the maize you brought to the market today?---

6. At what prices are you selling the maize?------------------

   ----

7. How did you transport the maize to this market?------------

   ----

8. How much did you pay for transporting the maize to this market?---

   ----

9. In which other markets do you sell maize regularly?--------

   ----

10. Do you normally store any maize in this centre at the end of the market day? yes/no. If yes, where do you store the maize and at what cost?--

   ----

11. Which other commodities are you selling together with maize?

----

12. How much were you charged by the market officials before being allowed to sell--

----

-END-

APPENDIX 3: EXPLANATORY VARIABLES FOR REGRESSION ANALYSIS ON MAIZE YIELD (YLD)

VARIABLE NAME	SYMBOL	VARIABLE TYPE	VALUE-LEVEL
1. AGRO-ECOLOGICAL ZONE	GAEZ	CATEGORICAL	1- SUGAR-CANE ZONE 2- MARGINAL SUGAR-CANE ZONE 3- COFFEE ZONE & COFFEE-TEA ZONE
2. AVERAGE ANNUAL RAINFALL	AAR	CATEGORICAL	1- 1600-1800 MM 2- 1400-1600 MM
3. SOIL FERTILITY STATUS	GSOT	CATEGORICAL	1- HIGH 2- MODERATE 3- LOW
4. PLANTING DATE	GDPL	CATEGORICAL	1- JANUARY/EARLIER 2- FEBRUARY 3- MARCH 4- APRIL/LATER
5. FERTILIZER APPLCATION.	GFER	CATEGORICAL	1- FERTILIZER/ MANURE 2- NONE
6. INTERCROPPING	INT	NOMINAL	0- NOT PRACTICED 1- PRACTICED
7. SEED TYPE	GSEE	CATEGORICAL	1- HYBRID SEED ONLY 2- LOCAL SEED ONLY 3- 2nd GENERATION HYBRID SEED ONLY 4- ALL SEED TYPES
8. WEEDING DATE	FWD	CATEGORICAL	1- FEBRUARY/EARLIER 2- MARCH 3- APRIL/LATER
9. LAND PREPARATION DATE	GLPD	CATEGORICAL	1- DECEMBER 1985/EARLIER 2- JANUARY TO FEBRUARY, 1986. 3- MARCH, 1986/LATER

10. CROP ROTATION	CRR	NOMINAL	0- NOT PRACTICED 1- PRACTICED
11. AGE (YEARS)	GAGE	CATEGORICAL	1- YOUNG (18-44) 2- MIDDLE AGE (45-64) 3- OLD (65 & ABOVE)
12. OCCUPATION	GOCC	CATEGORICAL	1- EMPLOYED 2- NOT EMPLOYED
13. SEX	SEX	NOMINAL	0- MALE 1- FEMALE
14. EDUCATION	GEDU	CATEGORICAL	1- NONE 2- PRIMARY 3- SECONDARY & ABOVE
15. RELIGION	GREL	CATEGORICAL	1- SEVENTH-DAY ADVENTIST 2- OTHERS 3- NONE
16. RECEIPT OF REMITTANCES	REM	NOMINAL	0- NO 1- YES
17. EXTENSION CONTACT	EXT	NOMINAL	0- NO 1- YES
18. FARM POPULATION	POP	CONTINUOUS	(EXPRESSED IN NOS.)
19. CREDIT RECIPIENTS	CRE	NOMINAL	0- NO 1- YES
20. FAMILY LABOUR (SIZE)	LAB	CONTINUOUS	(EXPRESSED IN NOS.)
21. USE OF CASUAL LABOUR	CAS	NOMINAL	0- NO 1- YES
22. USE OF COMMU-AL LABOUR	COM	NOMINAL	0- NO 1- YES
23. MAIZE HECTARAGE	HMA	CONTINUOUS	(EXPRESSED IN HECTARES)
24. TOTAL FARM SIZE	FAR	CONTINUOUS	(EXPRESSED IN HECTARES)

25. TOTAL SUGAR -CANE LAND	HSU	CONTINUOUS	(EXPRESSED IN HECTARES)
26. TOTAL COFFEE LAND	HCO	CONTINUOUS	(EXPRESSED IN HECTARES)
27. REGISTRATION OF LAND	REG	NOMINAL	0- NO 1- YES
28. SEPARATE MAIZE FIELDS	NOP	CONTINUOUS	(EXPRESSED IN NOS.)
29. MODE OF LAND ACQUISITION	GACQ	CATEGORICAL	1- INHERITANCE 2- PURCHASE 5- OTHER
30. OWNERSHIP OF TRACTOR AND/OR OX-PLOUGH AND AT LEAST TWO OXEN	OXP	NOMINAL	0- NO 1- YES

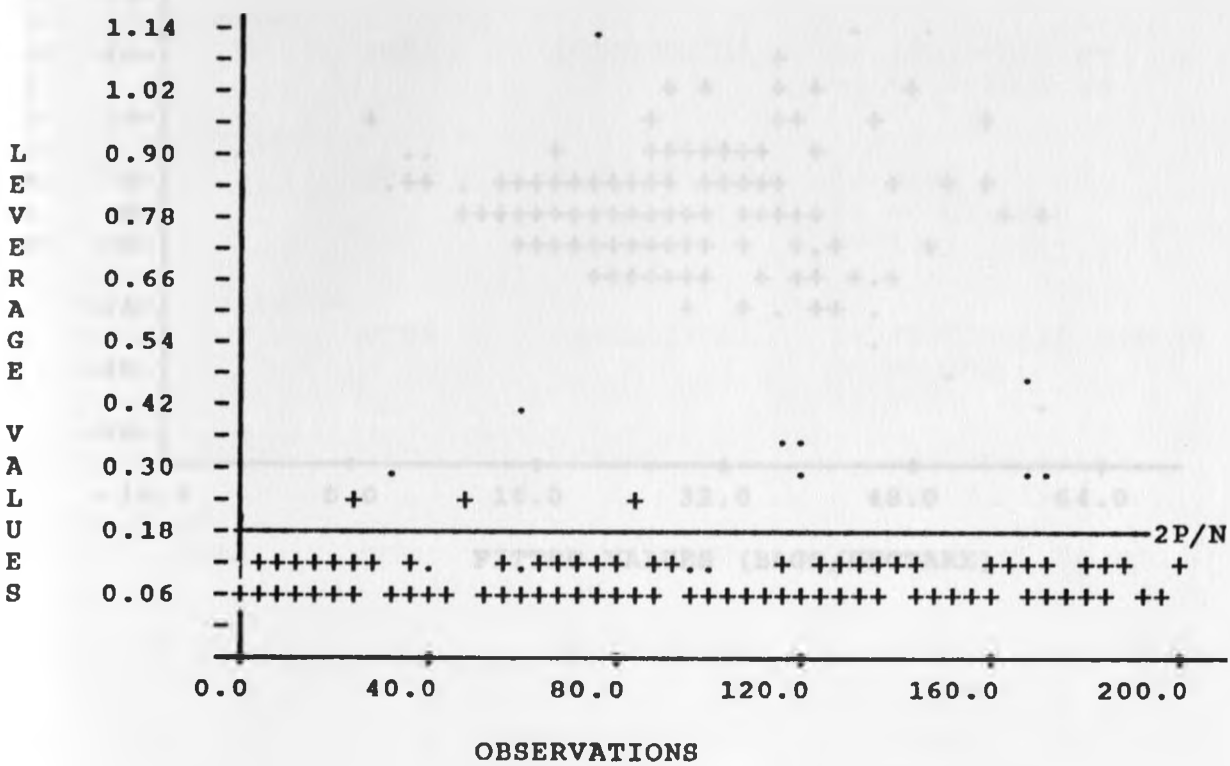
APPENDIX 4 SUMMARY OF MODELS FITTED ON MAIZE YIELD (YLD).

