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NYERI FARMING SYSTEMS VIEWED FROM PHYSICAL AND SOCIO-ECONOMIC ASPECTS

BY

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A THESIS SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF MASTER OF ARTS IN ECONOMIC GEOGRAPHY IN THE UNIVERSITY OF NAIROBI

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ABSTRACT

This study aims at making a detailed analysis of the physical and socio-economic aspects in relation to the small-holder farming systems in Nyeri district. The presentation of the physical factors is limited to the examination of the natural environmental factors namely; climate, soils, and land surface configuration. On the other hand, the socio-economic factors focus on certain salient features of the Nyeri farming community and how it relates to land use, which include, inter alia, the background of the farmers and their family organisation. The major inputs of land and labour are examined as well as other inputs such as capital, implements, fertilizer and chemical sprays. Institutional attributes such as accessibility to credit, product market opportunities, exposure to information through extension services and farmer training institutes, and so on, are also examined.

It is proper that a topic such as "Nyeri Farming Systems viewed from physical and socio-economic aspects" should be examined at this time, when Kenya is facing multiple challenges of rapid population growth rates, diminishing land productivity, inadequate food supply, insufficient rural and urban income generating activities and deteriorating foreign exchange reserves. It is again at this particular time that the Government of Kenya has implemented a major policy shift in the National development planning from the former centralized decision making framework to a decentralized district focussed approach. This study is therefore relevant in time and space to the National economic development needs, its attention having been focussed at the district level.

The general objective of this study was to examine some physical and socio-economic characteristics that act as potentials and/or constraints to small-holder agricultural development, with particular emphasis on Nyeri district.Specifically, the study was to investigate into the influences of soils, climate and the land surface configuration on the farming systems, and also to analyse farm production and productivity of the principal farm enterprises; namely; cash crops, food crops and the animal husbandry sector.

The study's hypotheses are investigated on the basis of an intensive socio-economic survey based on 166 small-holder farmers in Nyeri district. By means of statistical analysis the key variables that influence agricultural production are identified.The following variables were hypothesized to have significant contribution to level of agricultural production performance; 1.farm size, 2. distance to the nearest market centre, 3.availability of credit/loans, 4.farmer's period of experience on the farm, 5. frequency of agricultural extension visits, and 6. frequency of attendance to farmer training centre.

The study methodology which involved a thorough primary and secondary data collection and its subsequent analysis, was found suitable for this study because; the multi-stage sampling procedure that was used in data collection has the single advantage of leading to substantial savings in research costs, while still maintainig the merit of yielding a representative and unbiased sample.

According to the objectives and the subsequent hypotheses advanced in this study, it was established that: 1. Rainfall, its distribution and reliability, soils, land surface configurations, and variations in temperatures offer, to varying degrees, certain limitations to plant growth and are therefore important factors in determining the existence of a farming system. 2. The indigenous knowledge of the farmers on farming activities is an important attribute that should always be considered when planning for the agricultural sector. 3. The existing agricultural extension personnel is inadequate to offer an appreciable coverage of the many small-holder farmers in the district, which is a major constraint to development of better farm management techniques. 4. Besides other infrastructural facilities, the development of better roads and easily accessible markets would give a great boost to agricultural production in the district. 5. Lack of loanable funds from both private and public money lending institutions is a major constraint limiting agricultural development on the small-holder farms. 6. The sizes of the farms, though they do not appear to result in noticeable economic differentiation, are a major limitation to application of capital intensive technology and also are a key disincentive to financing agencies.Thus, if agricultural production on the small-holder farms is to be increased, it appears that more attention needs to be paid to other sources of loanable funds.

In summary the main problems affecting agricultural development in Nyeri can be grouped into three; 1. those originating from the natural physical and biological environment, and therefore the farmer has no control over them ,for example, rainfall, its amount and distribution. 2. Institutional constraints that is, the procedures and technical requirements that pre-empt the opportunities of the small-holder farmers to avail themselves farm inputs and other services. 3. Endogenous constraints- for example, scarcity of labour, land scarcity and insufficient technical know-how.

The overall policy implications of our research findings are that planners in both the Government and Non-Government institutions need to recognise the various characteristics embodied in different farming systems, and thus develop policy guidelines that will encourage a more efficient use of land resources. Since the Kenya Government's National objective is to alleviate rural and urban poverty, then the Government should aim at assisting and promoting those activities that support capital formation in the agricultural sector, These may include increased land productivity and external sources of earnings.Similarly, greater attention should be paid on the intensification of agricultural production, through extended teachings on new and better methods of farm management. The Government and its people should aim at seeking alternative avenues for employment, to relieve the land the existing population pressure.

In its concluding remarks, the study has recommended further lines of research that could help not only to bridge the gaps left by the current study, but also that will highlight some planning policies that will link research work into the wider areas of National economic and resource planning.Due to the Government concern over the rising costs of purchased agricultural inputs, poor farming techniques, that have resulted in massive soil erosion, and the low returns per unit of input, it is recommended that: a further study be conducted that will identify locally available organic or inorganic materials that could be used in place of imported fertilizers and insecticides. Also recommended is a study into better farming methods that will curb the rate of soil loss and an investigation into better animal fodder and the development of zero-grazing systems.

Finally, the major conclusions that emerge out of this study indicate that the small-holder farmers in Nyeri district are capable of producing more food and cash income that would go a long way in alleviating hunger and poverty in the rural areas, but their full potential is rarely realized due to lack of adequate support services. If progress will ever be realized in this sector, therefore,more research and finance will have to be channelled into this sector.

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CHAPTER ONE

STATEMENT OF THE RESEARCH PROBLEM

The central premise of this study is that a detailed analysis of the current smallholder farming systems in Nyeri District from a physical and socio-economic viewpoint, is an important step in understanding the prevalent smallholder farm production potentials and constraints. This study has therefore, briefly examined some of these factors in order to assist us in drawing meaningful conclusions on the effect such may have on the variations in farm enterprise production levels within the smallholder farm sector.

The study also examines the institutional support services extended to the smallholder farmers *vis-a-vis* the capacity to harness them within a whole spectrum of other constraints. It is hoped that the emergent understanding will encourage further research and influence planners and investors into a direction that will gainfully support this important sector of the Kenyan economy.

The fundamental importance of smallholder agricultural sector has been expressed in a wide literature. This sector dominates the economic lives of about

80%[1] of the rural population. Yet, detailed knowledge about the large variation of these production systems and their respective economics has been scarce.

Considerable attention, however, is currently being given to improving production and living conditions of the majority living in the rural areas, as stipulated in the 1979/83 Development Plan and the National Food Policy Paper No. 4 of 1981. This has come in the wake of greatly increased interest in higher food production, stemming from recent food shortages and bleak production forecasts. It is partly due to these reasons that there arises an immediate need to examine and evaluate possible avenues through which food production among smallholder farming systems may be enhanced.

The term farming systems is somewhat confusing and has been the object of many discussions, definitions, and papers. In this study, the definition given by Shaner , W.W. (1982) is used, since it seems to be more encompassing. To quote,

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1 Central Bureau of Statistics (1980) Nairobi

"Farming Systems has been seen to mean: a unique and reasonably stable arrangement of farming enterprises (crops and/or animals) that the household manages according to well-defined practices in response to physical, biological, socio-economic and institutional envrionments, and in accordance with the household's goals, preferences and resources"[1]. This definition, therefore, incorporates all those characteristics that dominate farmer circumstances, excluding any processes beyond that normally performed on the farm.

While in the technically advanced countries, the decisions of a farmer may not be unduly influenced by the physical attributes of land, the ecological element is a dominant factor in pre-scientific societies[2]. The nature and type of farm operations therefore depend largely on ecological conditions and the level of technology. Thus, the two aspects could be useful criteria for identifying the potentials

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1. Shanner, W.W. et al. (1982) Readings in farming systems research and development. P.214. Westview Press.
2. Benneh, G. (1973) Small-Scale Farming Systems in Ghana. P.135. Africa, Vol. 43, No. 2.

created by the natural environment and the constraints resulting from low-levels of technology. The technical elements of the environment examined in this study include: rainfall, temperatures and the land surface configurations.

The socio-economic factors influencing decision-making processes at the household level are divided into two categories. The first category includes those factors that have direct primary influence on the production operations, such as farm size. The second category includes those factors that have indirect influence on production operations, and therefore, are exogenous to the farm. These latter factors, however, exercise enormous influence on the former to such an extent that they are likely to result in comparable differences between and among farmers in the same locality. For the purposes of analysis, credit availability, exposure to information through extension systems, training of farmers through the established training institutions and the existence of product market systems are the main factors taken to constitute the exogenous factorial attributes. A closer examination of these factors, which are endogenous and/or exogenous to the farm, explains the spatial

variations in farming activities.

The traditional farming systems in Nyeri District have undergone a number of structural transformations in the last three decades or so. Probably the most notable factors that initiated massive changes were the imposed foreign land tenure systems and the ensuing introduction of new varieties of crops and animals, coupled with rising population. Two lines of development are of interest to this study. First, the 1950s and 1960s welcomed the incorporation of export commodity production into the peasant productive repertoire, the implication of which was to involve the farmer in an extra but highly promising enterprise. Hence, the place of export commodities within the overall farm activities is examined in this study in order to adequately appreciate the farmer's decision-making environment. Secondly, as the population grew, the pressure on land increased. This, it would seem, culminated in land subdivision, intensification of land use or reduced period of the fallow phase in the farming systems. This, according to Grove, A.T. (1951), is always accompanied by a decline in soil fertility and the productivity of both land and labour.

Information on the distribution of farm sizes, subdivisions, ownership of other land, inter-cropping, fallowing and rotational practices has been assembled to facilitate a clear description of the distribution of farm resources and the way farmers have responded to changing conditions of population pressure and diminishing land resources in the survey area.

Although valuable research work has been done in the past in relation to smallholder production problems, there has been a tendency to concentrate on only a few farm components that interact at the farm level and therefore a comprehensive picture of how components behave could not be obtained. However, as Beets, W.C. (1982) notes,"at the minimum, an intuitive knowledge of interacting factors is essential and a deductive rather than 'an empirical' approach may be used." P.6

It is hoped that this study's findings will have addressed some of the critical issues confronting farmers and that planners will benefit from these findings by applying them practically to the benefit of the farmers.

1.1 LITERATURE REVIEW

The subject of agricultural development is not being addressed here for the first time. In fact, the bulk of literature on the subject as regards Nyeri District is simply too enormous to be exhausted. Neither is the writer's approach assumed to be unique or superior. What is probably different is the strength of emphasis on certain aspects that the researcher feels have as yet to be brought together comprehensively with respect to the study area.

It is not the intention of this researcher therefore to go into the details of most of the theoretical and factual contributions to peasant production economics, but rather to review, in general terms, a few studies related to physical and socio-economic context of farming systems. It is hoped that the literature review, though brief, provides the fundamental reasons for a need to re-examine some of the past theories and facts on the general farming environment.

The literature review is divided into three main sections. The first set of literature examines theoretical contributions in the field of agricultural development. Section two looks specifically at literature related to factual findings based on case studies. The final section focusses on

literature specific to the study area and critically examines the gaps and weaknesses of these studies, thus justifying the current efforts.

THEORETICAL CONTRIBUTIONS

ENVIRONMENT AND DECISION-MAKING BEHAVIOUR

A farming system as defined in an earlier section results from a complex interaction of interdependent components that provide the necessary conditions for its existence namely: "Soils, rainfall, temperatures, topography, plants, animals , social, economic, institutional and other environmental influences."

According to the proponents of environmental determinism the physical environment is assumed to control and condition agricultural decision-making. (Ackerman, E.A. 1963). Implicitly, this means that the resulting pattern of land use is environmentally determined. This approach has met a lot of challenges, especially from Social Scientists interested in social and economic behaviour of man. It is argued that this approach provides partial solutions to a problem that has many sub-problems and therefore demanding many sub-solutions.

Peter Gould (1963) in his article 'Man against his environment' wrote, to quote: "to be a man rather than an animal is in part to be able to recognise a variety of alternatives and in a rational manner, reasoning from those little rocks of knowledge that stick up above the vast sea of uncertainty, choose strategies to win the basic struggle for survival". Thus, Gould, P. (1963) argued that man is capable of picking up strategies based on probabilistic notions that would counter-act the uncertainities created by the environment. This he called the Game theoretic framework.

The concept of game theory has not received a positive welcome from a number of social scientists such as Pred,A. (1969) who states that, "solutions derived from game theoretic framework,however ingeniously conceived, are of dubious worth. This is primarily so, because in striving to rectify the usual geographic phenomenon, Gould has resorted to computational superman of game theory". Pred, A. adds further, that, "this concept is so devoid from psychological reality as to be of very limited utility as a tool for analysing the real-world spatial patterns".

Seddon, D. (1977) contends that, "the physical environment alone cannot be said to determine the pattern of economic and social context within a given area, it does nevertheless impose certain constraints and provide certain opportunities for its human inhabitants". Seddon, continues to state that, "however, the physical environment must be considered as an integral and dynamic element of the total environment within which individual men and women live their lives". Therefore, Seddon sees the physical environment not in isolation but as part of the dominant attributes that influence decision-making behaviour of peasant farmers in the production process. He thus, differs considerably from pure environment-deterministic approach or the conventional economist approach. The latter approach to land use analysis tends to equate human behaviour with the profit maximization motives. To this Seddon D. (1977) reacts: "While there can be no doubt that men do make decisions and adopt strategies in the production process as in other fields of social life, it is essential, to recognise that the individual choice is conditioned, in the final analysis, by the existing structure of the physical environment, technology and political economy".

From the foregoing discussion, it can be appreciated that the physical environment, though it does not work alone, has an important place in determining the various agricultural activities undertaken by man. Specifically, Ahn, P.M. (1975) singles out climate, soils and relief as the major environmental factors influencing agricultural possibilities in the Tropics. Ahn, P.M. (1975) explains that, "in planning for agricultural development, we have always to distinguish between what is technically possible to grow in any particular area, given the local soils and climate and the current technical knowledge and what is economically profitable". Thus, Ahn incorporates the environmental and economic aspects in decision-making.

The nature and the types of soils that exist in a particular place depend on a number of factors such as the parental material, climate, vegetation and relief. These soil forming factors, according to Ahn P.M. (1975), are responsible for causing differences between soil qualities and their potentials for agricultural utilization.

Shackleton, R.M. (1945) carried out a study on geological characteristics of Nyeri District.

This study has comprehensively shown the various geological structures found in the District. This is a resourceful contribution that provides useful background information. Valuable as this work has been, however, it has not related the geological structures to the soil types and the terrestrial land use systems.

The Kenya Soil Survey (1982) provided a comprehensive agro-climatic map of Kenya, which is up-to-date with moisture availability index, temperature zones, soils and vegetation types. The map, however, is too general, since it covers the whole country. For specific regional analysis a more detailed larger scale map is required.

Woodhead, T. (1968), as part of East African Meteorological Department's record, provided a climatological synthesis for Kenya. The data contained in this document has been analysed to indicate a number of climatological aspects that may influence agricultural production and consequently, following the path of environmental determinism, farm decision-making. However, like most other studies based on physical sciences, the information given in this document has limited use to planners unless incorporated into findings of other Earth Sciences.

So far, it is now possible to appreciate the difficulties of employing the available environmental information to specific micro-analysis. Despite these difficulties, the current study has combined technical information from a variety of sources in an attempt to bridge the gaps that these quoted studies could possibly have left out.

DEVELOPMENT OF SMALLHOLDER AGRICULTURAL SYSTEMS

THE SOCIO-ECONOMIC VIEW OF DECISION-MAKING

The foregoing discussion relates to some physical determinants of agricultural development. In this section a more specific review of literature related to the subject is examined. The review carries contributions from a variety of sources on this most debated and challenging issue. It moves from the broad subject of global agricultural development to specific regional studies.

A considerable body of knowledge exists on the behaviour of farming communities the world over. However, much of this knowledge is hard to draw upon for specific regional planning purposes, basically because it is at times too general. Again some of their findings are superseded by the rapidly

changing social and economic circumstances. It is probably due to these reasons that Wharton,C.R.(1969) stressed the need for more detailed analysis of the economics of small scale farming systems. Such analysis ought to be continuous, every time incorporating new variables. Ever since, massive information is now available at global, national and regional levels. Apparently, much of the information in these studies has been given complex analytical treatments thus limiting their uses to only those planners in the same disciplines.

Conventional economists approach to land use analysis has been highlighted in a number of basic textbooks on economics. In general terms, the theories postulate an 'economic man' who, in the course of being economic, is also rational. This man is assumed to have knowledge of relevant aspects of his environment which, if not absolutely complete, is, at least, impressively clear and voluminous. (Found, C.W. 1971). According to Baumol W.J. (1961), the successful utilization of this decision theory depends on the ability to order the consequences associated with an action, "that is an explicit statement of the decision-makers preferences, a careful exposition of

the alternative actions that are open to him and finally a model that relates these alternative actions to the stated preferences in a manner that permits an efficient choice to be made among alternatives.

These traditional economic theories and the concept of economic man have been questioned by among others, Simon, H.A. (1955), Pred, A. (1969(and Rogers, E.M., (1962). Three basic concerns are expessed namely, (1) the logical consistency of the assumptions involved (2) the motives ascribed to economic man and (3) the knowledge level and mental acumen attributed to economic man.

Simon, H.A. (1955) expressed doubts on the assumption that man optimizes some objectives. He argues that, "it is so far beyond the capabilities offered in the extended environment that man probably seizes on the first satisfactory decision which he encounters". The approach, according to Simon, H.A. (1975), is unsatisfactory, because the real World is characterized by existence of imperfect knowledge about the occurrence of a number of factors. According to Simon, therefore, most of the economic models applied to

the farm environment reveal objectives that are not necessarily those of the farm decision-makers.

Following Hagerstrand, T. (1966), farmers usually prefer to adopt land use types which their neighbours have found to be successful, rather than experimenting with new practices. Hagerstrand states that "the role of information diffusion preceding adoption is quite important and the contagious process between farmers is critical in spite of the existence of mass media or an extension agency, since face to face process and advice from trusted neighbours and friends is legitimized." This theory has not gone without criticism. Barry and Marbel (1968) suggest that "what is needed is a resource theory of innovation diffusion where individual access to the means of production, the state of the market and related infrastructure are involved".
According to Harvey, D. (1966), ' an individual farmer makes decision with respect to the available resources at his disposal and the value that he attaches to short-term and long-term goals". Thus, decisions have been seen to vary with the internal characteristics.