NOTE: SEE APPENDIX 3 FOR FULL NAMES OF THE ACRONYMS.

MODEL	TERMS
NULL	YLD=1
ONE	YLD=1+GAEZ+AAR+GSOT+GDPL+GFER+INT+GSEE+FWD+GLPD+ CRR+GAGE+SEX+GOCC+GEDU+GREL+REM+EXT+CRE+POP+ LAB+CAS+COM+HMA+FAR+HSU+HCO+REG+NOP+GACQ+OXP
TWO	SAME AS MODEL ONE
THREE	YLD=1+GAEZ+AAR+GSOT+INT+GSEE+FWD+GAGE+GEDU+EXT +FAR+HSU+NOP
FOUR	SAME AS MODEL THREE
FIVE	SAME AS MODEL THREE
SIX	YLD=1+HMA+AAR+GAEZ+GSOT+NOP+FWD+INT+HSU+FAR+GSEE +EXT+GAGE+GEDU
SEVEN	YLD=1+HMA+AAR+GAEZ+GSOT+NOP+FWD+INT+HSU+FAR+GSEE +EXT+GAGE+GEDU+AAR.GSOT+AAR.GSEE+GSOT.GSEE +GAGE.GEDU
EIGHT	SAME AS MODEL SEVEN
NINE	SAME AS MODEL SEVEN
TEN	SAME AS MODEL SEVEN
ELEVEN	YLD=1+HMA+AAR+GAEZ+GSOT+NOP+FWD+INT+HSU+FAR+GSEE

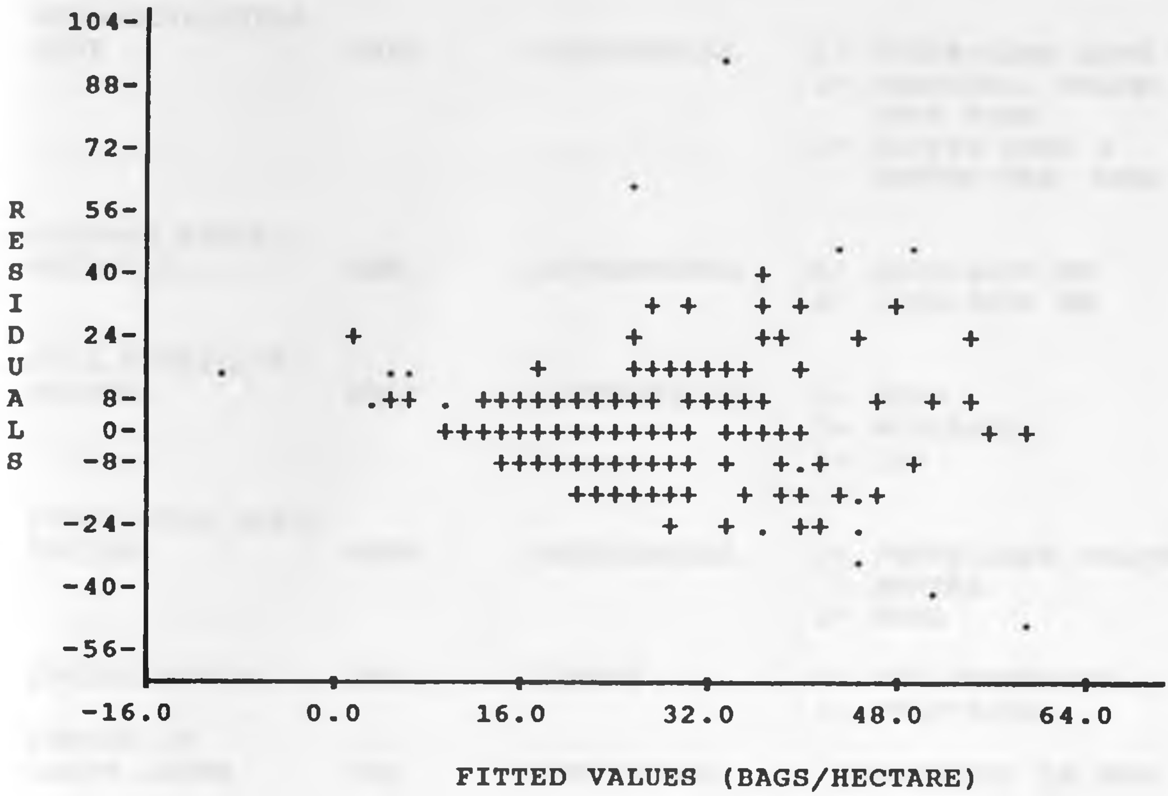
APPENDIX 5 - PLOT OF LEVERAGE VALUES FOR FINAL REGRESSION MODEL ON MAIZE YIELD.

(POINTS WEIGHTED OUT ARE REPRESENTED BY (.))



APPENDIX 6 - PLOT OF RESIDUALS FOR FINAL MODEL ON MAIZE YIELD.

NOTE: POINTS WEIGHTED OUT ARE REPRESENTED BY PERIOD (.)



APPENDIX 7 - EXPLANATORY VARIABLES FOR REGRESSION ANALYSIS ON MAIZE HECTARAGE (HMA)

VARIABLE NAME	SYMBOL	VARIABLE TYPE	VALUE-LEVEL
1. AGRO-ECOLOGICAL ZONE	GAEZ	CATEGORICAL	1- SUGAR-CANE ZONE 2- MARGINAL SUGAR-CANE ZONE 3- COFFEE ZONE & COFFEE-TEA ZONE
2. AVERAGE ANNUAL RAINFALL	AAR	CATEGORICAL	1- 1600-1800 MM 2- 1400-1600 MM
3. SOIL FERTILITY STATUS	GSOT	CATEGORICAL	1- HIGH 2- MODERATE 3- LOW
4. FERTILIZER APPL-CATION.	GFER	CATEGORICAL	1- FERTILIZER AND/OR MANURE 2- NONE
5. INTERCROPPING	INT	BINARY	0- NOT PRACTICED 1- PRACTICED
6. NUMBER OF CROPS GROWN	CGR	CONTINUOUS	(EXPRESSED IN NOS.)
7. SEED TYPE	GSEE	CATEGORICAL	1- HYBRID SEED ONLY 2- LOCAL SEED ONLY 3- SECOND GENERATION HYBRID SEED ONLY 4- ALL SEED TYPES
8. LAND PREPARAT-ION DATE	GLPD	CATEGORICAL	1- DECEMBER/EARLIER 2- JANUARY/FEBRUARY 3- MARCH/LATER
9. CROP ROTATION	CRR	BINARY	0- NOT PRACTICED 1- PRACTICED
10. AGE (YEARS)	GAGE	CATEGORICAL	1- YOUNG (18-44) 2- MIDDLE AGE (45-64) 3- OLD (65 & ABOVE)

11.	OCCUPATION	GOCC	CATEGORICAL	1- EMPLOYED 2- NOT EMPLOYED
12.	SEX	SEX	BINARY	0- MALE 1- FEMALE
13.	EDUCATION	GEDU	CATEGORICAL	1- NONE 2- PRIMARY 3- SECONDARY AND ABOVE
14.	RELIGION	GREL	CATEGORICAL	1- S.D.A 2- OTHERS 3- NONE
15.	PRESENCE OF FARM OWNER	OWN	BINARY	0- ABSENT 1- PRESENT
16.	RECEIPT OF REMITTANCES	REM	BINARY	0- NO 1- YES
17.	EXTENSION CONTACT	EXT	BINARY	0- NO 1- YES
18.	TOTAL FARM SIZE	FAR	CONTINUOUS	(EXPRESSED IN HECTARES)
19.	OWNERSHIP OF A TRACTOR/ AN OX-PLOUGH AND AT LEAST TWO OXEN	OXP	BINARY	0- NO 1- YES
20.	FARM POPULATION	POP	CONTINUOUS	(EXPRESSED IN NOS.)
21.	CREDIT RECIPIENTS	CRE	BINARY	0- NO 1- YES
22.	USE OF CASUAL LABOUR	CAS	BINARY	0- No 1- YES
23.	USE OF COMMU- AL LABOUR	COM	BINARY	0- NO 1- YES
24.	SUGAR HECTARAGE	HSU	CONTINUOUS	(EXPRESSED IN HECTARES)
25.	TOTAL COFFEE LAND	HCO	CONTINUOUS	(EXPRESSED IN HECTARES)
26.	NUMBER OF FARMS	NOF	CONTINUOUS	(EXPRESSED IN NOS.)

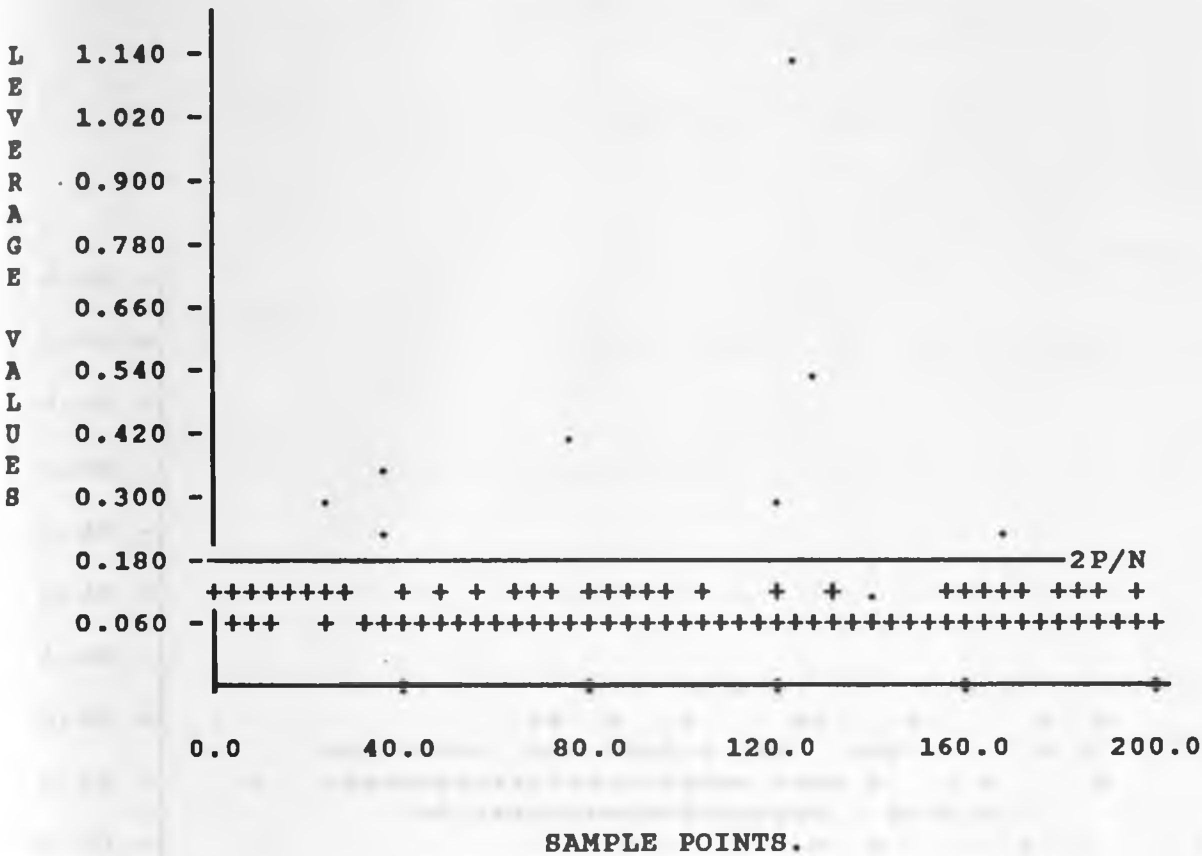
27. REGISTRATION OF LAND	REG	BINARY	0- NO 1- YES
28. NUMBER OF SEPARATE MAIZE FIELDS	NOP	CONTINUOUS	(EXPRESSED IN NOS.)
29. MODE OF LAND ACQUISITION	GACQ	CATEGORICAL	1- INHERITANCE 2- PURCHASE 3- OTHER
30. INTERACTION EFFECT BETWEEN NUMBER OF MAIZE FIELDS AND OX-PLOUGH OWNERSHIP	NOX		
31. INTERACTION EFFECT BETWEEN NUMBER OF MAIZE FIELDS AND PRESENCE OF FARM OWNER	NOW		
32. INTERACTION EFFECT BETWEEN PRESENCE OF FARM OWNER AND OX-PLOUGH OWNERSHIP	OOX		
33. INTERACTION EFFECT BETWEEN LENGTH OF FALLOW PERIOD AND OX-PLOUGH OWNERSHIP	OXF		
34. INTERACTION EFFECT BETWEEN FARM SIZE AND NUMBER OF MAIZE FIELDS	NFA		

APPENDIX 8 - SUMMARY OF MODELS FITTED ON MAIZE HECTARAGE (HMA)
NOTE: SEE APPENDIX 7 FOR KEY TO THE ACRONYMS.