To sum up the above discussion, it is recognized

theoretically, that there are a number of factors that influence the decision-making framework of the farmers, none of which can be easily isolated to be more important than the others.

TRADITIONAL AGRICULTURE: THEORY AND EMPIRICAL FINDINGS

"Traditional agricultural systems" has been a theme stressed by a number of researchers interested in the various dynamics involved in their management, operations and development. Notable theoretical contributors include: T.W. Schultz (1964), J.W. Mellor (1966), H. Ruthenberg (1971) and D.W. Norman (1975), among others.

In his seminal book "Transforming Traditional Agriculture", Schultz, T.W. (1964) attributed the traditional agriculture to a system that is in a particular state of technical and economic equilibrium. An equilibrium based on "the state of the arts underlying the supply of reproducible factors of production, the state of preferences and motives underlying the demand for sources of income and the period of time during which the two states remain constant". After a careful analysis, Schultz contends

that, 'these farmers are generally efficient in the use of their resources even though they are poor'. Thus,'they are more secure in what they know about the factors they use than farmers who are adopting and learning how to use new factors of production'. Although Schultz presented no empirical evidence from Africa, the policy implications of his findings are important, since it indicates that additional agricultural output must come through technical change and not through a re-allocation of resources (Baker, D.C. 1982). There are possible dangers, however, of employing such findings in planning for smallholder agricultural development in Kenya, because implicit in the findings is an assumption of farmers operating on a homogeneous ecological and economic space. According to Heyer ,J. and Waweru ,J.K. (1976), "Kenya has a variety of small farm systems ranging from those based primarily on annual food crops to those in which permanent crops play a minor role; from systems in which most production is for subsistence purposes to systems which are relatively commercially orientated; from systems in which livestock are peripheral to systems in which livestock play an integral part; and from systems in which

there are virtually no purchased inputs to systems in which purchased inputs, including hired labour, play a significant part. Hence, farmers demonstrate cross-sectional differences which cannot be given such a generalised approach.

Mellor,J.W. (1966) addressed himself to this problem of smallholder agricultural development. He argued that 'variations between and among smallholder farmers is a reflection of physical, economic and cultural differences'. It is these factors which in turn affect the level of resource use as well as the acceptability and response to innovations. Therefore, as Mellor argues, one of the appealing means of increasing production within the context of traditional agriculture would be to study these differences and from such study develop a set of recommendations that might be used for planning purposes.

Concern over the role of indigenous knowledge systems in farm planning has received increased attention among researchers and agricultural scientists. Examples of research on indigenous knowledge include those of D.W. Norman's Study on 'Economic rationality of traditional Hausa dryland farmers in the North of Nigeria (1976) and Okigbo,B.N. (1978). Indigenous

Knowledge Systems, according to Baker,D.C. (1982), can be a valuable input into research on farming systems, integrated pest management, soil fertility and livestock systems. The central theme of these studies is that 'farmers, however uneducated they may look, know their soils, climates, seasons and, above all, their crops'. If attempts are to be made, therefore, to encourage farmers to shift from traditional hand cultivation based primarily on mixed crops to more technically advanced cultivation, it will be useful to understand better the social, economic and environmental relationships facing the farmers and their perception of these relationships. (Mbilinyi,S. 1975, Okigbo,B.N. 1978 and Norman,D.W. 1982).

Bagwati (1970) put forward a thesis that provision of incentives to the farmers is a necessary condition for agricultural growth. This may take the form of stabilized commodity prices or extension of better infrastructural support systems. He castigated the economists obsolete proposition that traditional societies were structured in such a way that economic motivation had no function to perform in them. Bagwati, however, has not extended his study to give empirical findings to show the effect of these variables on the level of production.

The link between population growth, land use and the structure of agricultural production has been the subject of numerous studies, (Boserup 1965, Datoo B.A. 1973 and Ruthenberg, H. 1980). A common agreement is that land use patterns in much of Africa have dramatically changed over the last two or three decades. According to Datoo, B.A. (1973) "one of the most important impulses to which peasant agricultural systems have had to react to has been an increase in population"(pl) A number of structural changes have come about as a result. Of great concern probably is the splitting up of farms into smaller and smaller uneconomic units, shortened fallow period and land use intensification and its relationship to maintenance of soil fertility. Jain (1965) expressed concern over the splitting of big holdings into small-holdings. This he associated with the inefficient use of resources which consequently lowers gross farm output. Though other researchers, such as Heyer, J. et al (1974), have shown that smallholdings are more productive than large holdings, there has been no agreement on the ceiling size levels. This is an area of great controversy which can only be resolved by increasing the volume of knowledge on all the various structural factors that work in concert at

the farm level.

GENERAL FARMING SYSTEMS: THE KENYAN CASE STUDIES

Since literature on agricultural development in Kenya is so vast, only a few studies which shed light on the two issues of physical and socio-economic characteristics have been sampled for the purposes of this study.

Probably the study by R.S. Odingo (1971), on the "Kenya Highlands" is the most quoted piece of work that has successfully combined a number of physical and socio-economic aspects in one comprehensive framework. However, this study is based on a period of time when the Kenyan history was on a transitional period (1960 - 1963) and therefore much emphasis was placed on European plantation agriculture. Ever since, a lot of changes have taken place and possibly the fulcrum of the problem has shifted.

Hussain, S.A. et al.(1982), in a farming systems study in Makueni location of Machakos District, identified a number of constraints limiting the productivity of the farming systems as: (1) Low and declining soil fertility which resulted from overgrazing and the subsequent soil erosion;(2) hard soils and poor

conditions of oxen prior to the rains; (3) labour constraints during the peak period; (4) shortage of dry season feed, and (5) lack of knowledge on various farming practices. This study has offered useful guidelines on which studies for other areas of Kenya could be based. It differs from the current study on three aspects:(1) its geographical coverage is so small that it is not possible to explain variations across different agro-ecological zones, (2) the authors examine some variables which are not of our current study's concern, and (3) the study was conducted in a semi-arid area of Kenya with medium to low potential for agricultural development.

Cowen,M.P. (1974) comparing the income levels of two adjacent sub-locations in Nyeri District, found out that the sub-location with a higher man/land ratio, and a lower mean size of holding showed a slightly higher average annual rate of growth in total income than the other which had a relatively lower man/land ratio and a higher mean size of holdings.

Such a finding, especially when it concerns two so closely related sub-locations, cannot be explained

with the kind of simplicity this author has given. More information is required to prove that there is, in fact, such gradient. He did not take into account other farm enterprises besides tea and dairying.

The simple fact that the author did not take into consideration the agro-climatic differences makes the analysis the more less convincing. A movement from one agro-climatic zone to the next may reveal a drastic change in crop combination. The argument here is that farmers in the latter sub-location could be growing more coffee and less tea and therefore if this aspect is ignored the final conclusion may give misleading information.

The issue of cash crop production, as opposed to food crop production is an area of concern, not only at the national but also at the global level. A number of scholars have addressed themselves to this issue. Etherington,D.M. (1971) noted that the smallholder tea farmers in Kenya have attained very high standards of tea growing at continental level. The success is a reflection of many years of careful preparation and not the existence of economies of scale. This observation was also made by Heyer,J.

et al. (1971). According to J. Heyer, there was a dramatic increase in production of high value cash crops in the country since independance. This she observed had given hope that rural unemployment problem was to be reduced through increased rural incomes.

This success story is however deceptive. Clayton,E. (1973) observed that such an increased emphasis on export crop production may in the long run lead to shortage of arable land on which to grow food crops.

Sillitoe,K.K. (1963) had observed that the area under cash crop in Nyeri District, at the dawn of independence, was only 5% of the total cultivated area. Today existing statistics show that the area under coffee alone is 16% of the total cultivated land. The farm-to-farm variation is unknown. However, knowing the vigour with which cash-crop growing was taken in the later years of post-independence, it is possible that it has surpassed the area under food crops in the total cultivated area.

Lawi-Odero-Ogwel and Clayton,E. (1973) applied a regional programming model to the smallholder farmers in Nyeri District. Coffee proved to be the most profitable cash crop enterprise, whereas pyrethrum and

pineapples were least profitable. The economic part of the model includes some simplifications which limits its usefulness as an adoptable planning tool.

The foregoing review of literature is far from complete, but brief as it is, it has to some extent curved the way for the need to re-appraise past theories and empirical findings on which planning for the agricultural sector has always been based.

1.2 SUITABILITY AND IMPORTANCE OF THE RESEARCH

In view of the fact that only about 17.5% of Kenya's land falls under the high and medium agricultural potential, one is bound to question the ability of the agricultural systems to support her projected population of over 28 million by the year 1995 and beyond.

The 1979/83 National Development Plan underscored the urgent need to address the problem of food versus population. In the relevant section it states: "As a result of rapid population growth, the amount of good agricultural land capable of producing adequate income with existing technology is becoming scarce. In these circumstances, it

is the policy of the Government to increase the productivity of all types of land during the planning period. The Government will institute programmes which will enable farmers to use higher levels of purchased inputs, especially fertilizers. The expanded use of these inputs will increase productivity and encourage multiple farming in suitable areas"

It was with this desire to have the country self-sufficient in food production, that the Government formulated, the 1981 Sessional Paper No. 4 on National Food Policy. This Policy Paper outlines guidelines whose implementation would go a long way in guaranteeing the country's medium-term food self-sufficiency.

The National Food Policy Paper, however, does not provide clear guidelines on how the country's limited agricultural resource base could be utilized to meet current and future food requirements. It has laid undue emphasis on the required production levels in the medium-term, rather than attempting to offer methods of identifying problems facing food producers and how they could be mitigated in order to lift the levels of production.

The past and the current Development Plans have emphasized a great deal the need to extend development benefits to the rural areas, not enough has been said about the need to understand the farmer's environment and how to incorporate him into the development programmes.

The above line of discussion should not be misconstrued to mean that there has not been considerable attention given to improving the lives of the majority in the rural areas. In fact, a number of integrated rural development programmes have been launched in most parts of the country as demonstrated by Machakos Integrated Development Programme or the South Kwale District Special Development Programme.

The central issue, therefore, may not necessarily be lack of tangible programmes. The problem is the people and the physical and economic environments upon which production decisions are based.

Nyeri District was found to be a suitable area where the outlined problems could be investigated successfully, since it contains a diversity of these problems. The District has a topography that varies tremendously - from very rugged landscape to gentle rolling

slopes, expansive flat terrain to big depressions and river valleys etc. Moreover, the climatic factors show distinct variations with altitude. All these physical factors have resulted in different farming systems which call for specific recommendations.

On the socio-economic front, the District experiences land pressure due to high population growth and other population associated problems, such as outmigration, underemployment and environmental degradation.

The survey in this area, it is hoped, has allowed for a deeper understanding of the farming systems, and the existing potentials and constraints to further development. It should, however, be noted at the outset that the study has just given general ideas that may pave the way for a more specific examination of the outlined problems.

1.3 RESEARCH OBJECTIVES AND SCOPE OF THE STUDY

The general objective of this study was to examine some physical and socio-economic characteristics that act as potentials and/or constraints to smallholder agricultural development with particular emphasis on Nyeri District. The results were hopefully to

help identify some socio-economic and physical constraints pertaining to the various farming systems and need for further studies in the area. Specifically, the study seeks to investigate into the following:

(1) Physical determinants of farming systems

(i) rainfall distribution and effectiveness

(ii) soils and topography

(2) Endogenous and exogenous factors that may influence and result into differences in production performances among smallholder farms in Nyeri District namely:(i) The significance of farm size variation to smallholder farm agricultural production.

(ii) The influence of the farmer's period of experience on the farm and other farm related activities to the smallholder farm agricultural production.

(iii) The role of farmer training institutes in influencing the level of smallholder farm agricultural production.

(iv) The role of agricultural credit and loan facilities in smallholder farm agricultural production.

(v)The relationship between agricultural extension services and smallholder farm agricultural production.

(vi) The relationship between the distance to the nearest market centre and the level of smallholder farm agricultural production.

An attempt is also made on a rather broad spectrum to identify some problems that farmers face in relation to crop/animal production systems, with a view to strengthening our qualitative analysis of the subject farming systems.

1.4 RESEARCH HYPOTHESES

As a consequence of the above stated objectives the following hypotheses were formulated.

1. "Variations in farming system types are directly related to the variations in monthly and annual average precipitation and temperatures, soils and land surface configurations".
2. "The size differences in the smallholder farms are too insignificant to have any noticeable contribution to the variations in agricultural production".
3. " The period of experience on the farm and farm related work is a significant factor that contributes to the variation in the smallholder farm agricultural production".
4. "Training offered at farmer training institutes contributes significantly to the level of smallholder farm agricultural production".
5. "Availability of loans and/or credits to smallholder farmers significantly contributes to the variation in smallholder farm agricultural production".
6. "The growth in agricultural extension services is significantly related to the level of smallholder farm agricultural production"

7. "Distance to the nearest market centre significantly relates to the level of smallholder farm agricultural production".

The above hypotheses are later on in chapters four and five discussed and/or subjected to statistical analysis, thus rejecting or accepting them as a basis on which future planning and research in this aspect of agricultural geography may be built.

1.5 OPERATIONAL DEFINITIONS

For the purpose of this study a number of operational definitions are provided. These definitions are mainly borrowed from other studies and Government publications.

SMALLHOLDER FARMS

The term small-holder farms used in this study as one of the operational terms, is a source of great controversy. According to the Nyeri Development Plan 1979/83 - the small-holder farms are those that range from 0.4-8 Ha. and according to the Statistical Abstract (1980) small holder farms range from 0.2 - 12 Ha. In this study the lower limit of the Statistical Abstract, that is 0.2 Ha and the upper limit of Nyeri Development Plan that is 8 Ha will be taken to define a small holder farm. So that, the small holder farms will range between 0.2 - 8 Ha. The

reasons for the choice has been justified by reviewal of the available statistics on farm sizes in Nyeri District - which shows that more than 50% of the farms are less than 2 Ha, among which one would expect a substantial number of farms to be at 0.2 Ha especially with the recorded rate of farm informal sub-divisions.

HOUSEHOLD

Shaner, W.W. et al (1982) defines a household as a social organization in which members normally live and sleep in the same place and share their meals. The Central Bureau of Statistics (C.B.S.) (1977) define a household as "a person or group of persons living together under one roof or several roofs within the same compound on homestead area sharing a community of life by their dependence on a common holding as a source of income and food, which normally but not necessarily involves them eating from a "common pot".

FARM ENTERPRISE

An individual crop or animal production function within a farming system which is the smallest unit for which resource use and cost return analysis is normally carried out. An enterprise is thus a sub-system of crop or animal system and of the farming system as a whole (Harwood, R. 1978).

BIO-PHYSICAL FACTORS

The term encompasses all those elements of the natural environment such as soils, topography, water, temperatures and biological factors such as weeds, and pests.

SOCIO-ECONOMIC FACTORS

The term has been used to include not only the endogenous characteristics of the farming communities, such as age, training and experience but also economic and institutional factors such as market, credit and extension programmes.

A SYSTEM

A system is a set of objects where each object is associated with a set of feasible alternative states; and where the actual state of any object selected from this set is dependent in part or completely upon its membership of the system (Rothsten,J. 1958)

CROPPING SYSTEMS AND LIVESTOCK SYSTEMS

These are subsystems within the farming system. A cropping system is a set of one or more crops, comprises all components required for production including the interactions between other households

enterprises and the physical, biological and socio-economic environments (Harwood,R. 1979)

AGRO-CLIMATIC ENVIRONMENTS

These are areas where a crop exhibits roughly the same biological expression ---these environments are however, often modified by socio-economic circumstances that produce different recommendation domains (CIMMYT, 1980).

A FARM SYSTEM

A set of spatially definable areas in which either crops, animals or both are produced, and a homestead area where the farm house is located. (Hart, R.D. 1982 p.46)

The above definitions form part of the whole set of terminologies applied in various sections of this study. They have been included here to simplify the task of adding more definitions in the context of the discussion. However, whenever, it deems appropriate, additional definitions are included in the course of the discussions.

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1.6 THEORETICAL FRAMEWORK

Social scientists have long been interested in the operative characteristics of individuals in their own environments and their decision-making processes. They have tried to discover generalizable traits of individuals and organisations that would permit the construction of an acceptable explanatory model.

A review of literature indicates that there are a number of conceptual ways of examining factors that influence decision-making at the farm level namely: (1) Environmental (2) Economic and (3) Behavioural or Social. This study has put together the general ideas expressed in literature into two descriptive conceptual models.

REGIONAL DESCRIPTIVE CONCEPTUAL MODEL

In this model the agricultural system was conceptualized as a system with a bio-physical subsystem on one hand and socio-economic subsystem on the other.