MODEL	TERMS
NULL	HEC=1
ONE	HEC=1+GAEZ+AAR+GSOT+GFER+INT+FAL+CGR+GSEE+GLPD+CRR+GAGE +SEX+GEDU+GOCC+GREL+OWN+REM+FAR+OXP+CRE+POP+CAS +COM+HSU+HCO+NOF+GACQ+NOP+REG
TWO	SAME AS MODEL ONE
THREE	HEC=1+GAEZ+GSOT+FAL+GSEE+GLPD+GEDU+OWN+FAR+OXP+HCO+NOF +NOP
FOUR	SAME AS MODEL THREE
FIVE	SAME AS MODEL THREE
SIX	HEC=1+NOP+GLPD+GSOT+FAR+GAEZ+GSEE+OWN+HCO+OXP+FAL+GEDU+ NOF
SEVEN	SAME AS MODEL SIX
EIGHT	HEC=NOP+GLPD+GSOT+FAR+GAEZ+GSEE+OWN+HCO+OXP+FAL+GEDU
NINE	HEC=1+NOP+GLPD+GSOT+FAR+GAEZ+GSEE+OWN+HCO+OXP+FAL
TEN	HEC=1+NOP+GSOT+GLPD+GAEZ+FAR+GSEE+OWN+HCO+OXP+FAL
ELEVEN	HEC=1+NOP+GSOT+GLPD+GAEZ+FAR+GSEE+OWN+HCO+OXP+FAL+NFA +NOW+NOX+OOX+OXF+NOP.GSOT+GSOT.GSEE+GAEZ+HCO +GSOT.OXP+GSOT.FAL
TWELVE	HEC=1+NOP+GSOT+GLPD+GAEZ+FAR+GSEE+OWN+HCO+OXP+FAL+NFA +NOX+OXF+NOP.GSOT+GSOT.GSEE+GSOT.FAL
THIRTEEN	HEC=1+NOP+GSOT+GLPD+GAEZ+FAR+GSEE+OWN+HCO+OXP+FAL+NFA +NOX+OXF+NOP.GSOT+GSOT.GSEE
FOURTEEN	HEC=1+NOP+GSOT+GLPD+GAEZ+FAR+GSEE+OWN+HCO+OXP+FAL+NOX +NOP.GSOT
FIFTEEN	HEC=1+NOP+GSOT+GLPD+GAEZ+FAR+GSEE+OWN+HCO+OXP+FAL+NOX +NOP.GSOT+GSOT.FAL
SIXTEEN	HEC=1+NOP+GSOT+GLPD+GAEZ+FAR+GSEE+OWN+HCO+OXP+FAL+NOX +GSOT.FAL
SEVENTEEN	HEC=1+NOP+GSOT+GLPD+GAEZ+FAR+GSEE+OWN+HCO+OXP+FAL+NOX
EIGHTEEN	HEC=NOP+GLPD+GSOT+FAR+GAEZ+GSEE+OXP+HCO+OWN+FAL+NOX

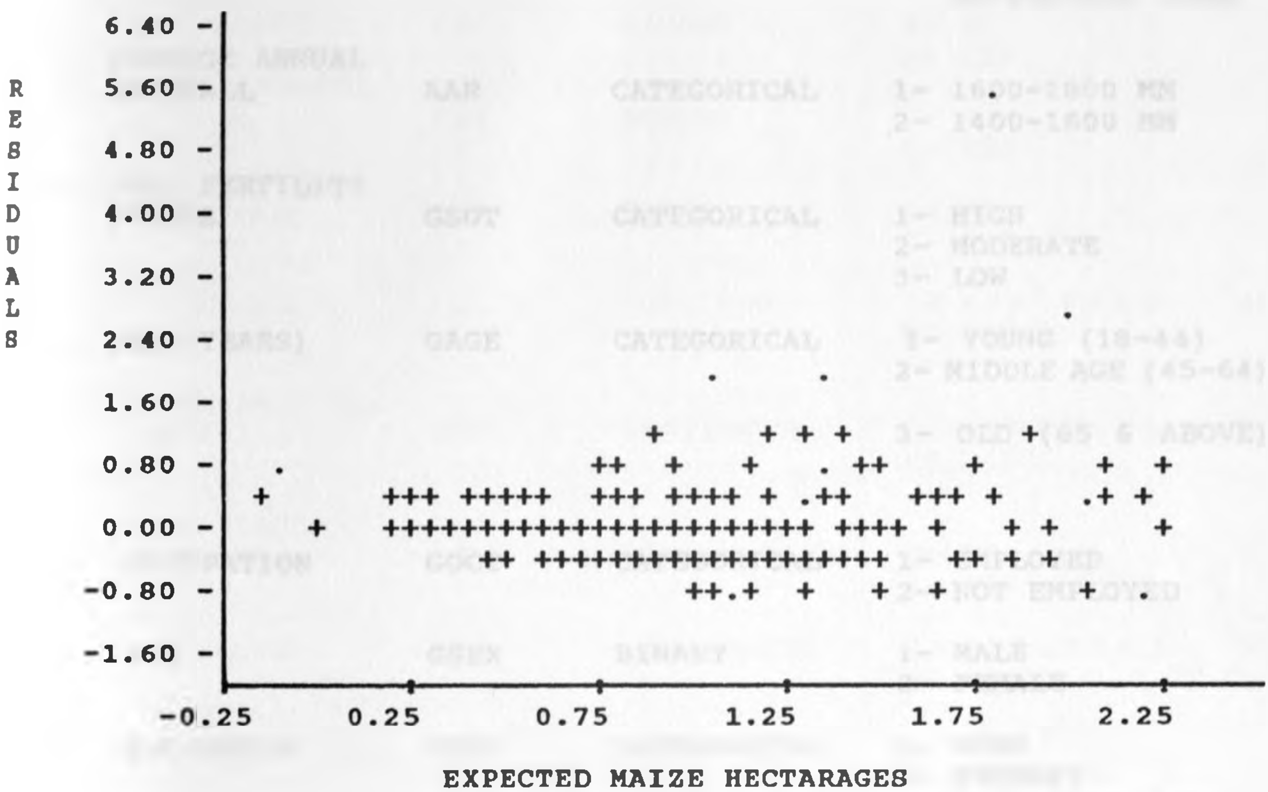
APPENDIX 9 - PLOT OF LEVERAGE VALUES - FINAL MODEL ON MAIZE HECTARAGE.

[UNITS WEIGHTED OUT (.)]



APPENDIX 10 - PLOT OF RESIDUALS-FINAL MODEL ON MAIZE HECTARAGE.

[UNITS WEIGHTED OUT (.)]



APPENDIX 11 - EXPLANATORY VARIABLES FOR REGRESSION ANALYSIS ON ADOPTION OF INNOVATIONS.

VARIABLE NAME	SYMBOL	VARIABLE TYPE	VALUE-LEVEL
1. AGRO-ECOLOGICAL ZONE	GAEZ	CATEGORICAL	1- SUGAR-CANE ZONE 2- MARGINAL SUGAR-CANE ZONE 3- COFFEE ZONE & COFFEE-TEA ZONE
2. AVERAGE ANNUAL RAINFALL	AAR	CATEGORICAL	1- 1600-1800 MM 2- 1400-1600 MM
3. SOIL FERTILITY STATUS	GSOT	CATEGORICAL	1- HIGH 2- MODERATE 3- LOW
4. AGE (YEARS)	GAGE	CATEGORICAL	1- YOUNG (18-44) 2- MIDDLE AGE (45-64) 3- OLD (65 & ABOVE)
5. OCCUPATION	GOCC	CATEGORICAL	1- EMPLOYED 2- NOT EMPLOYED
6. SEX	GSEX	BINARY	1- MALE 2- FEMALE
7. EDUCATION	GEDU	CATEGORICAL	1- NONE 2- PRIMARY 3- SECONDARY AND ABOVE
8. RELIGION	GREL	CATEGORICAL	1- S.D.A 2- OTHERS 3- NONE
9. PRESENCE OF FARM OWNER	OWN	BINARY	0- ABSENT 1- PRESENT
10. EXTENSION CONTACT	EXT	BINARY	0- NO 1- YES