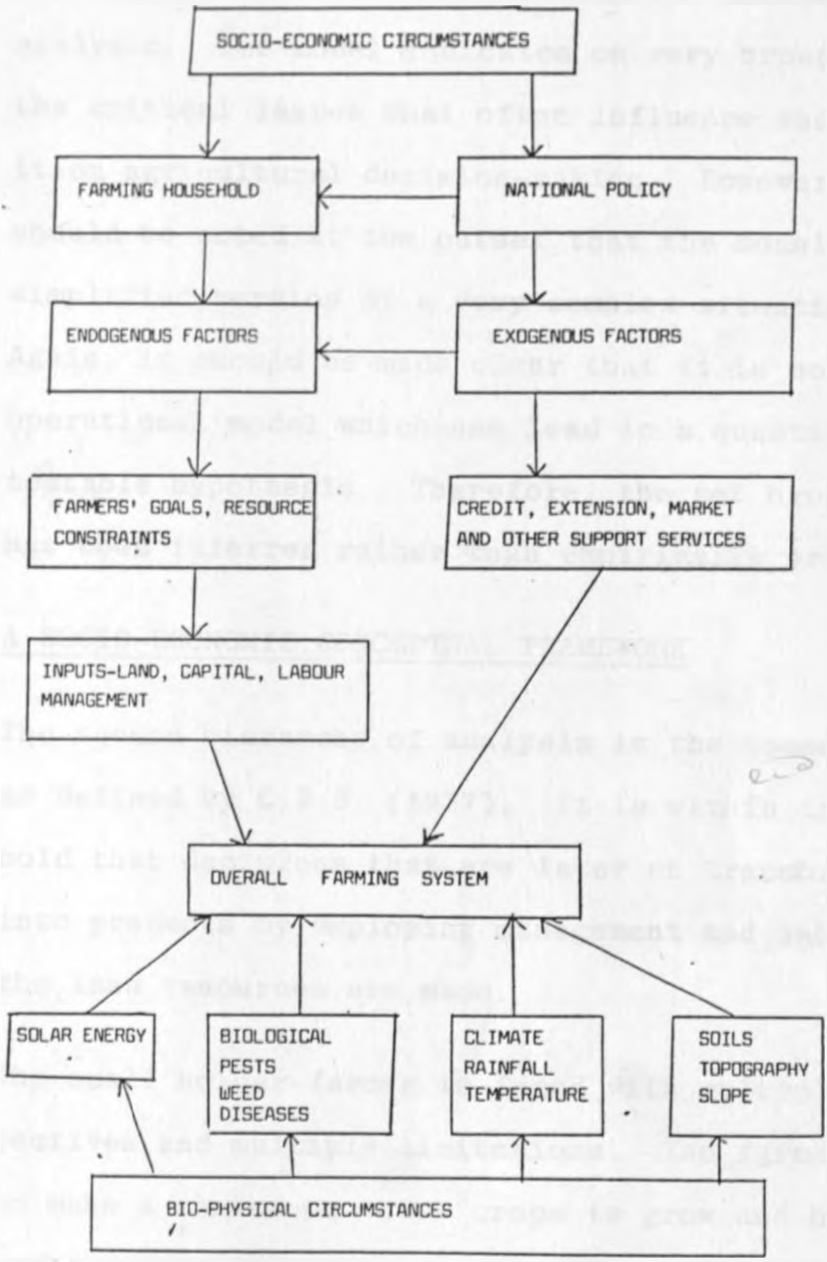
In the words of Norman ,D.W. et al (1982) (1) The technical elements of the environment-rainfall, temperature, soil types - establish certain physical and biological constraints on agricultural production system (2) The human environment in which any household lives limits its behaviour and (3) The National

institutions and objectives exert a pervasive influence on the social and economic structures that evolve as modernization and development occur as well as specifically affecting certain prices for export crops money supplies and the links. This agrees with Spedding ,C.R.W. (1975) statement that, "no single factor determines the choice of a farming system, and neither is there a single dominant reason for the final choice."

Within this background a regional agricultural system conceptual model is provided. According to Hart ,R.D. (1982) this includes all the farms in the geographic region, their marketing, credit, information centres and the infrastructure that ties these regional subsystems together. Banta ,G.R. (1982) introduces additional factors into the theoretical model which creates a broader picture of the circumstances under which farmers operate. These are land, water, solar energy, labour, management ability, technical knowledge, power, cash, nonfarm inputs, credits and markets.

FIG 1.1

A GENERAL DESCRIPTIVE CONCEPTUAL MODEL



Source: Modified from C.I.M.M.Y.T. (1980) Planning Technologies appropriate to Farmers. Concepts and procedures - Nairobi.

The above regional conceptual model forms the first hierarchy of this study's descriptive and empirical analysis. The model indicates on very broad terms the critical issues that often influence and condition agricultural decision-making. However, it should be noted at the outset that the model is highly simplified version of a very complex situation. Again, it should be made clear that it is not an operational model which can lead to a quantatively testable hypothesis. Therefore, the set hypothesis has been inferred rather than empirically proven.

A SOCIO-ECONOMIC CONCEPTUAL FRAMEWORK

The second hierarchy of analysis is the household as defined by C.B.S. (1977). It is within the household that decisions that are later on transformed into products by employing management and labour into the land resources are made.

The small holder farmer is faced with multiple objectives and multiple limitations. The farmer has to make a choice on which crops to grow and how much of each to grow under certain levels of resource limitations. From an economic point of view, the most significant characteristics of smallholder farmers is the small resource base on which to operate. They have an extremely low level

of human capital in terms of education, knowledge and health with which to work, and lack accessibility to institutional support services such as credit and extension (Dillon,J. and Hardakes,J.B. 1980). When resources are limited, the key to the well-being of the farm families is the interaction of varied but complimentary enterprises (Harwood,R. 1979 p.5). Thus according to Kolawole (1974) mixed farming is an attractive system to most farmers in the tropics.

The simple fact that the small holder farmer has little or no control over the input supply subsystem or the product market subsystem, results in the farmer operating in a dynamic and uncertain environment. It is within such a conceptual framework that the choice of an enterprise and the associated management strategies should ideally take place (Dumsday,K.G. and Flinn,J.G. 1977).

The socio-economic factors influencing decision-making processes at the household level, are of variable magnitudes. On the first hand, they are related to internal characteristics of the household such as the size and composition of the unit, which determines its consumption needs and its

production capacity. (Vedeld,T. 1981). On the second hand they are related to external factors such as market, credit and other agricultural support services.

While the above aspects could be said to describe the common characteristics of small farmers their modus operandi exhibit tremendous diversity. In consequence, small farmers cannot be thought of as a homogeneous group even within a relatively small region (F.A.O. 1980).

Through the analytical model provided in chapter three the main socio-economic variables examined in this study are discussed. Later on in chapter five statistical data is fitted into the analytical model thereby completing the analysis:

1.7 SUMMARY OF CHAPTERS

The study is organized into six chapters. The statement of the research problem, objectives, research hypothesis, literature review and the theoretical framework are the subjects of chapter one. Chapter two offers a summary background information to the study area, a short history of agricultural develop-

ment and briefly examines the institutional setting of agricultural support services in the District. The research methodology employed in this study is presented in chapter three.

Chapter four examines a set of natural environmental factors such as rainfall (amount, distribution, reliability and effectiveness) soils and slope gradients. An attempt is made to relate at a rather general level the variations in the natural environmental factors to the farming system types. The ensuing analysis of the gathered information has thus helped us to test by inference hypothesis one advanced in chapter one.

Chapter five forms an analysis of the central issues that qualified the need to undertake the study. It is divided into three main sections. The first examines general characteristics of Nyeri small holder farming systems - thus addressing resource utilization and methods of soil fertility maintenance. Section two attempts to define at a rather broad front, the inter-relationships between crop farming and livestock economy. The ecological and socio-economic constraints pertaining to these practices

are discussed. The. farmers' production priorities with respect to his needs, perception and institutional support accorded to him are generally examined. The last section subjects the gathered data into analytical tests in order to verify the truthfulness or falsehood of the hypothesis advanced in chapter one. The chapter closes with a brief summary of the findings.

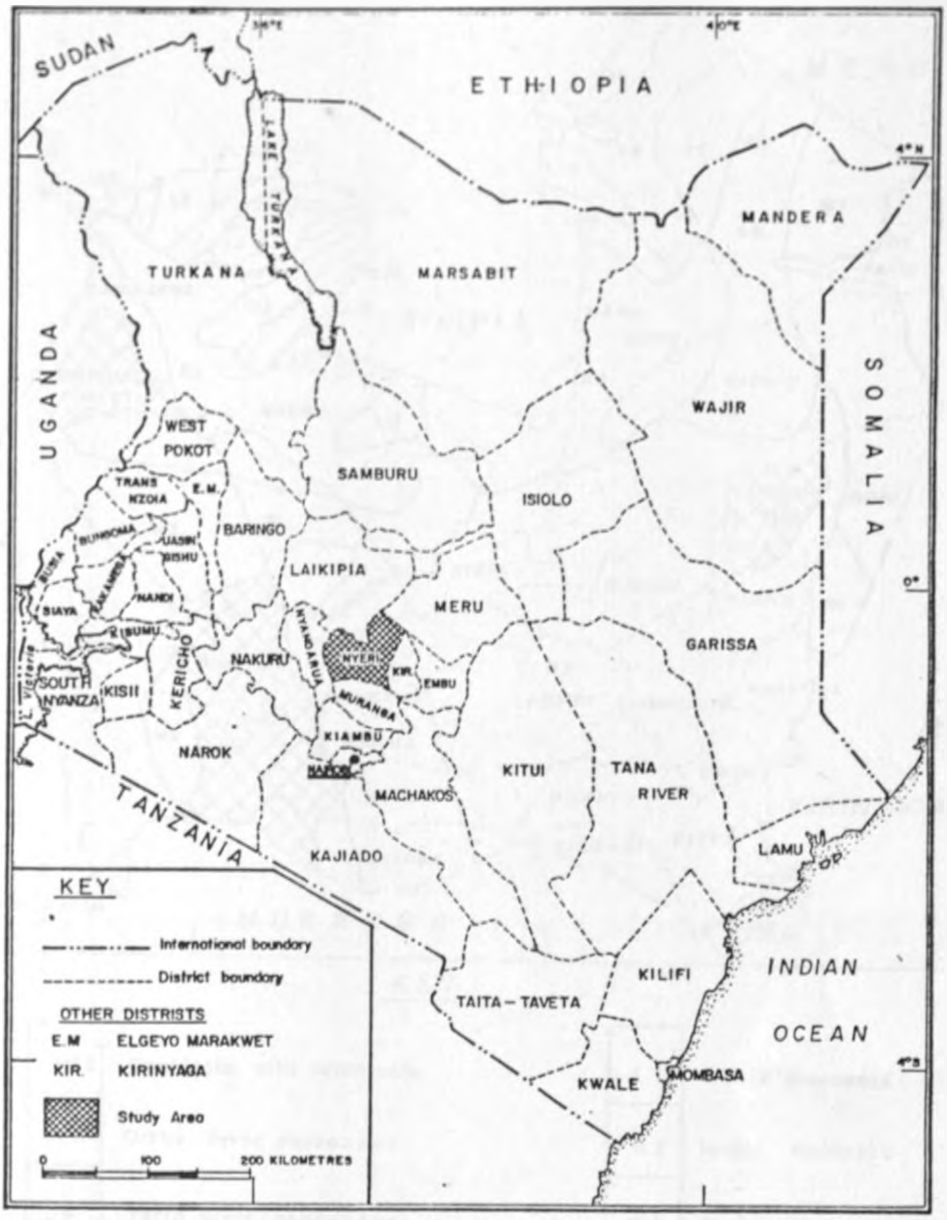
Chapter six contains a summary of all the identified farm production potentials and constraints, other research findings, plus an outline of recommendations for future lines of research and planning. It is divided into four main sections. Section one discusses the main findings of the study, directing special attention to physical and socio-economic determinants of the farming systems. Section two looks at possible areas of intervention by both the Government and Non-Governmental organizations in order to enhance food production and generation of higher incomes among small holder farmers. Section three is a brief outline on further lines of research for scholars and section four carries the main conclusions that emerge out of this study.

CHAPTER TWO

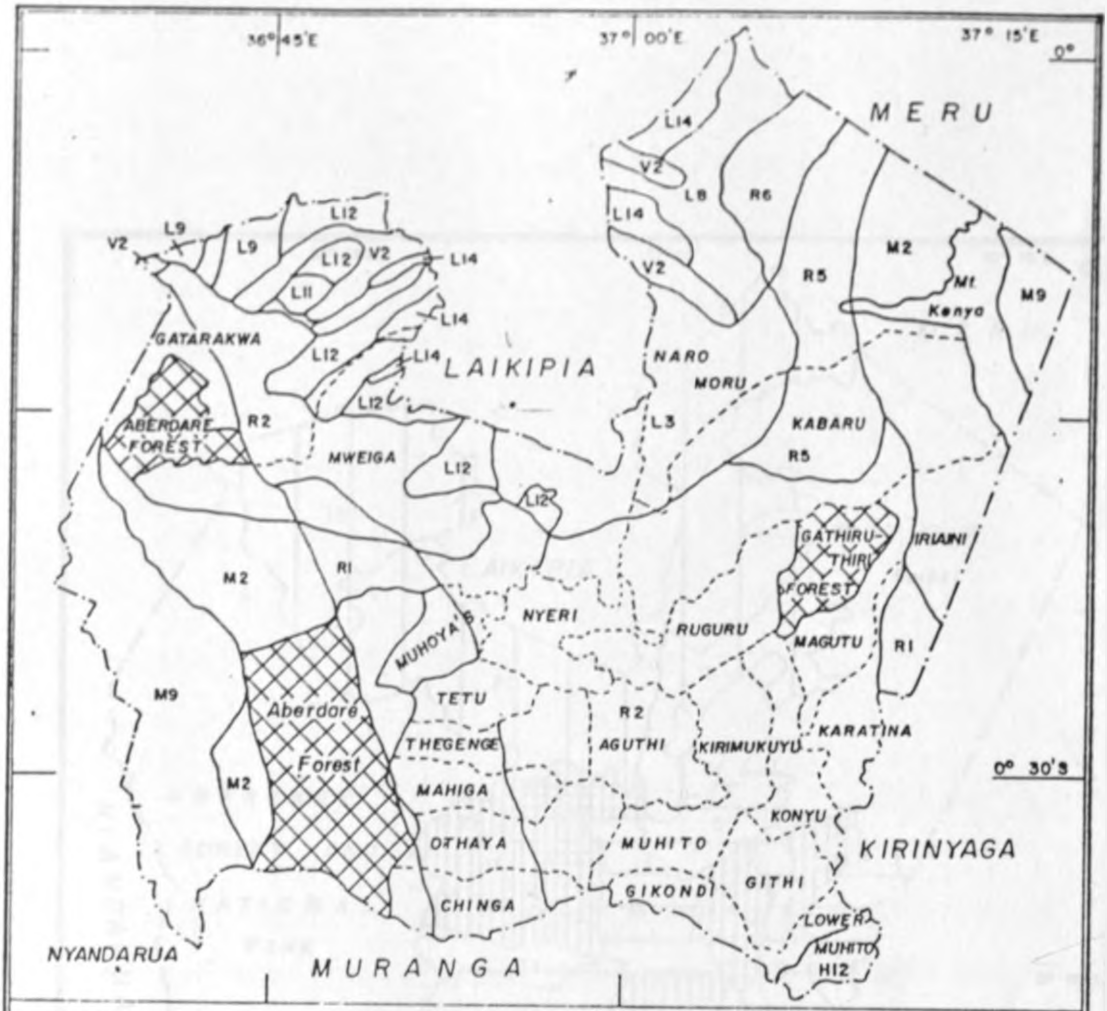
BACKGROUND HISTORICAL AND INSTITUTIONAL SETTING OF AGRICULTURAL DEVELOPMENT IN THE STUDY AREA

Nyeri District which is by far the largest of the five districts of the Central Province of Kenya, extends from 36° 37'E to 37°15' E Longitude and the Equator to 0° 37' S Latitude. (Map 1)
The district, with a total area of 3,284 square kilometres, is a region of considerable topographic, soils, climatic and socio-economic contrasts. The altitude varies, on the average, from 1,600 m. to 3,000 m. above sea level, with Mount Kenya and the Aberdares rising to 5,199 m and 3,999 m above sea level respectively.

The presence of Mount Kenya to the East and the Aberdares to the West, together with their intensive drainage systems, have all influenced the topographic structure of the district. Likewise, the origin of their formation and the morphological changes have had a lot of influence on the soil types to be found in this district. (Map 2)
As to be discussed in greater details in Chapter Four of this thesis, the district enjoys a fairly well



MAP I: THE LOCATION OF THE STUDY AREA IN KENYA.



KEY

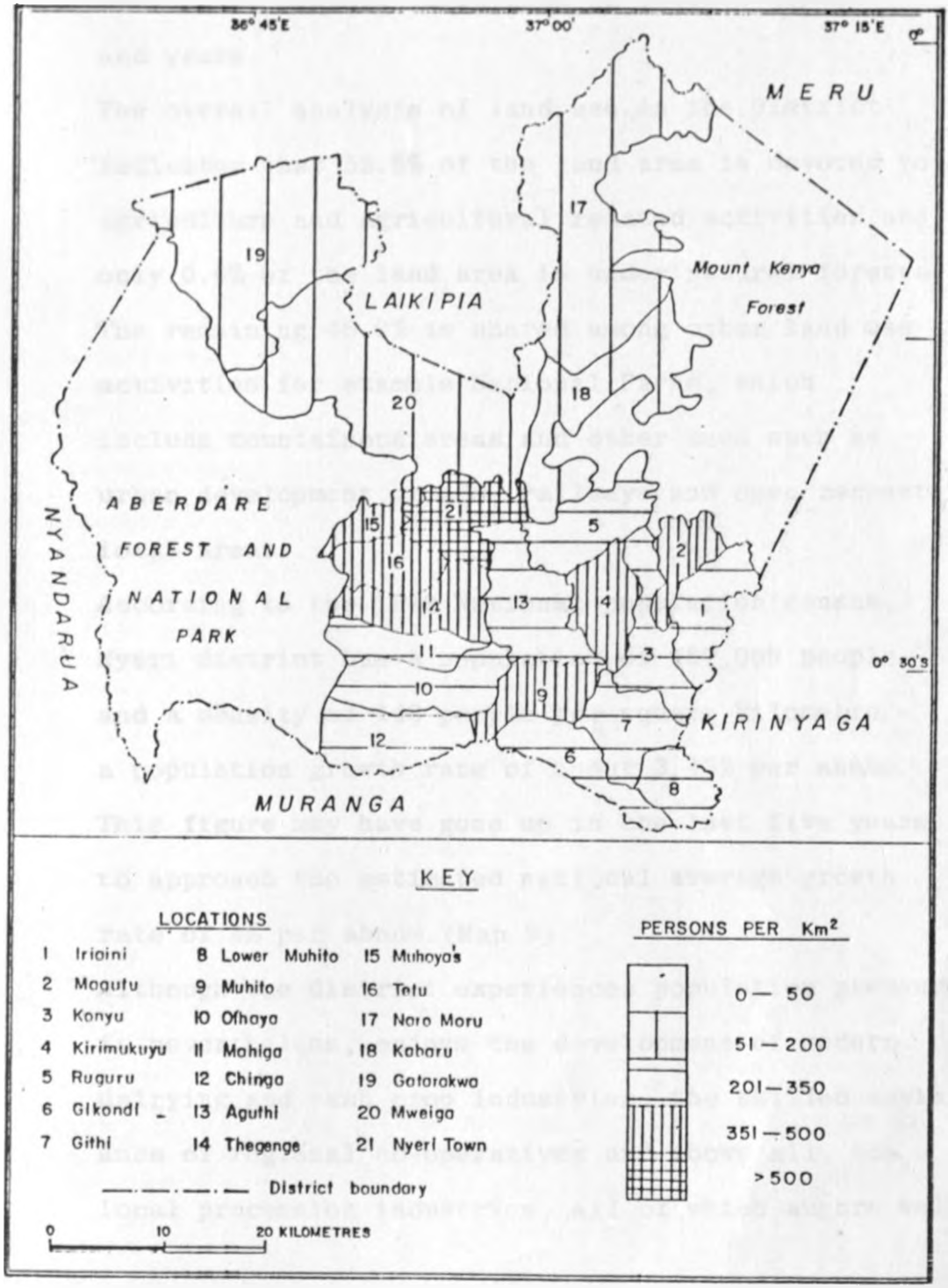
H12	Combisols with ferralsols
L 3	Ortho luvic phaeozems
L 8	Verto luvic phaeozems
L 9	Phaeozems with eutric planasol
L 11	Pellic vertisols
L 12	Pellic vertisols and verto luvic phaeozems
	Forest
	District Boundary

L 14	Eutric planasols
M 2	Humic Andosols
M9	Dystric histosols with lithosols
R 1	Ando humic nitisols and humic nitisols
R5	Nito ferric luvisols with humic nitisols
R 6	Verto luvic phaeozems
R2	Humic nitisols

0 10 20 Km.

MAP 2: SOIL MAP AND ADMINISTRATIVE LOCATIONS OF NYERI DISTRICT

SOURCE Kenya Soil Survey 1982 Exploratory Soil Map of Kenya.



MAP 3: POPULATION DENSITY MAP OF NYERI DISTRICT 1969.

Source: Kenya, Republic of (1979) Nyeri District Development Plan 1979/83.

distributed rainfall pattern, especially in the south with notable variations in between months and years.

The overall analysis of land use in the District indicates that 52.5% of the land area is devoted to agriculture and agricultural related activities and only 0.6% of the land area is under natural forests. The remaining 46.9% is shared among other land use activities for example National Parks, which include mountainous areas and other uses such as urban development, roads, railways and open recreational areas.

According to the 1979 National population census, Nyeri district has a population of 487,000 people and a density of 148 people per square kilometre - a population growth rate of about 3.43% per annum. This figure may have gone up in the last five years to approach the estimated national average growth rate of 4% per annum. (Map 3)

Although the district experiences population pressure, it nevertheless, enjoys the development of modern dairying and cash crop industries, the skilled assistance of regional co-operatives and above all, the local processing industries, all of which augurs well

with a developing economy. (cf. Clayton, E. 1973).

The District is divided into six administrative divisions which are further subdivided into 21 locations and 151 sub-locations, as shown below:

Table 2.0 Administrative Regions

DIVISION	NUMBER OF LOCATIONS	NO. OF SUB-LOCATIONS
Mathira	5	36
Tetu	4	43
Mukurweini	4	23
Othaya	3	25
Kieni East	2	8
Kieni West	2	10
Municipality	1	6
T O T A L	21	151

With that brief background information to the study area we enter the second level of discussion in this chapter which mainly examines the historical events that gave way to the present land use systems in the District. As will be shown in the subsequent section, the existing land tenure system in the District draws

mainly from the designs formulated in the 1950s by J.M. Swynnerton the then Assistant Minister of Agriculture in Kenya. Although the objectives upon which the Swynnerton Plan was built were plausible it will be shown that, this did not augur well with the traditional land ownership system which was so designed as to cater for most members of the community.

2.1 A SHORT HISTORY OF AGRICULTURAL DEVELOPMENT IN NYERI DISTRICT

As in much of the country, farming in Nyeri District has undergone the stepwise evolution from gathering and hunting to sedentary agriculture. However, there are some historical particularities that cannot be generalized.

The early history of agricultural development in this Kikuyu District is based on the theory of agricultural evolution as postulated by Ruthernberg, H. (1966). However, there is little reliable documented information that would elucidate factually the stages of development before the coming of the White Settlers.

According to this chronological sequence the advent of colonisation found the Nyeri Kikuyus practising a system of farming known as the shifting cultiv-

ation. Conklin, H.C. (1961) defined the system as "any continuing agricultural system in which impermanent clearings are cropped for shorter periods in years than they are fallowed". This system was made possible by the availability of large tracks of land which were either unoccupied or were sparsely populated. Several factors may have rendered this system of farming untenable: increased population growth, changes in land tenure laws, leading in some cases, to increased private land ownership, introduction of cash crops et cetera all of which may have restricted the territorial ranges of the shifting cultivators. The range of crops that were being cultivated during these times was quite narrow. Similarly animal husbandry was mainly extensive grazing of traditional breeds such as zebu cattle.

The evolutionary process acquired different dimensions especially due to colonial intervention, moving sequentially from semi-permanent to permanent cultivation as shown in the table below.

TABLE 2.1

EVOLUTION OF FARMING SYSTEMS IN A KIKUYU DISTRICT OF KENYA

YEAR	TYPE OF FARMING	CROPPING PATTERN	LIVESTOCK ECONOMY	LAND RIGHTS
About 1860	Shifting cultivation	Beans/Maize Mixed cropping	Ample grazing Zebu cattle and goats	Ample land, communal rights of land use
About 1920	Semi-permanent cultivation	Maize,beans sweet potatoes mixed cropping	Limited grazing land, zebu cattle and goats	Limited land, rights of land use, communal grazing
About 1950	Permanent cultivation	maize,beans sweet potatoes bananas,wattle	Road side grazing some grade cattle.	Rights of land use, mostly communal grazing turned into individual cropped plots
About 1960	Permanent crops, permanent cultivation, some ley farming	Coffee,maize beans, sweet potatoes, bananas, vegetables, leys,pineapples	Road side grazing some grade cattle	Private property rights, land can be leased and mortgaged.
Estimated expansion path in the 1980s	Permanent crops, permanent cultivation some sprinkler irrigation.	Coffee, tea beans, hybrid maize, sweet potatoes, potatoes, fodder grass Application of mineral fertilizers and stable manure.	grade cattle mostly zero grazing, pigs poultry	Private property rights, land can be leased and mortgaged.

Source: Hans Ruthenberg (1966): African Agricultural production development policy in Kenya 1952-1965. Africa - studiend. Ifo-Inst. wr 10. BerlinHeidelberg. New York 1966.

Two historical periods are worth noting in relation to the factors that have led to the current farming systems in Nyeri District. The 1950s and 1960s underlined the necessity for agricultural reforms and transformation. It was under the famous Swynnerton Plan (1954) that the lands were consolidated and later registered. There were a number of official reasons forwarded as a case for this exercise. The African land tenure system "was said to be inimical to proper land use and rapid agricultural development in that, the structure of access to use rights encouraged fragmentation, subdivisions and was a source of disputes which was inconducive to long-term capital investment' (H.W.O. Okoth-Ogendo 1976). However, there were enormous disadvantages pertaining to this exercise of land reform. The benefits formerly enjoyed by the land-users, through cultivation of different parcels of land were removed. It also created the problem of landlessness. As Okoth-Ogendo (1976) notes, that 'land reform in Central Province was used "essentially" to reward the loyalists among the Kikuyu peasantry at the expense of the Mau Mau supporters'. Or as Lundgren L. (1980) puts it, that the object was not purposefully meant to simplify the procedures of economic and technical support to the farmers but was also

meant to create a stable, politically conservative middle class. Thus the plan failed in its objectives since it condoned the presence of Europeans in the Highlands and landlessness and poverty in perpetuity for Africans.

A point of particular interest to this study, is that through this plan cash crop economy was allowed to penetrate into the heartlands of the agriculturalists and herders. The presence of cash-crops created monocultural systems which to this day play a central role in the Nyeri farmer's decision-making framework. New areas of concern were formed which promised the farmers greater returns per unit of land and labour input. However, these systems contained in themselves problems, constraints and potentials that are no longer limited to the farmer's endongenous characteristics. In fact, the politics of cash-crop growing, marketing and distribution of receipts is an item that cannot possibly be ignored in the overall agricultural policy formulation in Kenya. The role of cash crop economy in Nyeri District is examined in depth in Chapter five. However, it is important to note in passing the rate of cash crop development in the

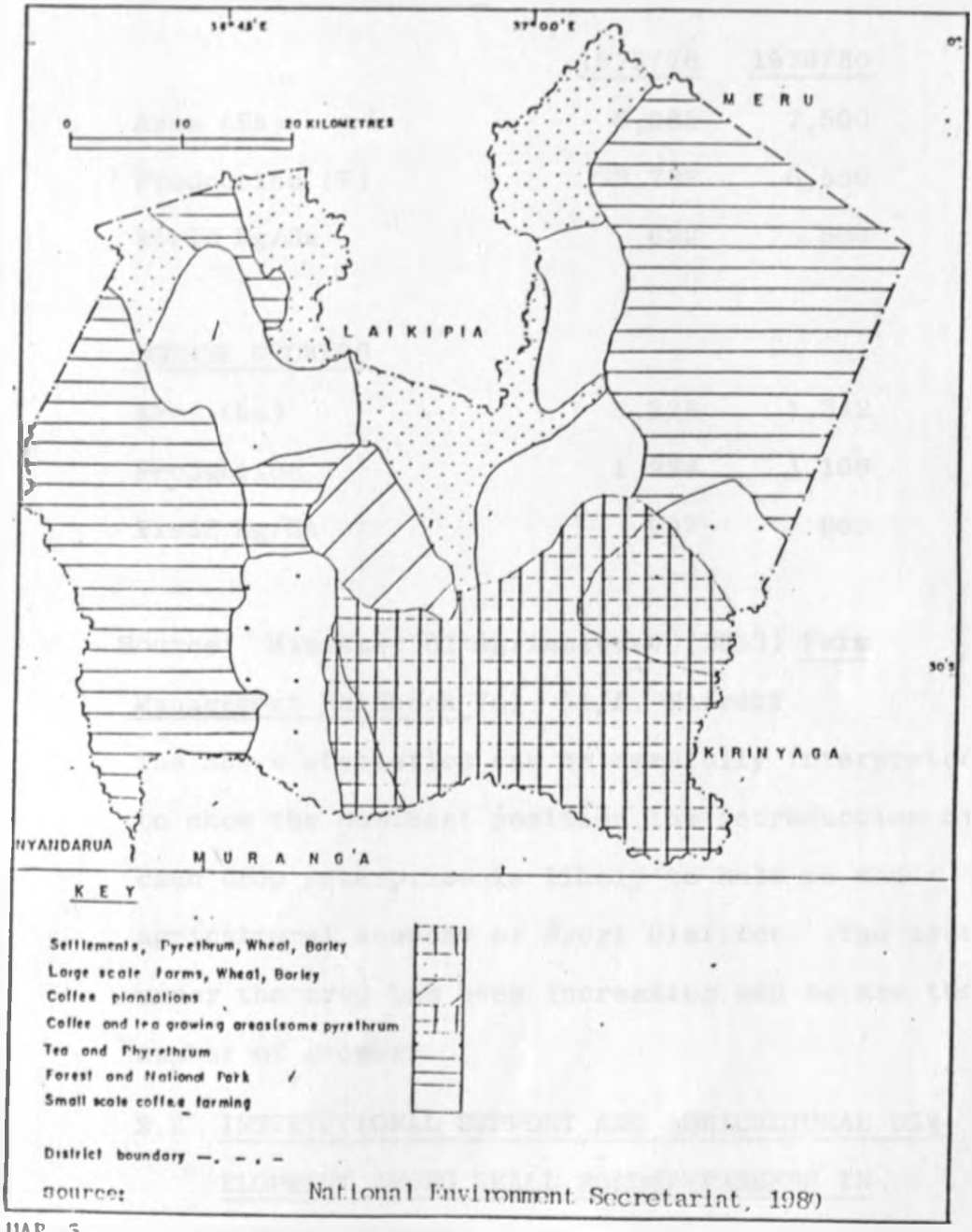
District has acquired an upward rise in the last half decade, following the celebrated coffee "boom" of the 1970s. This is illustrated below by the spatial expansion of cash-crops in terms of hectarage, the rate of adoption and the level of turnover.

Table 2.2

TEA - AREA - PRODUCTION - GROWERS - RETURNS

DIVISION			1975/76	1979/80
MATHIRA	Area	Ha.	4,271	1,462
	Production	Tons	4,271	5,861
	Growers		3,246	3,803
	Yield/Ha		3,702	4,009
	Value/Ha	Shs.	6,862	12,864
TETU	Area		580	831
	Production		1,070	1,445
	Growers		1,771	2,274
	Yield/Ha		1,845	1,739
	Value/Ha		3,378	5,199
OTHAYA	Area		2,052	2,617
	Production (T)		7,450	10,125
	Growers		5,071	6,129
	Yield/Ha		3,631	3,869
	Value/Ha	Shs.	6,643	11,568

Source: KTDA quoted in Farm Management Handbook (1983) Ministry of Agriculture.



MAP 3 COMMERCIAL FARMING IN NYERI DISTRICT

TABLE 2.3

COFFEE PRODUCTION AND YIELDS NYERI DISTRICT CO-OPERATIVE GROWERS

	1975/76	1979/80
Area (Ha)	6,085	7,500
Production (T)	3,786	6,550
Yield Kg/Ha	622	869
ESTATE GROWERS		
Area (ha)	1,228	1,342
Production	1,224	1,166
Yield Kg/Ha	997	869

Source: Ministry of Agriculture (1983) Farm Management Handbook Vol. 11/A. Nairobi.

The above statistics can be carefully interpreted to show the dominant position the introduction of cash crop enterprise is likely to hold in the agricultural economy of Nyeri District. The area under the crop has been increasing and so are the number of growers.

2.2 INSTITUTIONAL SUPPORT AND AGRICULTURAL DEVELOPMENT AMONG SMALL HOLDER FARMERS IN NYERI DISTRICT

The traditional agricultural sector in Nyeri

District is characterized by small-holdings some as small as 0.2 hectares in size. The mode of production is typical of small scale operation applying simple technology and low levels of industrial inputs. The economic undertakings rarely attracts capital from private commercial institutions. Hence, unlike large-scale farmers, the small holder farmer experiences a considerable lack of private institutional support, plus a set of other production problems which differ considerably from farm to farm and region to region.

With the progressive modernisation of agricultural production in Nyeri District, the use of purchased inputs is likely to go up with time. This development invites a more efficient input distribution system. According to the DAOs Official Report (1982) some of the commonly encountered problems of inappropriate packaging, insuffieient supplies and inadequate information accompanying farm inputs have all been identified as areas hindering proper application of scientific methods of farming in Nyeri District among small holder farmers.

Distribution of farm inputs to the small holder farmers has been made more difficult by the lack of

well-established institutions that are entrusted to the work. The private traders, who undertake the work of buying and distributing the required farm inputs are sometimes far placed in the main centres such as Nyeri Town. According to Mathira DEO's Report (1982) traders have been unwilling to purchase inputs from the wholesalers until the first onset of rains. This leads to delays in sowing and thus affects the final level of output, since the sown crops do not tap all the moisture during the rainy period. However, the quicker growing varieties are unlikely to be affected, but if the farmer wished to have a sequence of more than one crop in the same growing season, this may be handicapped.

The distribution of farm inputs and information has been relatively more efficient for those enterprises where there exists well-established institutions to undertake the supply of inputs and sale of farm products. The success of tea, coffee, pyrethrum and dairy enterprises in the District has been due to the existence of a well organized collecting and marketing structure offered by the Kenya Tea Development Authority (KTDA), Co-operative

Societies, Marketing Boards and the Kenya Co-operative Creameries, (KCC).

The KTDA supplies planting materials and fertilizers to farmers on credit terms. At other times the KTDA makes advances to farmers who are establishing new tea hectareages for amounts as small as 0.3 hectares (Trapman C. 1974). Supervision of cultivation of the crop is assisted by the KTDA extension.* Scientific work on better methods of growing several tea varieties and their specific agronomic requirements is one notable research works, being conducted at Kagochi Tea Farm in Mathira Division. A number of factories for processing the green tea leaves are well distributed in all tea growing areas in the District. Chinga, Ragati, and Gathuthi tea factories cater for small scale tea growers in Othaya, Mathira and Tetu respectively. A new factory is also planned for Iriaini in Othaya Division (Development Plan 1979/83).

The attractiveness of tea enterprise is further enhanced by the payment system. Tea growers receive their receipts at the end of each month. This means that the farmer can be in a position to

* Tea Officer, Mathira Division (1983): Personal Communication.