11. TOTAL FARM SIZE	FAR	CONTINUOUS	(EXPRESSED IN HECTARES)
12. OWNERSHIP OF A TRACTOR/ AN OX-PLOUGH AND AT LEAST TWO OXEN	OXP	BINARY	0- NO 1- YES
13. FARM POPULATION	POP	CONTINUOUS	(EXPRESSED IN NOS.)
14. CREDIT RECIPIENTS	CRE	BINARY	0- NO 1- YES
15. USE OF CASUAL LABOUR	CAS	BINARY	0- No 1- YES
16. USE OF COMMU-AL LABOUR	COM	BINARY	0- NO 1- YES
17. SUGAR HECTARAGE	HSU	CONTINUOUS	(EXPRESSED IN HECTARES)
18. TOTAL COFFEE LAND	HCO	CONTINUOUS	(EXPRESSED IN HECTARES)
19. REGISTRATION OF LAND	REG	BINARY	0- NO 1- YES
20. MAIZE HECTARAGE	HMA	CONTINUOUS	(EXPRESSED IN HECTARES)
21. HECTARAGE UNDER DROUGHT RESISTANT CROPS	DROT	CONTINUOUS	(EXPRESSED IN HECTARES).
22. NO. OF WHEEL BARROWS OWNED	WLB	CONTINUOUS	(EXPRESSED IN NUMBERS)
23. DISTANCE TO NEAREST ADOPTER OF HYBRID ALONE OR IN COMBINATI-ON WITH OTHER SEEDS.	HYSK	CONTINUOUS	(EXPRESSED IN KILOMETRES.)
24. DISTANCE TO THE NEAREST MARKET	DSMK	CONTINUOUS	(EXPRESSED IN KILOMETRES)

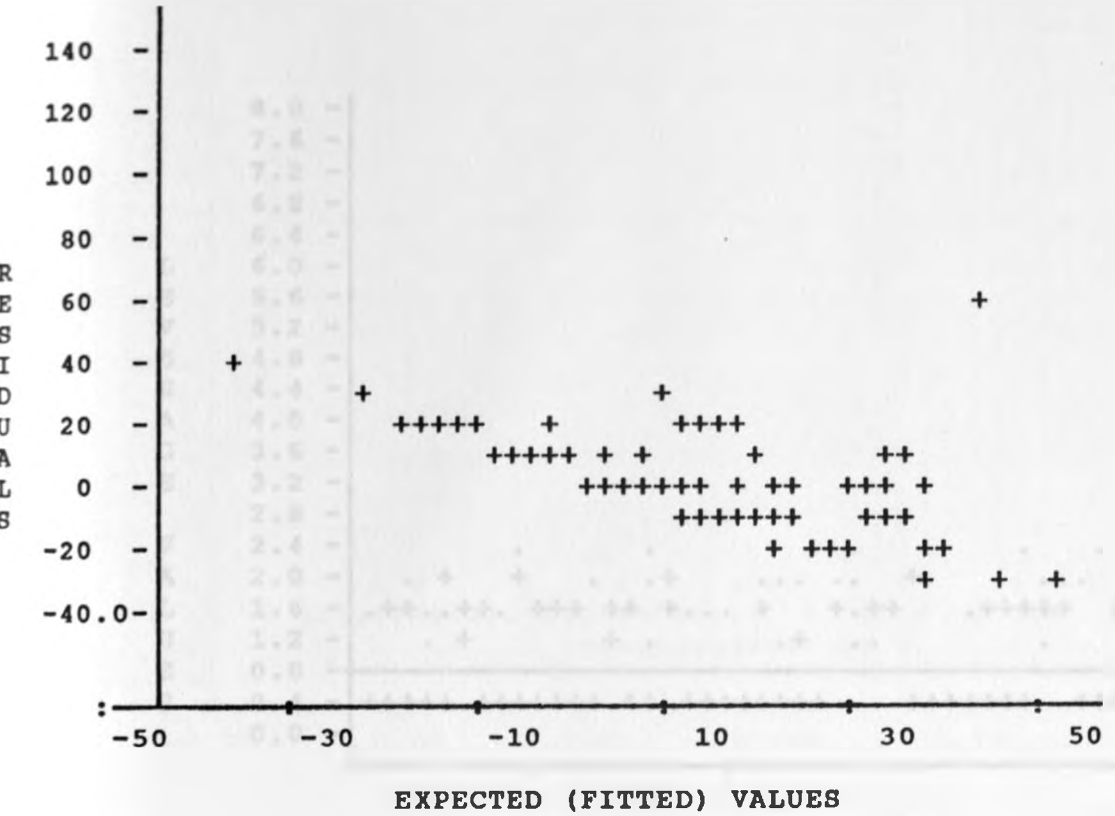
25. DISTANCE TO THE NEAREST ROAD	DSRK	CONTINUOUS	(EXPRESSED IN KILOMETRES)
26. RELIANCE ON NEIGHBOURS FOR AGRICULTURAL INFORMATION	INN	BINARY	0 - NO 1 - YES
27. RELIANCE ON VILLAGE BARAZAS FOR AGRICULTURAL INFORMATION	INB	BINARY	0 - NO 1 - YES
28. KNOWLEDGE OF CREDIT INSTIT-UTIONS	KNC	BINARY	0 - NO 1 - YES
29. DISTANCE TO NEAREST ADOPTER OF MANURE/FERT-ILIZER	MOFK	CONTINUOUS	(EXPRESSED IN KILOMETRES)
30. TOTAL NUMBER OF FARM ANIMALS	ANI	CONTINUOUS	(EXPRESSED IN NUMBERS)
31. NUMBER OF OX-CARTS OWNED	OXC	CONTINUOUS	(EXPRESSED IN NUMBERS)
32. DISTANCE TO NEAREST ADOPTER OF HYBRID SEED/ MANURE OR FERT-ILIZER COMBINED	HYPK	CONTINUOUS	(EXPRESSED IN NUMBERS)