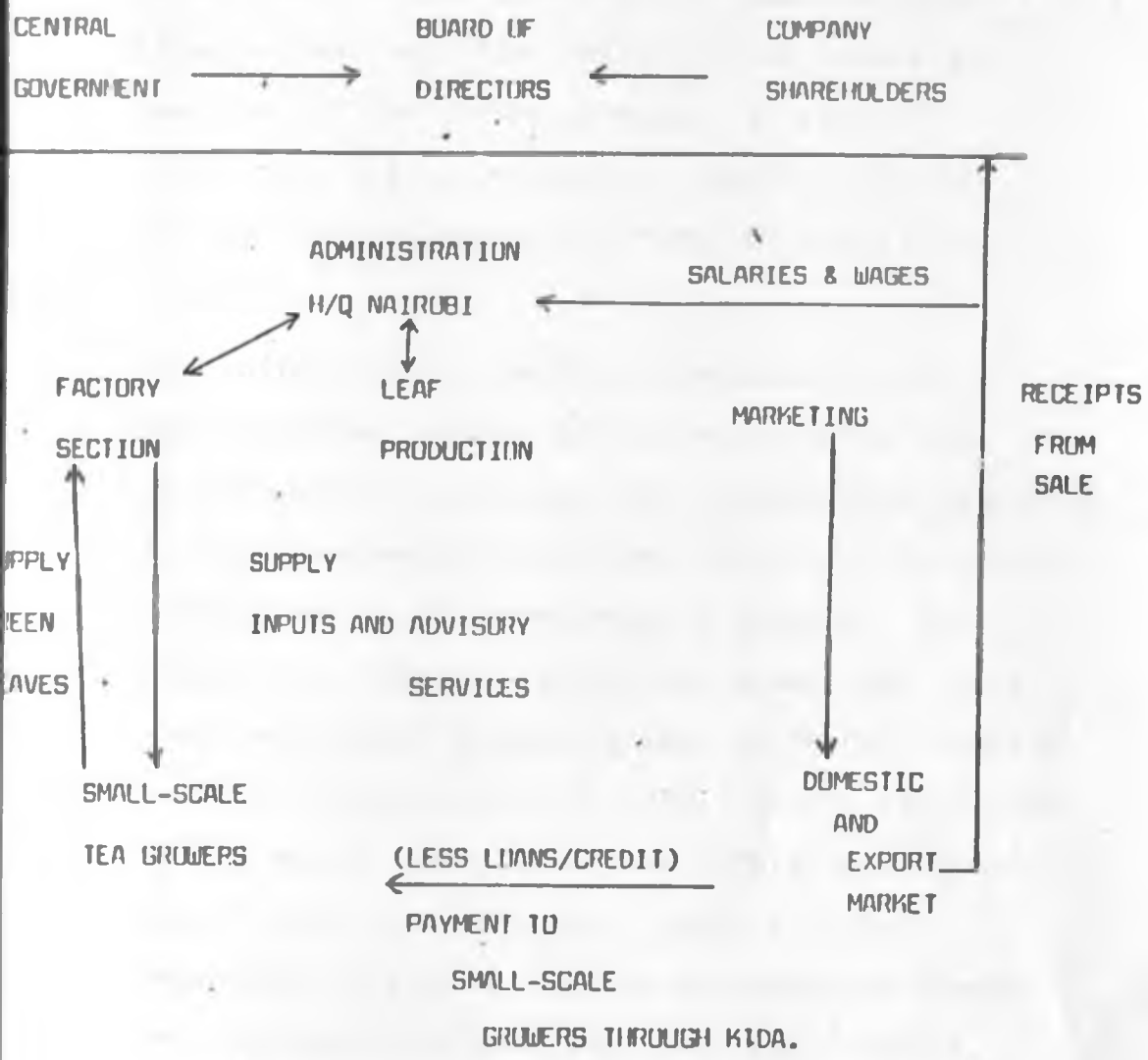
meet his commitments on farm and off farm. The KTDA has further encouraged the development of this enterprise through improved tea roads and very efficient tea leaves collecting system.

ORGANISATION OF THE KTDA

The financing of the continuous expansion of tea production is a joint venture between the KTDA, Kenya Government, World Bank and private tea companies (Republic of Kenya 1969 p.246) The Authority is not involved in tea production on large estates as those in Kericho. It is mainly involved in the promotion of small scale tea growers in the District. Below is a Schematic illustration of its main organisation divisions.

FIG. 2.1

ORGANIZATION OF THE K.T.D.A.



Source; Christiansson C. (1980) Othaya Land use Socio-economy and Environment. Stockholm.

The Coffee enterprise is more widespread in the District than either tea, pyrethrum or dairy. The small scale coffee growers are organized under co-operative societies which provide inputs and markets for the coffee growers. At present there is a coffee co-operative society for each of the four Divisions that form the South Nyeri region.

The coffee industry is not as advanced in its organizational aspects as the tea industry described above. In the past the Co-operative Societies have had innumerable problems related to the general administration and management of finance. This subject is, however, beyond this study, but it is worth mentioning in passing that of 76 Co-operative Societies registered up to 1980, 19 were liquidated and 21 were dormant during the 1979/83 Development period (Dev. Plan 1979/83). This is a clear revelation of a fact that the Co-operative movement is confronted with problems that are probably reflected by what is seen as minor political crisis.

The method of payment to the farmers is a further disincentive to the development of the enterprise. The growers are paid about four months after delivering their harvest. This does not take into

consideration that the farmer has to employ casual labourers or even permanent labourers to perform various duties on the farm, such as pruning, spraying, harvesting and transporting and who cannot wait until the farmer gets his receipts from the Co-operative bank. Hence the farmer may have to borrow funds or sell other commodities to meet these financial commitments. This maybe one of the reasons why a coffee farmer may be reluctant to employ labour or prune, spray or cultivate on time. This enterprise therefore may develop at times at the expense of other farm enterprises.*

Coffee growers, however, look upon this enterprise as a source of great security, since one can obtain loans or credit as long as one is a member of a certain Coffee co-operative Society. As a result there has been quite a bit of expansion in coffee hectarage in the last two decades since Independence.

2.3 OUTLOOK ON THE FUTURE DEVELOPMENT IN THE STUDY AREA

Identification of development potentials and con-

*Ngina Ngacha - DEO Mathira. Personal Communications

straints in the District would lead to a number of development propositions that are likely to enhance development of the region in the context of both agriculture and agricultural related processing industries.

Thus far the District has a number of tea processing factories, coffee pulp factories and a dairy product factory.

The foreseeable potentials for industrial development will have to depend on processing of agricultural products such as fruits and horticultural commodities.

In order to boost up industrial development that draws upon agricultural raw materials, the constraints that militate against higher agricultural production must be overcome, and areas of higher potentials for future development must be identified. The current study is one such effort that hopes to bring to light areas for interventions.

The proposals to be forwarded in this thesis will hopefully generate further research in this District in various aspects of agricultural geography. Thus developing an inventory of knowledge and experience for planners and Research

Scientists. The replication of which will bring about more comprehensive and integrated development policies and programs in the country.

CHAPTER THREE

RESEARCH METHODOLOGY

The success of any piece of research work depends upon a comprehensive method of obtaining information about the characteristics of interest. The techniques employed in the processing, analysing and presenting the acquired information are vital tools that bear strongly upon the successful interpretation of the research results. This is what is embodied in the research methodology. Prewitt K. (1975) simply defines it as: "systematic research procedures and techniques which help the researcher to avoid self-deception".

It is important to note at the outset that, since the study sought to identify the cross-sectional variations in farming practices and management options open to an individual or groups of farmers all parameters thought to influence farmers' decisions were to be considered and evaluated quantitatively. However, since it was not possible to accord quantitative values to all aspects under consideration, the unquantifiable parameters had to be held constant throughout the study. These latter variables include such aspects as social

relationships and other social/cultural practices, some economic and institutional factors such as product input/output, price fluctuations and finally some physical elements such as micro-variations in soils and climate.

Within that general background specific information and the subsequent methods of analysis were addressed namely: (1) The target population (2) The sample frame (3) Sources of information and basic data (4) Method of data analysis and (5) Methods of presenting research results.

3.1 THE TARGET POPULATION

The population was defined by all farming households in Nyeri District. However, since the study's premise was limited to small holder farmers (those owning farms between 0.2 - 8 Ha in size) the sample frame (defined below) was drawn from only that portion of the target population that fell under the definition of small holder farmers. According to the 1979/83 Nyeri Development Plan there are about 56,132 farming households in the District, of which about 90% (or 50,392 farming households) are small-holder farmers. The majority of these farming

households are to be found mainly in Tetu, Othaya, Mathira and Mukurweini Divisions.

3.2 THE SAMPLE FRAME

Although the population constitutes all the characteristics of interest it was not possible to carry out a study based on the population due to shortage of manpower, finance and time. Thus, some form of sampling was involved which defined the sample frame.

Jeffers, J.N.R. (1978) defines a sample as: "any finite set of individuals drawn from a population in such a way that values computed for the sample are representative of the complete population and may be regarded, therefore, as estimates of the values of the population". A sample frame may be defined as a list of those members of the population from which the sample is drawn.

The main purpose of defining a sample frame is to enable the researcher to select from the population a manageable set of members who more or less represent the characteristics possessed by the population. From the sample frame valid conclusions about the population could be drawn. The validity

of such conclusions, however, depends critically upon the sampled population and the procedure used in generating the sample.

It was realised that by drawing a sample, costs of interviewing the respondents were greatly reduced. It also made it possible to obtain more detailed information which otherwise would have been hurriedly passed through. It was later possible to extrapolate observations from the sample to the population.

To maintain the principal objective of determining cross-sectional differences between production performances across the sample it was necessary to employ a sampling procedure that would yield a representative and unbiased sample and still maintain the intended purpose. Multi-stage area sampling procedure was employed.

Multi stage area sampling procedure as the name implies involves area sampling as the first stage (Prewitt, K. 1975). This procedure was adopted because it was found to be more appropriate to the current study relative to other commonly used procedures, such as random sampling, stratified sampling or quota sampling.

One advantage of multi-stage area sampling when based on geographical units is that it can lead to a substantial savings in travelling costs when conducting the interviews (Dillon, J and Hardaker J.B. 1980). Again at the second and any subsequent stages the sampling can be constructed only for those units selected at an earlier stage (F.A.O. 1980). In other words it is possible to build the sampling frame as the process of sampling proceeds.

In contrast stratified sampling demands one to have a sampling frame including the necessary information for stratification, such as farm sizes, age or any other criterion for stratification. According to Dillon ,J. and Hardaker ,J.B. (1980) stratification has the disadvantage of complicating estimation of population parameters and hence sacrifices precision statistics from the sample data.

A major disadvantage that militated against the use of quota sampling is that, unlike multi-stage or stratified sampling, it is a non-probability procedure of drawing a sample. That is," there is no way of estimating the chances of any given individual being sampled, and indeed no assurance that every type of individual has some chance of

of being included". (Prewitt,K. 1975).

Simple random sampling has a number of obstacles which makes it less suitable for the current study. According to Harper,W.M. (1971) a random sample is not necessarily a good cross-section of the population. Again, this procedure is expensive and uneconomic. These obstacles are overcome by using multi-stage, quota or cluster sampling. (Harper,W.M. 1971).

Multi stage area sampling has one key disadvantage over simple random sampling in that, "it takes a larger multi-stage sample than a simple random sample to achieve the same degrees of precision in making estimates about the population" (Prewitt, K. 1975). To overcome this disadvantage some form of random sampling was involved.

In this survey six Divisions of Nyeri District were selected at the first stage. After an examination of farm sizes, Kieni East and Kieni West were excluded. The sampling population therefore consisted of Tetu, Mathira, Othaya and Mukurweini Divisions.

At the second stage sixteen locations were identified which had an aggregated total of 128 sub-locations. In the subsequent stage 63 sub-locations were purposively selected from the sum total of 128 sub-

locations. Purposive sampling as opposed to accidental or random sampling aims at a particular individual or group of objects of interest. In this case the aim was to ensure that the sample selected varied across the population. Using agro-climatic zone maps prepared prior to the actual survey, plus intensive discussions with Divisional Agricultural Officers, it was possible to identify those areas which were sharing more denominators in common than in others. Such denominators include the types of crops grown and the amount of rainfall received per annum.

The sample frame was drawn from the Central Bureau of Statistics (1979) Household Enumeration Areas. Using a Table of Random Numbers the number of households in each of the previously selected sub-locations was determined. In this way an aggregated sample of 198 households was obtained. This procedure has the merit of giving each household in the population an equal chance of being included in the sample.

In the final analysis, however, 32 respondents were eliminated from the analysis for lack of consistent and complete information. Reference to other studies of similar nature (Upton, 1967, Yang, 1982) showed

that the remaining sample of 166 households was sufficient to reduce the standard error terms to an acceptable level. Table 3.1 shows the final lists of the respondents interviewed and the number of sub-locations included.

It should be noted, however, that since the aim of the survey was to test the existence of relationships, rather than to estimate characteristics, the number of units drawn at each stage described above was not necessarily proportional to the size of the population.

CHARACTERISTICS OF THE SAMPLED POPULATION

TABLE 3.1

LOCALITY	TOTAL NUMBER OF SUB-LOCATIONS	NUMBER OF SUB-LOCATIONS SAMPLED	NUMBER OF FARMERS IN EACH LOCATION	NUMBER OF SMALL-HOLDER FARMERS MET.	DESTROYED QUESTIONNAIRES	NUMBER OF RESPONDENTS SELECTED	PERCENTAGE OF FARMERS INTERVIEWED
RUGURU	10	4	2,818	8	1	9	0.28%
MAGUTU	6	4	4,090	8	2	10	0.20%
IRIAINI	6	3	4,399	3	1	4	0.07%
KONYU	7	3	2,554	6	0	6	0.23%
KIRIMUKUYU	7	5	3,722	9	1	10	0.24%
GIKONDI	5	2	3,107	7	5	12	0.23%
GITHI	6	5	3,584	14	0	14	0.39%
MUHITO	9	6	3,557	6	3	9	0.17%
LOWER MUHITO	3	3	1,178	6	4	10	0.50%
OTHAYA	12	6	4,401	23	2	25	0.52%
CHINGA	7	4	1,772	16	1	17	0.90%
MAHIGA	7	5	2,080	10	3	13	0.48%
THEGENGE	12	5	5,971	8	3	11	0.134%
YETU	11	5	2,228	20	1	21	0.89%
AGUTHI	12	2	4,324	5	2	7	0.12%
MUKUYA'S	8	2	1,341	17	3	20	1.27%
TOTAL	128	64	50,392	166	32	198	0.33%

SOURCE: Fieldwork

3.3 SOURCES OF DATA

Various sources of data and information were utilised in order to obtain the relevant information required for both the descriptive and analytical work. These were mainly Primary and Secondary sources. The primary information was obtained through the administration of recording schedules whereas the secondary information was obtained from a number of sources as outlined below.

The respondents were asked to recall information for the preceding year in the case of the amount of product output obtained from a given farm enterprise. They were also required to furnish the interviewer with a set of other information related to internal and external factors that were thought to influence production performances at the farm-level in the following order:-

1) Farm information: Questions in this section probed on those aspects that are related to farm size and land tenure system, with a view to determine those constraints that pertain to land.

2) Crop enterprises: This section contains a list of the possible crop enterprises that an individual farmer is likely to grow. An investigation is

carried out to determine the farmers' future plans in relation to crop enterprises, uses of crop residues and the possible causes of crop failure.

3) Livestock Economy: examines the type of animals kept on the farm and specific problems faced in this regard.

4) Farm Inputs: Questions in this section probe into various types of farm inputs including farm equipments owned

5) Infrastructure: Looks into the extent to which a farmer avails himself of the available infrastructural facilities such as communications, credits, and extension services.

(6) Household data: This section was designed to bring out information concerning the household decision-making environment and the set of constraints met that limit the farmer and his family from achieving their expressed objectives.

On the other hand secondary information was obtained through a collection of readily available information in either published or unpublished forms, namely:

1. Kenya Soil Survey reports and maps, Nairobi.
2. Department of Meteorology, Dagoretti, Nairobi.
3. Wambugu Farmers' Training Centre, Nyeri.

4. Kenya Tea Developemnt Authority, Nyeri.
5. Agricultural Finance Corporation, Nyeri
6. Nyeri, District Development Plan 1979/83
7. Central Bureau of Statistics
8. National Environment Secretariat, Nairobi
9. Divisional Agricultural Officers' Annual reports, Nyeri.
10. Co-operative Societies report, Nyeri.

These documents were useful in the identification of a number of factors including constraints, problems and opportunities for growth and development related to social, economic and natural environment.

In addition to the Government and non-Governemnt records, Agricultural Officers and other knowledgeable persons(chiefs , headmen, agricultural extension officers) were informally interviewed in order to assess their perception of the problems facing the small holder farmers from whom the primary data and information was to be drawn. This exercise was done as an exploratory survey during and after the development of the survey forms. All this information helped in verifying some essential features of the small-holder farming systems.

3.4 DATA COLLECTION

3.5 METHODOLOGICAL ISSUES

Obtaining reasonably accurate data is a major problem in most research works concerned with farm production economics. Most workers get frustrated when they fail to achieve their expressed objectives. This in most cases occur because farmers do not maintain records on inputs and outputs. Therefore, the research workers in most cases depend on the farmers' ability to remember. Data on exact production, hectareage amount of labour man-hours used for various farm enterprises and activities, incomes realised by the individual farmers, and the costs of producing such products are non-existent on record.

Because of financial and manpower constraints it would not be possible for the research worker to offer a thorough all-year round survey of the activities on the farm. "Nor is this desirable since a sample would very soon take attitudes and behavioural characteristics foreign to the population from which it was originally drawn, under the pressure of continued observation". (Zuckerman, 1970 p.9)

In the past two decades or so researchers in Kenya have employed several methods of farm surveys to

collect farm-level information. Heyer,J. (1966) used a case study approach, relying on intensive observations on a small sample of farmers in Kenya. "The case study or model farm approach provides descriptive information on a single farm or a number of farms purposively selected to be representative or to reflect the practices of progressive farmers" (Baker,D.C. 1982). Therefore, this method is inappropriate where the objective of the study goes beyond a certain group of progressive farmers. Cost route and infrequent surveys have also been used by a number of researchers (MacArthur,J.D.1968, Hall,M. 1970). Although the two methods of information collection have proved quite effective in capturing input/output flow of data they are too costly to undertake.

Most advocants of farming systems research, such as Collinson, M.P. et al (1980), Gilbert,et al (1980) and C.G.A.R. (1981) insist on infrequent surveys (or informal surveys). This Method was employed in a recent survey by Hussain,S.A. et al (1982) in A Farming Systems Study in Makueni Location of Machakos District (Kenya). In the final synthesis Hussain reported: "the group found difficulties in

isolating constraints and potential points of intervention in the farming system from which to derive specific hypothesis for research. This was partly due to lack of awareness on the part of the group of the need to focus in fine detail on a limited set of topics and the emphasis placed on the achievement of a very detailed description of the farming system". (Hussain,S.A. et al 1982 p. 56). Another more important limitation noted in the survey methodology was that, "being essentially qualitative in nature, this type of survey cannot easily provide detailed representative quantitative data" (Hussain,S.A. et al 1982 p.57).

An alternative method which has been used in order to reduce the costs associated with multiple visit surveys is multi-stage sampling procedure (discussed above). It was found to be appropriate for the survey area because it ensured a more adequate coverage of the area within a short period at reduced costs.

The recording schedules were administered on a single visit basis whereby the respondent was required to recall information on past performances,

constraints and any changes that he hoped to initiate on the farm. This method had the advantage of reduced survey costs.

In addition to the formal survey forms extra notes were made on a separate piece of paper on any observable aspects that were not included but seemed important and relevant to the current survey.

The following is a more detailed description of the procedural approaches adopted in collecting the relevant data and information.

3.6 SURVEY DESIGN

Baker, D.C. (1982) observed that "in presenting results researchers have devoted little space to justifying the approaches they followed in collecting and analyzing survey data". Such observation has come in the wake of realization that the choice of data collection and analysis procedures may importantly influence survey results. To avoid any confusion as to how the information contained in this study was obtained, the study design of current research was structured along the following lines.

(i) The formal survey forms

(ii) Training and selection of interviewers

(iii) Field work

(iv) Data verification

(v) Data analysis

3.7 THE FORMAL SURVEY FORMS

A large body of knowledge exists on the various methods of designing rural survey forms. A review of some of these reports (Collinson,M.P. 1972, Norman,D.W. 1973, Prewitt,K. 1975, Yang,W.V.1982) indicate on general terms three possibilities of survey form design procedure.

(1) Open ended questions

(2) Closed ended (or structured) questions

(3) a combination of both.

Open ended questions allow farmers to identify problems in their own words. However, this method of questionnaire design tend to introduce intractable problems in the analysis and interpretation of data (Baker,D.C.1982). According to Prewitt,K. (1975) open ended questions create problems in that a respondent may interpret the question differently or may fail to grasp fully the intended meaning, thus the answers become so varied and unstandardised making analysis difficulty. Besides, there are also the

costs of preparing the open ended material for analysis. Prewitt, K(1975) adds that coding of open ended material in terms of a set of response categories can be very time-consuming and costly, especially if the sample is large."

More structured schedules may reduce ambiguity in the interpretation of data. They have, however, the disadvantage of restricting the choices open to the respondents. Thus, "a closed questionnaire forces the respondent to answer in ways that may not accurately or at least not adequately represent his thinking on the issue". (Prewitt, K. 1975).

A slight modification of a structured questionnaire was used in this study, where the respondent was given a selected set of responses and an open option to add any other answer outside the range of the alternatives given. This was done so as to benefit from the merits of structured questionnaire and still allow the respondents the freedom to adequately respond to the question.

3.8 SELECTION AND TRAINING OF INTERVIEWERS

Yang, W.Y. (1982) commented that "a good questionnaire or schedule and skill in subsequent analyses and presentation cannot compensate for mistakes made by enumerators". This spells the need to carefully select and train the enumerators.

Although the survey required more research assistants, only two were selected and trained for this purpose. The criterion of choice depended on their being conversant with both the geography of the area and the local language.

The research assistants were trained on: (1) How to use the schedules to avoid mistakes during the recording. (2) the significance and importance of the work (3) The meaning of each item in the recording schedule (4) techniques of collecting information from farmers and the methods of handling the forms.

During the survey, the researcher lived and worked in collaboration with the research assistants in order to motivate them, resolve any problems that were arising in completing the questionnaires and finally to mediate any problems of co-operation between the interviewers and the farmers. The questionnaires were checked constantly for incorrect recording, lack of data and inconsistency of information.

3.9 INTERVIEWING THE FARMERS

The fieldwork which covered Tetu, Mukurweini, Mathira and Othaya Divisions took about four months. The first month was spent collecting background infor-

mation from published and unpublished public and private documents while at the same time preparing the formal survey forms.

The actual fieldwork began in mid June 1983 and continued into July, August and ended in mid-September. In the process of collecting information directly from the farmers the researcher and the research assistants had first of all to explain to the farmers the nature and the purpose of the study. It was also made clear that the survey had nothing to do with the individual farmers' land or income, but that the survey was essential for local agricultural improvement, and that all information given by the farmer was held in great confidence.

The respondents were allowed freedom to respond to the question without attempting to provide ready answers to the slower respondents. At times farmers provided a lot of information covering most parts of the questionnaire and therefore, the interviewer went through the questionnaire with him just to confirm the answers given. Thus only in very rare occasions was the questionnaire followed chronologically. However, in order to ascertain the correctness of the choices given, it was important to suggest

indirectly to the farmer certain answers, but no deliberate attempt was made in leading the answers. The method adopted in interviewing the farmers had two basic advantages (1) it made it possible to make special notes on some characteristics that could not have been visualized when preparing the recording schedules. The information so obtained was later used in completing the qualitative models on component interactions and the identification of the interrelationship between the on farm production constraints. (2) Although the procedure employed was relatively more expensive compared to self-administered questionnaires, it had the advantage of allowing the researcher to apply self-judgement and on-spot-checks on the reliability of the information given by the respondent.

3.10 DATA VERIFICATION

Both the primary and secondary data and information was first organized and put in a form that could enable further processing. This exercise was important in order to qualify the potential uses of data in fulfilling the research objectives.

The verification exercise involved examining missing

observations, inaccurate data and falsified information. Similarly, it involved conversions of measuring units into some common denominators, for instance, acres into hectares and miles into kilometers.

During this period a code book was prepared and all the verified data was coded into computer sheets and later entered in a data file for further analysis with a statistical package (Statistical Package for Social Sciences).

3.11 DATA ANALYSIS

One of the objectives of this study was to establish relationships between and among various on-farm and off-farm components and how they influence production performances among small holder farmers. To achieve the objective a general approach and a uniform analytical procedure was employed so that data collected across the sample could be analyzed and compared. Thus, simple statistical analysis, tabulations, maps, graphs, histograms, bar charts, and frequency distributions are used throughout the analysis coupled with more complex statistical procedures.

The main aspect of the physical environment examined in this study were: rainfall, temperatures, soils and topography. The analysis of the latter two factors is rather difficult in the absence of specific field data, and therefore, a number of sources of information pertaining to their characteristics were compiled together in a descriptive format.

Since rainfall and temperature were hypothesized to be important factors in the farming systems, water budgets and water availability graphs were drawn employing data from a cross-section of meteorological records. Whenever available data allowed rainfall intensity, variability and probability were calculated.

The following are some of the methods and statistical formulae used throughout the analysis of moisture and temperature availability.

WATER BALANCE

There are a number of ways of expressing the water balance equation. In this study we have chosen one which is simpler to manipulate under the prevailing conditions of data shortage, that is:

Rainfal + inflow = changes in soil water moisture + percolation + runoff + evapotranspiration. Assuming that there is no inflow (for example irrigation water) and considering percolation and runoff as one item, the equation can be written as follows:

$P = E + S + R_o$

P = Precipitation

E = Evapotranspiration

S = Change in soil water storage

R_o = Runoff including percolation

(Runoff results, once the other factors are known)

(Source: Darnhoffer T.1983)

RAINFALL MEANS AND STANDARD DEVIATION

$$S = \sqrt{\frac{(\Sigma (x-\bar{x})^2)}{N}}$$

S = Standard deviation

X = The individual values of total annual rainfall

X = The mean of the sum of the total annual rainfall

N = The number of observations

RAINFALL RELIABILITY PARAMETERS

A frequently used measure of rainfall reliability is the coefficient of variation (v) defined as the

ratio of standard deviation to the mean.

$$COV = \frac{\sigma}{\bar{X}} \times 100\%$$

where: S is the Standard deviation while $\bar{X}$ is the mean of N observation of variable X. (Ogallo L.J 1981).

Rainfall intensity

I = P/N (Nieuwolt ,1977)

where:

I = Rainfall intensity

P = Total amount of rainfall for each month

N = Total number of rain days per month

Length of the growing season

Long periods = 0.159 (p) - 18.73, r = 0.88

Short periods = 0.126 (p) - 35.36, r = 0.85

(FAO/UNFPA, 1980)

This formula was however, used for comparison purposes only since the length of the growing period was graphically computed.

Having examined statistical tools for analyzing the physical environment data it is in order to extend our analytical framework to include statistical tools for analyzing the socio-economic data.

In this analysis multiple regression technique was used to analyze the input factors affecting crop production performances. This is a general statistical technique through which one can analyze the relationship between a dependent or criterion variable and a set of independent or predictor variables.[1] The advantages of using multiple regression analysis are that it reduces the dangers commonly encountered in "piecemeal" research of single inputs and it facilitates the investigation of broad problems which may not have been considered researchable before.

The multiple regression is a much more efficient method of analyzing data than cross-tabulation or single correlation analysis because we can:

(1) Determine the simultaneous impact of a number of variables on a single dependent variable

(2) find out the predictive accuracy of the independent variables combined

(3) determine the amount of variance in the dependent variable explained by each of the

1 Kim Jae - On and Kohout, F.J. (1975) Multiple Regression Analysis:- in Nie, N.H. et al (1975) SPSS. p. 320

independent variables.

(4) Discover the relative contribution of each independent variable.

(5) write a regression equation that will enable us to predict the dependent variable various values of the independent variables.[2]

The general form of a multiple regression is:

$$Y = B_o + B X_i + B_2X_{2i} + B_3X_{3i} + \cdots B_{pi} + Ei$$

where:

Y = the dependent variable

B_o = intercept term along X - axis

Bis = 1.....P the model regression parameters referred to as the partial regression coefficients.

Ei = random disturbance or error term:

$Ei - N (\emptyset , \emptyset^2)$

The data of multiple regression are represented in a matrix form as shown:

2 Nie, N.H. et al (1975) Statistic Package for Social Sciences.

X_1	X_2	X_3	$\cdots X_p$	Yo
X_{11}	X_{21}	X_{31}	$\cdots X_{p1}$	Y_1
X_{12}	X_{22}	X_{32}	$\cdots X_{p2}$	Y_2
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
X_{1n}	X_{2n}	X_{3n}	X_{pn}	Y_n
ΣX	ΣX_2	ΣX_2	ΣX_p	ΣY_o

The parameters of regression are valid for predictive purposes only when the following assumptions are met:

(1) Each array of Y of the population follows the normal distribution

(2) The regression of Y on $X_i \cdots\cdots X_p$ is linear or the regression equation is:

$$U_{y.x} = B_o + B_1 X_{11} + B_2 X_{2i} \quad B_p X_{pi}$$

(3) The variance of all arrays of Y of the population are equal.

(4) The samples are drawn at random (regarding Y)

(5) The X values are measured without error and/or remain constant for all samples and do not change from sample to sample.

If the above five conditions are fulfilled, the sum of squares of the dependent variable can be partitioned in an analysis of variance table and the general hypothesis can be tested that:

$B_1 = B_2 = B_3 \cdots B_p = 0$

The total sum of squares of the dependent variable (Y) can be partitioned into two components as shown:

TOTAL SUM OF SQUARES = REGRESSION SUM OF SQUARES + ERROR SUM OF SQUARES

A measure of goodness of fit is then provided by the coefficient of determination.

$$R^2 = \frac{\text{SS Reg}}{\text{SSy}}$$

which lies between 0 and 1. $R^2 = 0$ indicates the absence of any relationship at all in the data and $R^2 = 1$ indicates a perfect fit.

R is the multiple correlation coefficient, which is a measure of the association between the dependent and the independent variables.

Given the assumptions above the two expressions must be distributed as an F - distribution with P and (n - P - 1) degrees of freedom: The calculated expression

$$F = \frac{SS_{Reg/P}}{SS_{Reg/n-P-1}}$$

may be compared against against a critical value selected from the F distribution tables with P and (n-P-1) degrees of freedom to test a null hypothesis of no significant relationship among variables analysed. The F ratio tests whether the X_s exercise any influence upon Y.

3.12 RESEARCH LIMITATIONS

A number of factors may be taken to constitute the major weaknesses of this study. Some of these are related to the content matter of the study report and others are related to the methods applied in conducting the study. But, overall under all the constraints and identified shortcomings it is believed that the study objectives were achieved. The following is an outline of those factors that are believed to have affected the final findings of the study.

DATA COLLECTION PROBLEMS

(a) Nyeri District is a vast geographic area and could not possibly be given a fair coverage within the time and financial abilities that were open to this study.

(b) Most farmers in the District did not maintain farm records and therefore "recall method" was used.

Secondly, it was difficult to divide fields into plots because (i) in most cases different persons in the family farmed different parts of the field (ii) the size of the fields expressed in either acres or hectares did not take into account the topographic variations,a factor which tended to exaggerate the area of land a farmer owns that can be farmed. (iii) Specific areas covered by each crop were estimated by the farmer and there were no better methods available to clarify the reliability of such estimates.

PRODUCTION DATA

It was becoming increasingly difficult to obtain information on per enterprise output for some crops such as maize, potatoes, cassava, vegetables and other subsistence crops. This was basically because some crops were never harvested in full, but were collected from the farms as and when the need arose. The farmer often gave production figures in baskets thus making it difficult to estimate the quantity harvested. Therefore in the final analysis only for those crops that data seemed more reliable were included. This is a major shortcoming since all these crops influence and are part of the farming system. To make the analysis complete therefore

these crops were identified and listed as part of the farm enterprises since they involve the farmer in some form of decision-making. In addition secondary data was included in the analysis to render a clearer understanding to the subject.

INFORMATION

Obtaining accurate information from the farmers was pretty difficult in the absence of an agricultural extension officer. Some farmers wilfully and reluctantly withheld some vital information. In some cases, some of the questionnaires were only partly completed and hence had to be discarded in the final analysis.

ABSENCE

The period during which the fieldwork was conducted - June to August 1983 - were relatively busy times both on the farm and outside the farm. The farmer and his wife were either absent in markets, coffee factories or tea collecting centres. The interviewer relied on making appointments with a mumber of farmers. However, this only partially solved the problem, because only one of the farm worker was left at home to meet the interviewer, so that the major constraint arose from the fact that some information could only be obtained from both the

man and his wife or wives. In majority of the cases the wives did not know the size of the farm or the output obtained from coffee, tea and dairy. On the other hand, the men were reluctant to divulge the information related to food crops. This in the long run resulted in many questionnaires being discarded for lack of complete and reliable information.

POLITICAL FACTOR

The research period coincided with a time when the National Elections were just about to be held (1983) There were a lot of uncertainities among farmers. Thus besides farmers being out of their farms to attend campaign meetings and "Harambee" fund raising, they were more interested in political talks and expressed a lot of suspicions on the true objectives of the research. Especially information pertaining to land, acquired a wider dimension of sensitivity.

UNRELATED INFORMATION

At this time in Kenya's history the issue of soil conservation and environmental protection had become an important area which had been highly publicized in the rural areas. Farmers always expected a question related to the number of trees they have planted, the number of bench

terraces they had cut and so on. In most cases the farmers feeling that the question will never come up volunteered to give the information by carefully introducing the topic. Some farmers felt that they had given enough information as a result and did not want any more questions. This became another source of "bad questionnaires".

Efforts were however, put to try and obtain as much information as the farmer could offer by extending the period of stay on the farm. Therefore only those questionnaires with complete and reliable information were included in the final analysis.

METHODOLOGY

Finally, before proceeding with the rest of the chapters, it is important to point out that the researcher's methodological approach has a number of limitations as has been shown so far in this chapter and as will be seen in the subsequent chapters. Therefore, interpretation of the findings should be looked at in this light. This shortcoming has, however, been partially overcome by inclusion of a broad spectrum of qualitative information in the analysis, which has enabled the researcher to explore much more fully the underlying concepts.

CHAPTER FOUR

SOME PHYSICAL ENVIRONMENTAL FACTORS INFLUENCING AGRICULTURAL DEVELOPEMNT IN NYERI DISTRICT

4.1 INTRODUCTION

Agriculture dominates other economic activities as a source of income in Nyeri District. Thus, little material progress can be made in the social and economic lives of the people unless this sector is addressed directly. The physical potential for agricultural development in the District is high in relative terms, but the physical environment also creates immense obstacles to development. Some of these constraints can be overcome by application of advanced science and technology while others can hardly be overcome.

In this chapter, a detailed examination of some of these physical elements is given with a view to determine the extent of variations in agricultural activities that are brought about by the cross-sectional differences in the natural resource endowment.

The central thesis is that physical elements in any given location determine what a farmer can produce, how and when to produce. Here we have

in mind certain ecologic parameters such as rainfall (its intensity, effectiveness and reliability), temperatures, soils and topography. Of these parameters rainfall pattern, its distribution, reliability, intensity and effectiveness is possibly the most important factor to a farmer. It is the main cause of undertainties that surround the farmer's decision-making environment. On the other hand, soils, surface configusation of the land and temperatures are equally useful determinants of the farming activities at the regional level. However, some of these technical elements are difficult to quantify at this level due to paucity of accurate data. Therefore only those technical elements that are readily quantifiable will be included in the discussion, while the others are not. Only the climatic elements are examined deeply in an attempt to test in rather general terms hypothesis one stated in chapter one, that is, "variations in the farming system types are directly related to the variations in monthly and annual average precipitation and temperatures soils and land surface configurations". The initial intention of relating specific crop output to variation in climatic factors was dropped in favour of a general discussion due to lack of accurate cross-sectional data.

This chapter is divided broadly into four sections. Section one, and possibly the most important, contains

an analysis which covers three main agro-ecological zones - The upper and lower Highlands and the midland zones. Section two and three attempt to evaluate, at rather broad level, the relationships between soils, land surface configurations and the farming systems. Section four is a final synthesis of the descriptive and analytical findings which attempts to verify or reject the hypothesis that "variations in farming system types are directly related to the variations in monthly and annual average precipitation and temperatures, soils and land surface configurations."

4.2 SOME CLIMATIC ELEMENTS AND THEIR RELATIONSHIP TO FARMING SYSTEMS:

In view of the great expanse of the study area, it was found necessary to consider and analyse climatic data from more than one meteorological station, in order to evaluate local differences meaningfully. The choice of the meteorological station was determined by two considerations:

1) availability at the station of data records having all the parameters needed for the various computations.
2) the representativeness of the station to a given agro-ecological zone. Following these

requirements, two stations were chosen from the Upper Highland zone, one from Lower Highland zone and two from the Midland zone.

It is important to note at the outset that due to data limitation specific crop physiological requirements are not examined, rather from the analysis specific crop potentials and constraints are inferred depending on their existence in the particular zone. The fundamental importance of this analysis is that it provides a basis for making broad statements on the type of farming system that would be expected and is suited to the area.

This information, it is hoped, would make it easier to plan for the suitable crops.

The general farming calendar and the identified growing periods in each zone are positive attributes that would aid in planning for the agricultural sector. The farmer's behaviour towards the time of rainfall onset having been identified for each particular zone becomes an important planning tool that will synchronize recommended practices and the actual practices at the farm level.

The knowledge of the length of the growing season per zone is another positive attribute to this exercise. It makes it easier to relate the growing period with specific plant species physiological

requirements.

To accomplish the above tasks, water budgets have been computed for each of the identified Agro-ecological zones. The information is presented in the form of water availability diagrams and whenever possible, rainfall intensity, variability, reliability and effectiveness are calculated for each agro-ecological zone.