APPENDIX 12: EXPLANATORY VARIABLES FOR REGRESSION ANALYSIS ON AMOUNT OF MAIZE SOLD

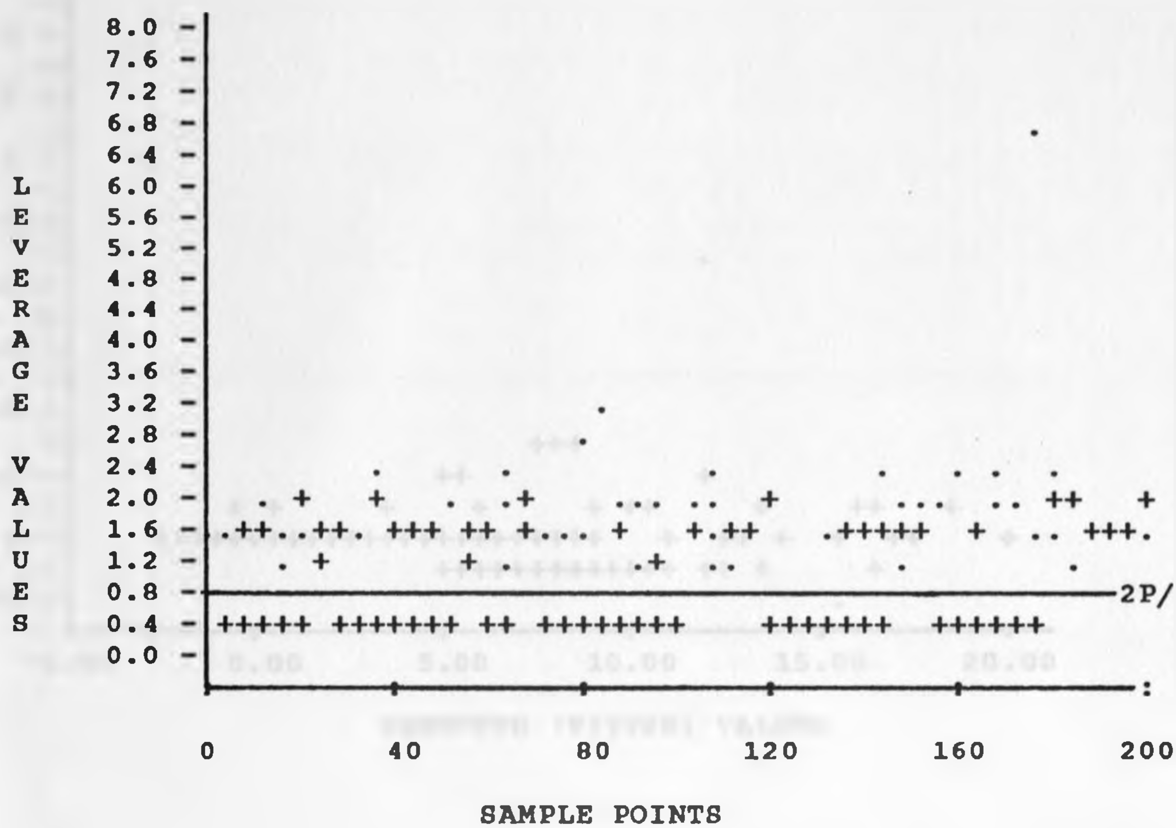
VARIABLE NAME	SYMBOL	VARIABLE TYPE	VALUE-LEVEL
1. AVERAGE ANNUAL RAINFALL	AAR	CATEGORICAL	1- 1600-1800 MM 2- 1400-1600 MM
2. SOIL FERTILITY STATUS	GSOT	CATEGORICAL	1- HIGH 2- MODERATE 3- LOW
3. AGE	GAGE	CATEGORICAL	1-YOUNG 2-MIDDLE AGE 3-OLD
4. SEX	GSEX	CATEGORICAL	1- MALE 2- FEMALE
5. OCCUPATION	GOCC	CATEGORICAL	1- EMPLOYED 2-NOT EMPLOYED
6. RELIGION	GREL	CATEGORICAL	1- S.D.A 2- OTHERS 3- NONE
7. FARM POPULATION	POP	CONTINUOUS	NUMBERS
8. GROSS MAIZE YIELD	GYL	CONTINOUS	90 KG. BAGS OF UNSHELLED MAIZE
9. AMOUNT OF MAIZE BOUGHT	MBOT	COMTINOUS	90 KG. BAGS OF SHELLED MAIZE
10. CASH-CROP HECTARAGE	CASH	CONTINOUS	HECTARES
11. CEREALS HECTARAGE	CER	CONTINOUS	HECTARES
12. TOTAL FARM SIZE	FAR	CONTINUOUS	HECTARES
13. MAIZE HECTARAGE	HMA	CONTINUOUS	HECTARES

14. OWNERSHIP OF OX-PLOUGH WITH AT LEAST TWO OXEN/TRACTOR	OXP	BINARY	0- NO 1- YES
15. POSEESSION OF WHEEL-BARROW	WLB	CONTINOUS	NUMBERS
16. MARKETING CHANNEL USED IN MAIZE SALE	MKCS	CATEGORICAL	1-FELLOW FARMER 2-LOCAL TRADER 3-LOCAL COOPERATIVE 4-LOCAL NCPB 5-1&2 6-1&4 7-1,2&3 8-NONE SELLERS
17. DISTANCE TO NEAREST MARKET	DSMK	CONTINOUS	KILOMETRES
18. DISTANCE TO NEAREST ROAD	DSRK	CONTINOUS	KILOMETRES
19. POSSESSION OF OX-CART	OXC	BINARY	0-NO 1-YES
20. TRADITIONAL GRAIN STORES	GST	CONTINOUS	NUMBERS
21. MODERN GRAIN STORES	GSM	CONTINOUS	NUMBERS