4.3 WATER AVAILABILITY ASSESSMENT FOR SPECIFIC AGRO - ECOLOGICAL ZONES IN NYERI DISTRICT

Individual plant species have specific water requirements to achieve certain levels of growth. Whether a plant species attains its water requirement level or not at a particular location is a factor dependent mostly on the level of precipitation, evapotranspiration rates, and the moisture holding capacity of the soil. To quantify the degree to which water requirements are met by the supply (Precipitation), the ratio between the rainfall amount and the potential evaporation or evapotranspiration is often used (Darnhofer,T. 1983). This ratio is used to characterize water availability classes in agro-climatic assessments.

The period during which water requirements by a particular plant species is met is commonly referred to as the growing period.

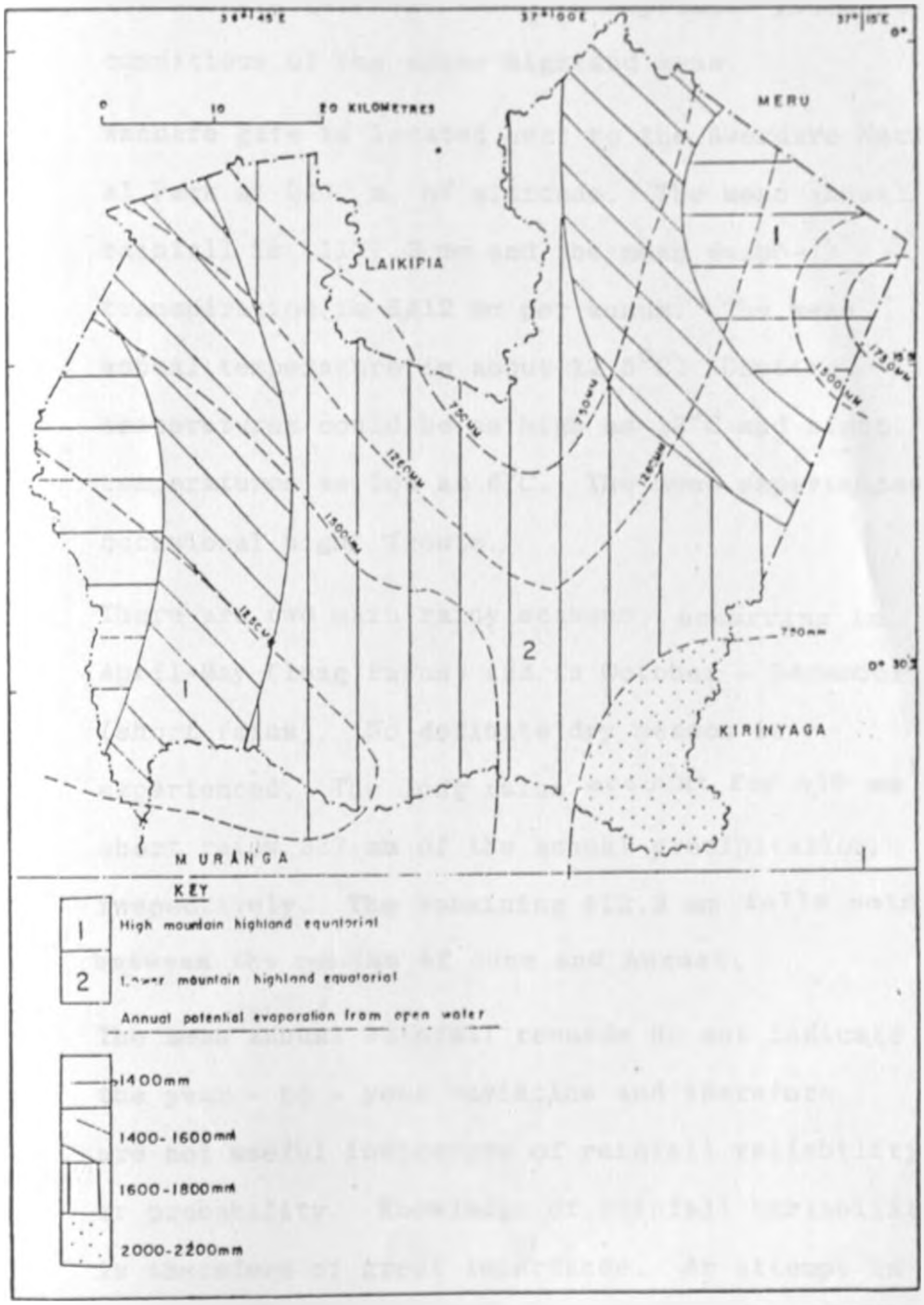
The Food and Agriculture Organisation of the United Nations,. (1978) defines the growing period as "the continuous time during the year, from the time when rainfall exceeds half the potential evapo-transpiration (calculated by Penman Method) until the time when rainfall falls below full potential evapotranspiration, plus a number of days required to evaporate assumed 100 mm of soil moisture reserve when available."

The potential evapotranspiration (E_T) is normally considered to be 20 to 25% less than E_o, (the potential evaporation from an open water surface), mainly due to higher radiative reflection (Albedo) of plant cover, compared with water surface (Darnhofer,T. 1983).

In addition to precipitation, evapotranspiration and soil water availability, local conditions and agricultural practices will similarly affect water requirements. However, it is difficult to quantify and analyse these effects since they would require specific local field data.

The following sections have outlined the specific methods used to compute climatological data at each meteorological station in each agro-ecological zone. The included map shows at a glance the immense

interaction between rainfall amounts and the level of potential evapotranspiration. It can be seen that potential evapotranspiration is lowest in the high mountain areas and highest in the lower mountain areas. These happen to be areas with higher to lower annual average rainfall, respectively (Refer to Map 6).



MAP 6: CLIMATE MAP OF NYERI DISTRICT (Source National Environment Secretariat 1980)

4.4 THE UPPER HIGHLAND ZONE

The rainfall, temperature and evaporation data for Wandare gate was taken to represent climatic conditions of the upper highland zone.

Wandare gate is located next to the Aberdare National Park at 2400 m. of altitude. The mean annual rainfall is 1177.3 mm and the mean evapotranspiration is 1412 mm per annum. The mean annual temperature is about 12.5°C. Daytime temperatures could be as high as 18°C and night temperatures as low as 6°C. The zone experiences occasional night frosts.

There are two main rainy seasons, occurring in April-May (long rains) and in October - December (short rains). No definite dry season is experienced. The long rains account for 438 mm and short rains 327 mm of the annual precipitation, respectively. The remaining 412.3 mm falls mainly between the months of June and August.

The mean annual rainfall records do not indicate the year - to - year variation and therefore are not useful indicators of rainfall reliability or probability. Knowledge of rainfall variability is therefore of great importance. An attempt is

made here to examine the reliability of rainfall records by the use of coefficient of variation for this zone.

The coefficient of variation is defined as the ratio of standard deviation to the mean, given by the following formula:

$V = 100\ S/\overline{X}$ (Ogallo,L.J. 1981).

Where S is the standard deviation, while $\overline{X}$ is the mean of N observations of variable X.

The table below gives the calculated monthly and annual standard deviation and coefficient of variation for the period 1972 - 1982.(Table 4.1)

Table 4.1

CALCULATED MONTHLY AND ANNUAL STANDARD DEVIATIONS AND COEFFICIENT OF VARIATION (C.O.V)

Month	Mean(mm)	S.D.(mm)	C.O.V.(%)
Jan	78.7	50	63.3
Feb.	92.4	56	60.6
Mar.	105.2	51	48.5
April	191.1	103	53.9
May	141.7	43	30.3
June	55.8	29	52
July	55.6	25	45
Aug.	69.2	41	59
Sept.	60.6	39	64
Oct.	96	24	25
Nov.	133.8	41	30.6
Dec.	97.2	48	49.4
ANNUAL	1177.3	171	14.5

The larger the coefficient of variation the greater the month-to-month or year-to-year rainfall variability. The 14.5% C.O.V. is comparable to 12.2% obtained, as the least value for East Africa, at Ngora, Uganda by Ogallo, L.J.(1981). However, there are big variations within each month, especially January-February and August-September. These are the months when dry conditions are likely to be encountered.

A further analysis of the climatic conditions involves the determination of the rainfall intensities. The mean rainfall intensity is often indicated by rainfall per rainy day using the formula:

$I = P/N$ (Nieuwolt, 1977).

where: P = total amount of rainfall for each month and N = total number of rain days per month.

The table below shows rainfall intensities for this zone as calculated from the mean monthly rainfall and mean number of rainy days.

Table 4.2 RAINFALL INTENSITIES

Month	Rainfall Mean (mm)	Mean no of rainy days	Mean rainfall per rain day
Jan	78.7	13	6.05
Feb.	92.4	12	7.7
Mar.	105.2	14.2	7.4
Apr.	191.1	20	9.6
May	141.7	19.5	7.3
June	55.8	12	4.7
July	55.6	14.3	3.9
Aug.	69.2	14.7	4.7
Sept.	60.6	.9.3	6.5
Oct	96	14.2	6.8
Nov.	133.8	19.3	6.9
Dec.	97.2	15	6.5
	1177.3	177.5	6.6

The annual rainfall per rainday is shown to be 6.6 mm. The greatest rainfall intensity is in the month of April while the lowest is in the month of July. It can be seen from the table that the intensity of rainfall varies tremendously from season to season being heaviest in the rainy season.

4.5 INTERPRETATION OF THE WATER AVAILABILITY DIAGRAM

The rainfall reliability and intensity analysis could not help us to estimate the amount of water available to the plants during the growing period. Therefore a further analysis was made using the water budget and water availability diagram to be able to assess the actual period over which plants can grow with adequate moisture available for their various physiological processes.

The water balance equation takes the form $P = E_o + S + R_o$ (Darnhofer T. 1983)

where P = Precipitation

E_o = Evaporation

S = Change in soil water storage capacity

R_o = Runoff including percolation

This formula is applicable where there is no inflow such as irrigation. Since in Nyeri District irrigated agriculture is rarely found on small holder farms, the analysis may not deviate from the actual environmental conditions facing the small-holder farmers.

4.6 THE WATER BUDGET

The water budget provided below was computed from an 11 year precipitation and evaporation data. The soil water reserve was empirically assumed at 100 mm according to F.A.O. (1978).

The information contained in the water budget table was later used to establish the water availability diagram which shows the conditions graphically.

At this site, the potential evapotranspiration is exceeded by the precipitation in April-May and November-December. The water surplus, however, does not meet the assumed soil water storage capacity of 100 mm. Accordingly, there is no run-off to be considered on the basis of the monthly data.

Rows ten and eleven indicate the monthly ratio P/E_o and Ep/E_o which designate the water availability classes. To estimate the availability of water periods to the nearest day, graphical smoothing

of the monthly rainfall and evaporation amounts is used (Darnhofer,T. 1983).

Now referring to the water availability diagram below, we can deduce a number of things.

SOIL UNIT:

NITOSOL — WATER BUDGET WANDARE GATE ABERDARE NAT. PARK NYERI. — LOCATION: 0° 15' S, 37°E — ALTI. 2400 M. A. S. L. — MEAN

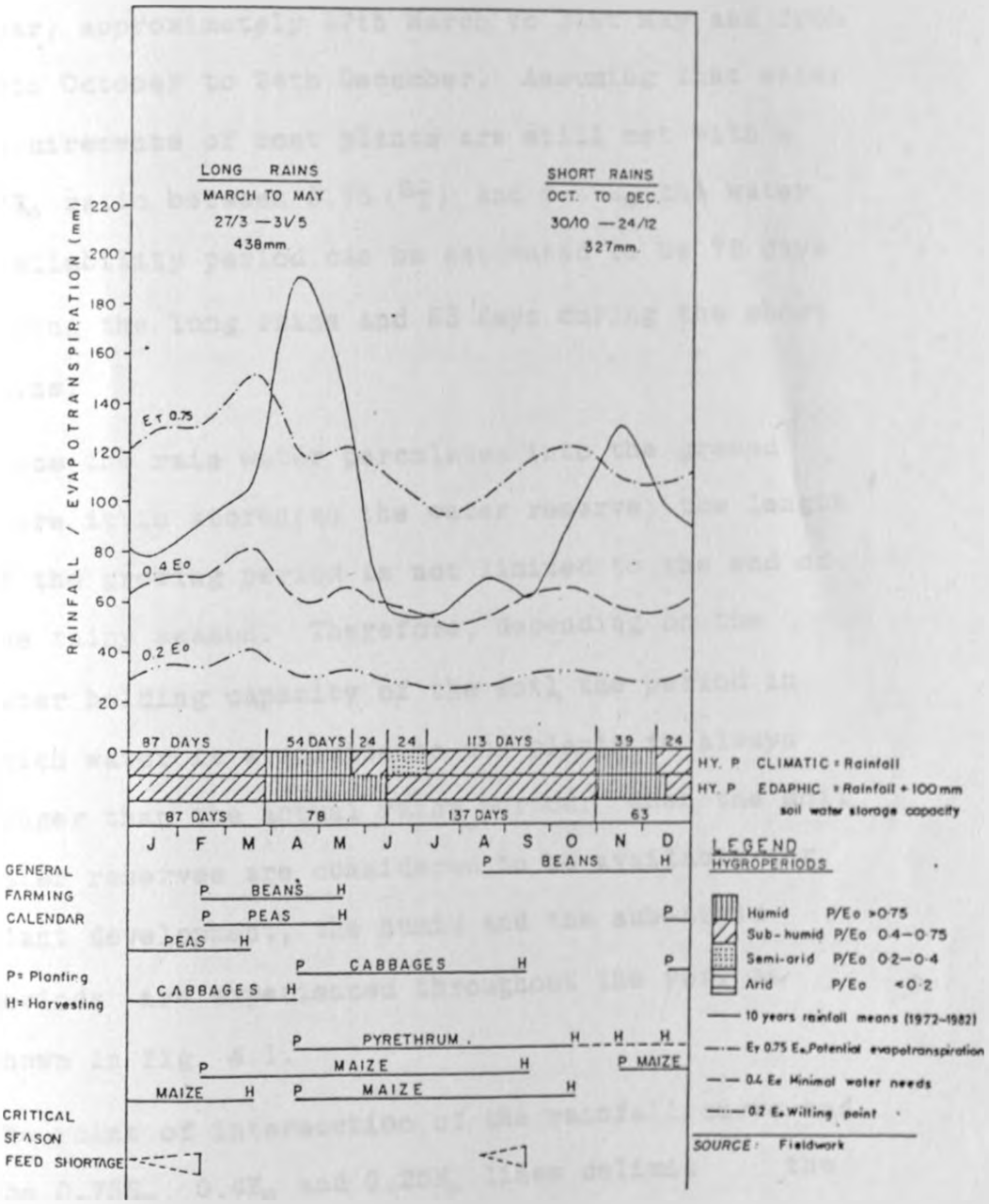
	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1. P(MM)	78.7	92.4	105.2	191.1	141.7	55.8	55.6	69.2	60.6	96	133.8	97.2	1177.3
2. E_T	129	131	152	117	122	109	94	101	117	122	110	108	1412
3. P-E_T	-50.3	-38.6	-46.8	74.1	19.7	-53.2	-38.4	-31.8	-56.4	26	23.8	-10.8	
4. GST				74.1	93.8						23.8		
5. GCH				74.1	19.7	-93.8					23.8	-23.8	
6. WD	50.3			38.6	46.8		38.4	31.8	56.4	26			287.4
7. WS													
8. E_p	78.7	92.4	105.2	117	122	109	55.6	69.2	60.6	96	110	108	1123.7
9. R_o													
10. P/E_o	0.46	0.53	0.52	1.23	0.87	0.38	0.44	0.51	0.388	0.59	0.91	0.68	
11. E_p/E_o	0.46	0.53	0.52	0.72	0.75	0.75	0.44	0.51	0.388	0.59	0.75	0.75	

E_T = Potential Evapotranspiration (0.75 x Pot. Evaporation E_o) in mm
P = Precipitation in mm (E_o Pan Evaporation or Calculated values)
WD = Water deficit
WS = Water Surplus
GCH = + Ground water charge or - Ground water discharge
GST = Ground water storage (maximum assumed 100mm)
R_o = Runoff (Surplus after 100mm ground charge)
E_p = Effective Rainfall: $E_p = P-R_o-GCH$
P/E_o = Water availability ratio without ground water reserves (climatic Hygroperiod)
E_p/E_o = Water availability ratio with ground water reserves (Edaphic Hygroperiod)

TABLE 4.3

Fig. 4.1 WATER AVAILABILITY DIAGRAM (monthly data)
NYERI: WANDARE GATE, ABERDARE NATIONAL PARK

LOCATION 0° 15 S, 37°E
ALTITUDE 2400 m
MEAN ANNUAL RAINFALL 1177.3 mm
MEAN ANNUAL EVAPOTR 1412 mm (1972-1982)



It can be seen that rainfall exceeds the value of potential evapo-transpiration twice on average year; approximately 27th March to 31st May and from 30th October to 24th December. Assuming that water requirements of most plants are still met with a P/E_o ratio between 0.75 (E_T) and 0.4 E_o the water availability period can be estimated to be 78 days during the long rains and 63 days during the short rains.

Since the rain water percolates into the ground where it is stored(as the water reserve) the length of the growing period is not limited to the end of the rainy season. Therefore, depending on the water holding capacity of the soil, the period in which water is available to the plants is always longer than the actual rainy period. When the soil water reserves are considered to be available for plant development, the humid and the sub-humid periods are experienced throughout the year as shown in fig. 4.1.

The point of intersection of the rainfall curve and the $0.75E_o$, $0.4E_o$ and $0.25E_o$ lines delimit the humid, sub humid, semi-arid and arid periods.

The analysis made in this study shows very clearly that the double rainfall peaks are separated by

two lower rainfall regimes in June-September and December-February, but there is no real dry month. Therefore, the pattern of rainfall distribution is not a strong limiting factor to plant growth during a normal year. However, referring to an earlier analysis on rainfall variability, it was shown that month-to-month variability, is high, especially in the months with lower rainfall regimes. These then are periods when optimal water requirements for some plants is never met. Crops with shorter growing cycle and low moisture requirements can, however, be grown.

The main climatic constraint is low temperature which often lead to occasional frosts. This factor selectively limits the range of crops that are found within this zone.