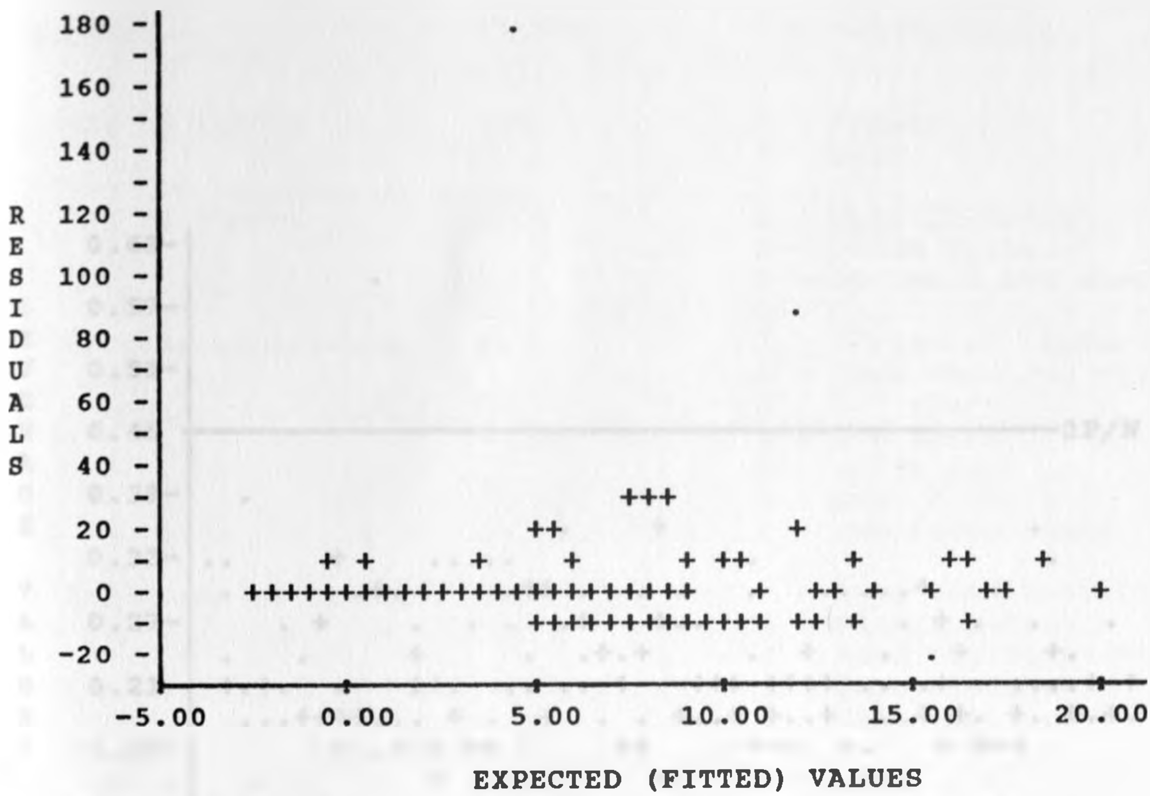
APPENDIX 13 - PLOT OF RESIDUALS FOR MODEL ONE - AMOUNTS OF MAIZE SOLD



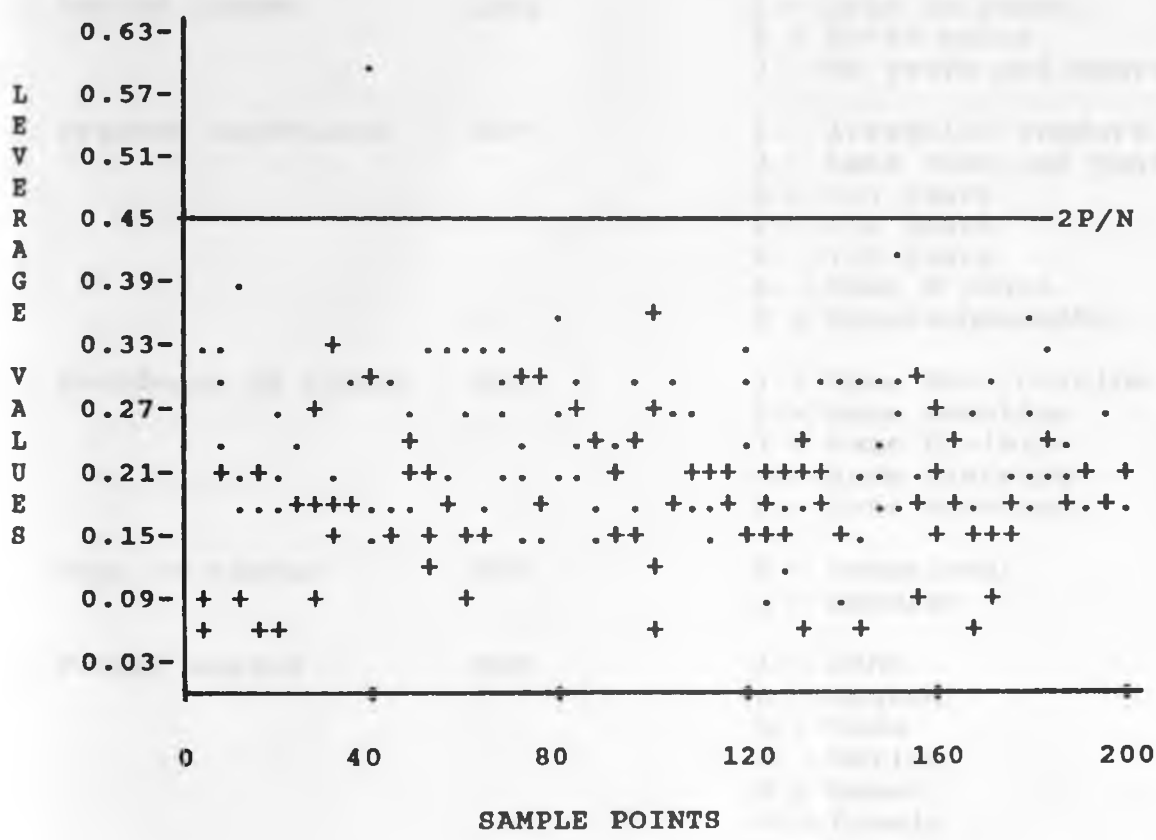
APPENDIX 14 - PLOT OF LEVERAGE VALUES - MODEL ONE - AMOUNTS OF MAIZE SOLD (UNITS WEIGHTED OUT (.))



APPENDIX 15 - PLOT OF RESIDUALS - MODEL FOUR - AMOUNT OF MAIZE SOLD [UNITS WEIGHTED OUT (.)]



APPENDIX 16 - PLOT OF LEVERAGE VALUES - MODEL FOUR - AMOUNT OF MAIZE SOLD [UNITS WEIGHTED OUT (.)]



APPENDIX 17 LIST OF EXPLANATORY VARIABLES FOR REGRESSION ANALYSIS ON QUANTITY OF MAIZE HANDLED AND MAIZE PRICES.

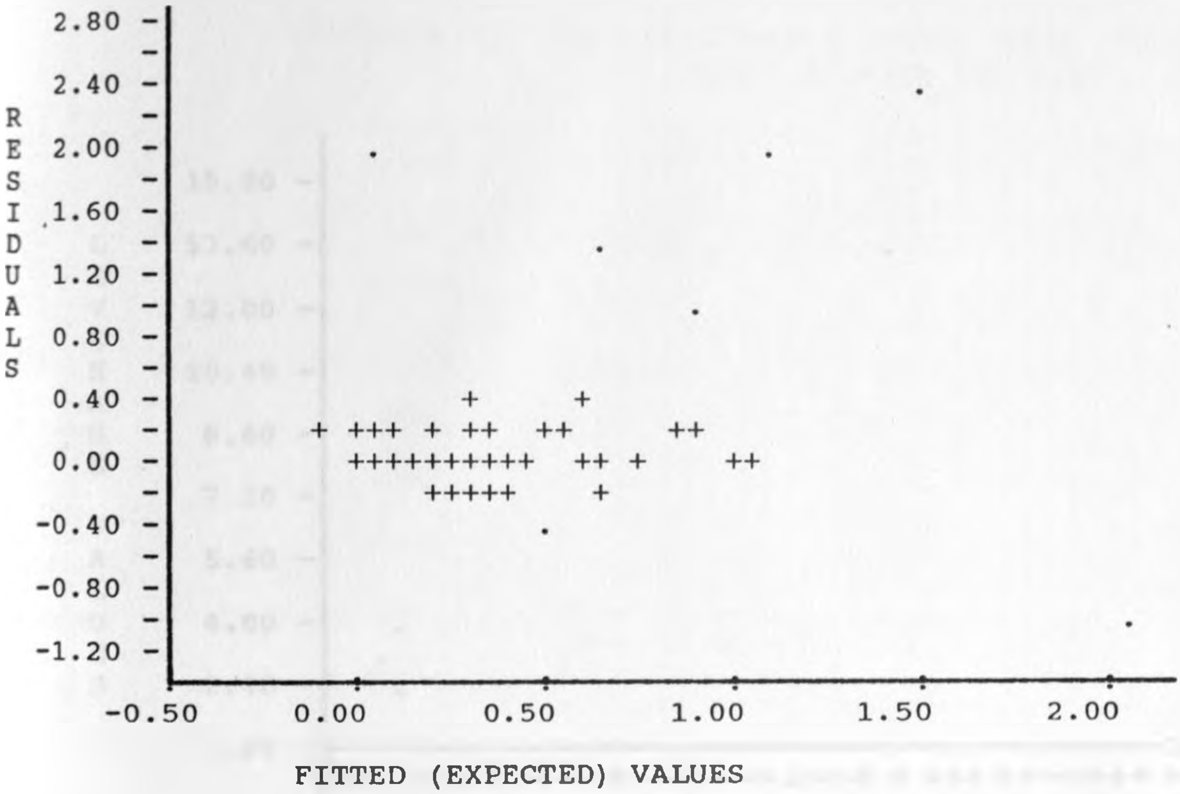
NOTE: ASTERISKS DENOTE DEPENDENT VARIABLES.

VARIABLE	SYMBOL	CATEGORIES/UNITS
1. Sex of trader	SEX	0 - Female 1 - Male
2. Age of trader	GAGE	1 - Upto 29 years 2 - 30-49 years 3 - 50 years and above
3. Traders experience	EXP	1 - Irregular traders 2 - Less than one year 3 - 1-3 years 4 - 4-6 years 5 - 7-9 years 6 - Over 9 years 7 - Non-respondents
4. Residence of trader	RES	1 - Same Sub-location 2 - Same Location 3 - Same Division 4 - Same District 5 - Same Province
5. Type of trader	TYP	0 - Occasional 1 - Regular
6. Market served	MAK	1 - Otho 2 - Angaga 3 - Dede 4 - Mariwa 5 - Ranen 6 - Riosir 7 - Rongo 8 - Awendo
7. Communication links of a market with other markets (rank)	COM	1 - Good (Rongo, Ranen & Awendo) 2 - Fair (Mariwa, Riosir & Dede) 3 - Poor (Angaga & Otho)
8. Size of market	SIZ	1 - Small 2 - Medium 3 - Large
9. Distance of market to nearest market	DSMK	Expressed in Kilometres.

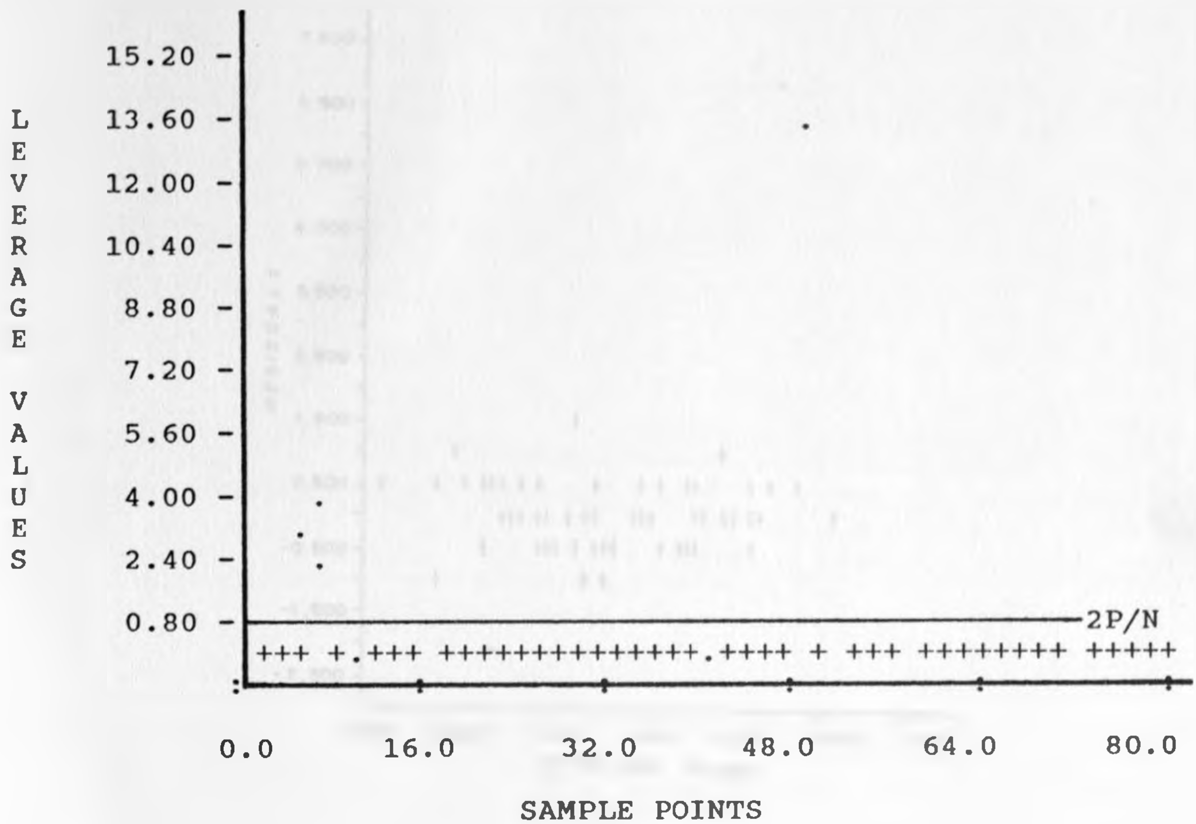
10.	Source of maize supply	SSP	1 - Own farm 2 - Local farmers 3 - Within same market 4 - Other markets
11.	Transport mode used	TRA	1 - None 2 - Human 3 - Animal 4 - Motor
12.	Number of markets visited	NMK	Expressed in numbers.
13.	Number of other commodities handled	NCO	Expressed in numbers.
14.	Use of storage storage facilities	STO	0 - No 1 - Yes
15.	Price at which maize was bought	BUY	Shillings per 2kg. tin
16.	Price at which maize was sold	SEL*	Shillings per 2kg. tin
17.	Transport costs	TCO	Kenya Shillings.
18.	Distance of market from sugar plantation	DSSK	Expressed in Kilometres.
19.	Profit margins	PROF	Expressed in Kenya Shillings.
20.	Quantity of maize handled	MAI	Expressed in number of 90 kilogramme bags.

APPENDIX 18 - PLOT OF RESIDUALS - MODEL FOUR-

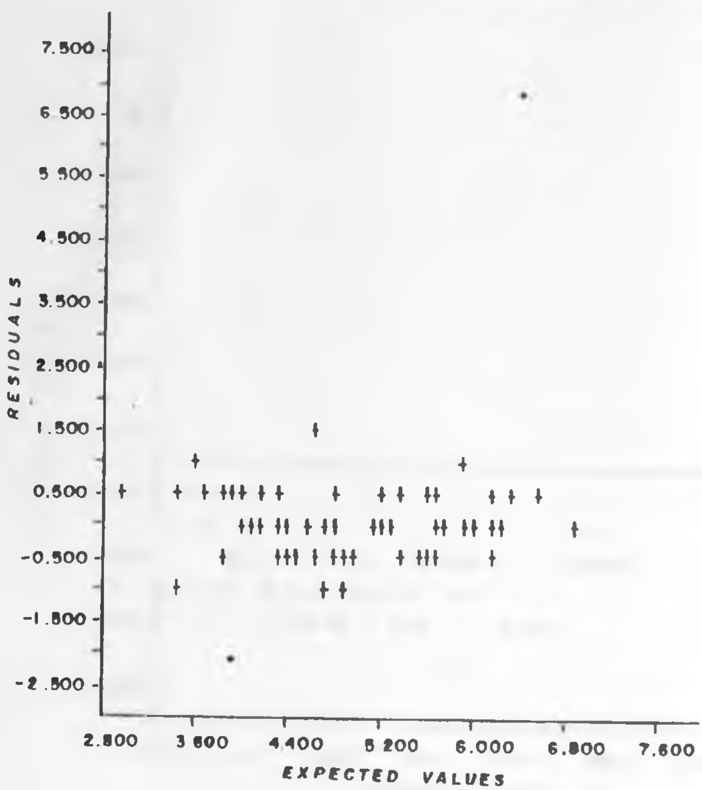
QUANTITIES OF MAIZE HANDLED [UNITS WEIGHTED OUT (.)]



APPENDIX 19 - PLOT OF LEVERAGE VALUES - MODEL FOUR - QUANTITIES OF MAIZE HANDLED (UNITS WEIGHTED OUT(.))



APPENDIX 20 : PLOT OF RESIDUALS – MODEL THREE – MAIZE PRICES
(UNITS WEIGHTED OUT (•))



APPENDIX 21 : LEVERAGE PLOT - MODEL THREE - MAIZE PRICES (UNITS WEIGHTED OUT (•))