A look at the available data (Rainfall, Evaporation and Temperature) and checking them against the various climatic or agro-climatic classification systems this zone can be related to: (1) Koppen classes (AM) Tropical rain forest, permanently humid with short dry season (2) Jaetzold, R. Upper Highland '1' Sheep - Dairy zone, with permanent cropping possibilities, divisable into a long to very long cropping

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season followed by a medium one (3) F.A.O. Major Climate '3' Cool tropics or tropical highlands with 270 days growing period.

The climatic conditions described above allow for the growth of peas, potatoes, cabbages, maize (only in frost free lower areas) and pyrethrum. However, as is explained in later chapters, pyrethrum is not widely grown . Besides crop farming, animal husbandry, mainly dairy cattle and sheep-keeping, is a widespread economic activity. This is made possible by the cool climate and availability of high quality feed from Kikuyu grass and napier grass which has been adopted by most of the farmers in Nyeri District.

The climatic conditions as described in this section in no way provide sufficient bases for planning for agricultural development in this zone. However, they show the degree to which climatic elements could be a source of great potential and constraints to plant growth.

4.7 KIANDONGORO METEOROLOGICAL STATION

An additional meteorological station was chosen from the upper highland zones to provide a good basis for comparison of the climatic conditions in this zone.

It is located at 0° 27'S, 36° 50'E at 2378 metres of altitude. The mean maximum annual temperature is 17.9^{o}C and the mean mimimum annual temperature is 9.5^{o}C.

A distinctly bimodal rainfall regime is encountered in the months of April-May (Long rains) and October-December (Short rains). The former period accounts for 691 mm and the latter 510 mm of the total annual rainfall. The remaining 594 mm is evenly distributed through the months of December to February and June to September.

The calculated rainfall intensity using the formula 1 = P/N is shown in the table below:

Table 4.4

CALCULATED RAINFALL INTENSITIES

Month	Mean Rainfall (mm)	Mean no. of raindays	Mean rainfall per rainday
Jan.	94	5	18.8
Feb.	84	4	21
Mar.	99	15	6.6
April	358	27	13.3
May	333	20	16.7
June	88	21	4.2
July	88	21	4.2
Aug.	87	22	3.9
Spt.	67	9	7.4
Oct.	178	9	19.8
Nov.	205	20	10.3
Dec.	127	14	9.1
ANNUAL	1795	187	9.6

The annual rainfall per rainday is 9.6 mm and the highest intensity occurs in the month of October. The months of June-July get the lowest intensity. This indicates the heaviest storms are experienced in the short rain period, unlike in the Wandare gate station where the heaviest storms are experienced in the long rains period.

Referring to the water budget and the water availability diagram, the potential evapotranspiration is exceeded by the precipitation in the months of March-August and October-December. The assumed 100 mm of soil water storage is met in eight our of twelve months. The water that cannot be absorbed in the soil is assumed lost through run-offs.

The last two rows indicate the monthly ratios P/E_o and E_p/E_o which refer to water availability classes. In nine cases the P/E_o is greater than E_p/E_o, which means that the supply of rainfall at this site in these times exceeds the actual evapotranspiration, otherwise referred to as effective rainfall.

The water availability period on both climatic and edaphic considerations is greater than 300 days (maintaining the earlier stated assumptions).

This site could be related to: (1) Jaetzold R. (1983)

Upper Highland '2', pyrethrum - wheat zone, with a very long cropping season and intermediate rains (2) Koppen's (AF) Tropical rain forest, permanently humid. (3) F.A.O. (1980) Major Climate '3' Cool tropical highlands comprising continuous growing periods.

At this site like the previous site rainfall is not a limiting factor to plant growing. Other factors such /low temperature, soil leaching and /as erosion could be contributing to low crop yields. At times too much rainfall could also be a limiting factor.

The farming system types are similar to those of the first site.

WATER BUDGET. KIANDONGORO, NYERI. MONTHLY AVERAGES

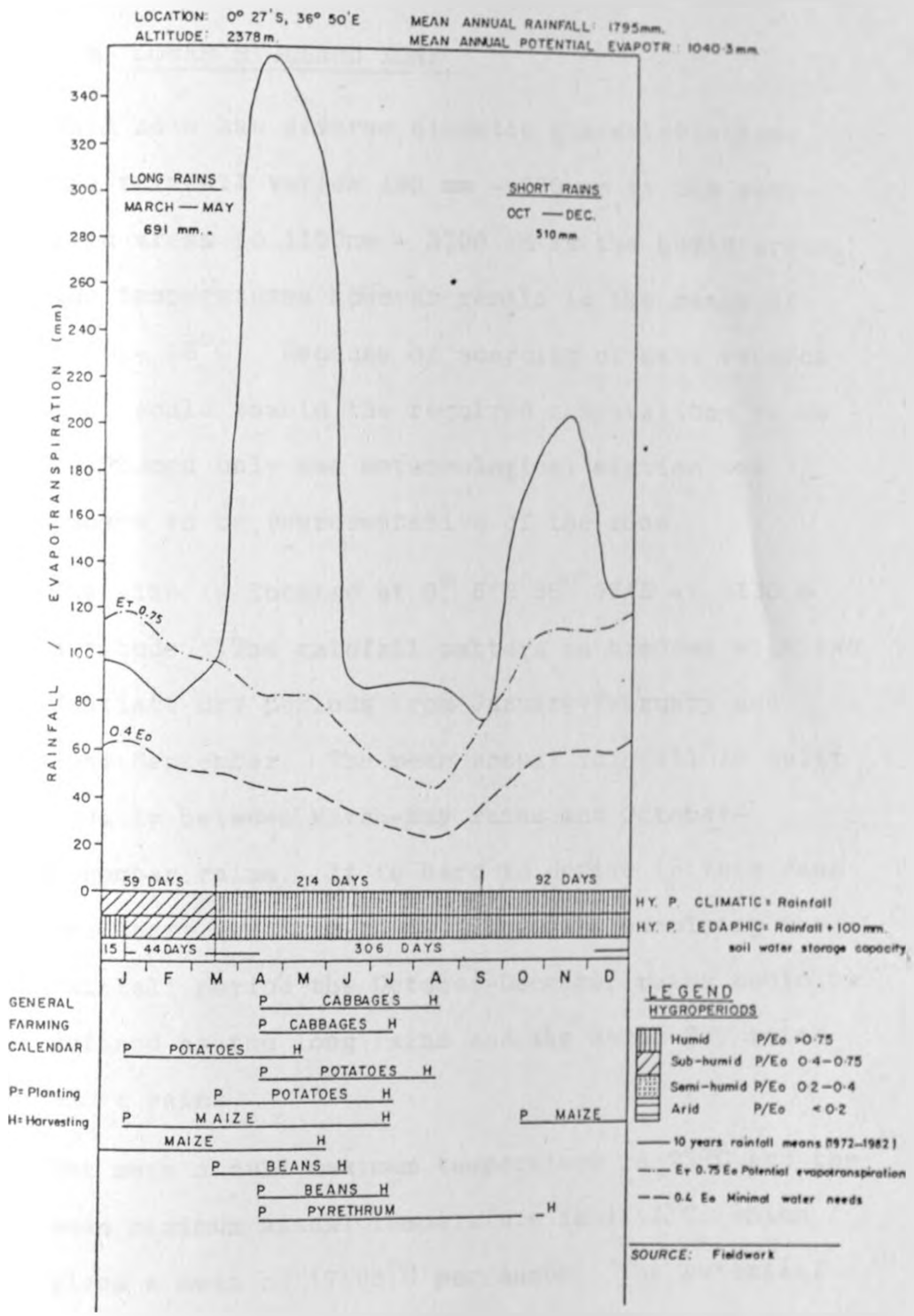
LOCATION: 0° 27' S 36° 50'E. 2378M ALT.

	J	F	M	A	M	J	J	A	S	O	N	D	TOTALS
P(MM)	94	84	99	358	333	88	88	87	67	178	205	127	1795
E_T	118.2	101.85	96.15	82.73	83.25	66.83	51.4	44.3	71.2	102.83	110.83	111	1040.57
$P-E_T$	-24.2	-21.85	2.85	275.27	-50.25	21.17	36.6	42.7	-4.2	75.17	94.37	16	
GST	75.8	53.95	56.8	100	49.75	70.92	100	100	95.8	100	100	100	
GCH	-24.2	-21.85	2.85	97.15	-50.25	21.17	36.6		-4.2	4.2			
WD													
WS			2.85	275.25		21.17	36.6	42.7		75.17	94.17	16	563.91
E_p	118.2	101.85	96.15	82.73	83.25	66.83	51.4	44.3	71.2	102.83	110.83	111	1040.57
R_o				178.12			7.52	42.7		70.97	94.37	16	
P/E_o	0.59	0.62	0.77	3.25	3.0	0.99	1.28	1.47	0.71	1.29	1.39	0.86	
E_p/E_o	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	

E_T = Potential Evapotranspiration (0.75 x Pot. Evaporation E_o) in mm.
P = Precipitation in mm (E_o Pan Evaporation or calculated values)
WD = Water deficit
WS = Water Surplus
GST = Ground water storage (maximum assumed 100mm).
GCH = Ground water charge or - Ground water discharge.
R_o = Runoff (Surplus after 100mm ground charge)
E_p = Effective Rainfall: $E_p = P - R_o - GCH$
P/E_o = Water availability ratio without ground water reserves (climatic Hygro period)
E_p/E_o = Water availability ratio with ground water reserves (Edaphic Hygro period)

TABLE 4.5

Fig. 4.2: WATER AVAILABILITY DIAGRAM (monthly data)
KIANDONGORO STATION, ABERDARE NATIONAL PARK



4.8 LOWER HIGHLAND ZONE

This zone has diverse climatic characteristics. The rainfall varies 450 mm - 900 mm in the semi-arid areas to 1100mm - 2700 mm in the humid areas. The temperatures however remain in the range of $14^{o}C$ - $18^{o}C$. Because of scarcity of data records that would enable the required computations to be performed only one meteorological station was chosen to be representative of the zone.

The site is located at 0° 6'S 36° 59'E at 2130 m altitude. The rainfall pattern is bimodal with two distinct dry periods from January-February and June-September. The mean annual rainfall is split equally between March-May rains and October-December rains. It is hard to define in this case the short and long rains. However, examining the rainfall period the October-December rains could be defined as the long rains and the March-May rains short rains.

The mean annual maximum temperature is $23^{o}C$ and the mean minimum annual temperature is $11.1^{o}C$. which gives a mean of $17.05^{o}C$ per annum. The potential evapotranspiration (assumed to be 75% of the potential evaporation) is of trimodal pattern, with maximal values of 102 mm in the months preceeding the most

important rainfalls (March, October). The calculated rainfall variability using the formula $V=100S/\bar{X}$ is 26.4%. This is a relatively high rainfall variability which indicates at the outset that rainfall can be a very strong limiting factor to crop production.

In addition to rainfall variability, the intensity of rainfall is also an important indicator of the effectiveness of rainfall. The calculated rainfall intensity using the formula I = P/N is tabulated below.

Table 4.6 CALCULATED RAINFALL INTENSITIES

Month	Mean Rainfall	Mean no of raindays	Mean rainfall per rainday
Jan.	43	3	14.3
Feb.	37	4	9.25
Mar.	72	9	9
Apr.	120	16	7.5
May	57	11	5.2
June	19	6	3.2
July	26	4	6.5
Aug.	26	7	3.7
Sept.	14	6	2.3
Oct.	72	14	5.1
Nov.	104	14	7.4
Dec.	73	7	10.4
ANNUAL	664	101	6.6

January is the month with the highest rainfall per rainday and September has the lowest with 2.3 mm. This indicates the large seasonal variation and also that the heaviest storms accur in months outside the main rainfall seasons.

Precipitation exceeds the potential evapotranspiration only in two months of the year, that is April and November. The assumed 100 mm of soil water storage is never met and therefore there is no runoff considered on the basis of monthly data.

Under the working assumptions there are 82 days which can climatically be said to be humid and sub humid in the first season and 84 days in the second season in similar respects. There is a period of 54 days which can be said to be arid and two others of 63 days and 82 days which are semi-arid.

This site could be related to:(1) Jaetzold R. (1983) Lower Highland '3' Wheat/Maize - Barley zone (2) Köppen's 'AW' Savanna, two wet seasons (3) F.A.O. (1980) major climate "3" cool tropics or tropical highlands with less than 120 days growing period.

WATER BUDGET NAROMORU/WARAZO, RUWARE FARM, NYERI. LOCATION. 0° 6'S 36° 59'E ALTITUDE. 2130M.

	J	F	M	A	M	J	J	A	S	O	N	D	TOTALS
P(MM)	43	37	72	120	57	19	26	26	14	72	101	73	664
E_T	102	102	102	102	85.5	74.25	74.25	102	102	102	74.25	102	1124.25
P-E_T	-59	-65	-30	18	-28.5	-55.25	-48.25	-76	-88	-30	29.75	-29	
GST				18							29.75	0.75	
GCH				18	-18						29.75	-29	
WD	59	65	30		28.5	55.25	48.25	76	88	30		29	509
WS													
E_P	43	37	72	102	57	19	26	26	14	72	74.25	73	615.25
R_o													
P/E_o	0.32	0.27	0.53	0.88	0.5	0.19	0.26	0.19	0.10	0.53	1.05	0.54	
E_P/E_o	0.32	0.27	0.53	0.75	0.5	0.19	0.26	0.19	0.10	0.53	0.75	0.54	

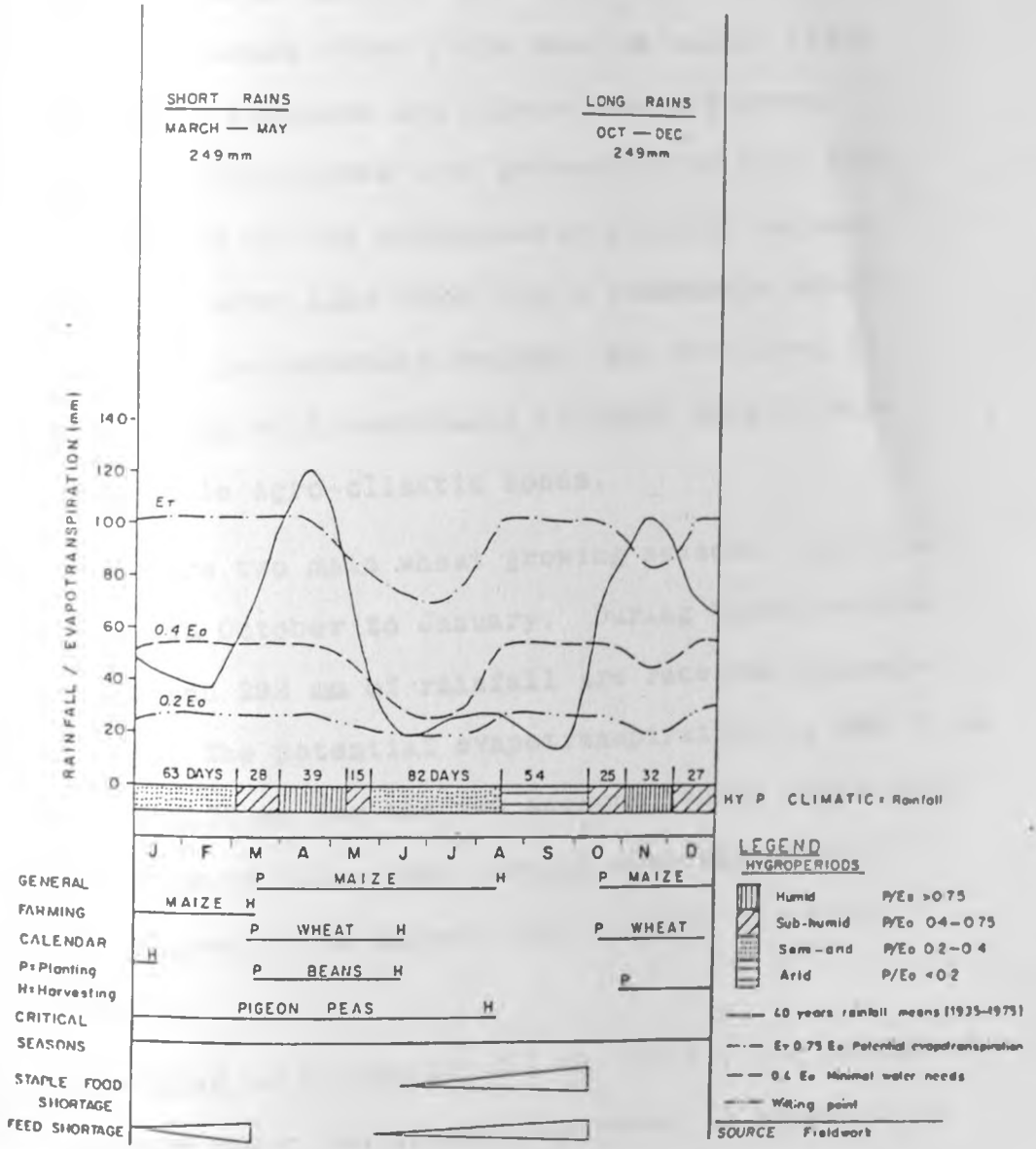
E_T = Potential Evapotranspiration (0.75 x Pot. Evaporation E_o) in mm
P = Precipitation in MM (E_o Pan Evaporation or Calculated values)
WD = Water deficit
WS = Water Surplus
GST = Ground water storage (maximum asumed 100mm)
GCH = Ground water charge or - Ground water discharge
R_o = Runoff (Surplus after 100mm ground charge)
E_P = Effective Rainfall i.e. $E_P = P - R_o - GCH$
P/E_o = Water availability ratio without ground water reserves (climatic Hygro period)
E_P/E_o = Water availability ratio with ground water reserves (Edaphic Hygro period)

TABLE 4.7

Fig. 4.3: WATER AVAILABILITY DIAGRAM (monthly data)
NYERI: NAROMORU/WARAZO RUWARE FARM

LOCATION: 0° 6'S, 36° 59'E
ALTITUDE 2130 m

MEAN ANNUAL RAINFALL. 664 mm (1935–75)
MEAN ANNUAL POTENTIAL EVAPOTR. 948 mm



The main restriction for annual crops in the bimodal area is the short duration of the humid season (humid = P exceeds 0.75 E_o)

The main crops grown in this area are wheat and barley, though other crops such as maize, beans, potatoes, cabbages and pigeon peas are grown. As previously noted crop production in this area is limited by the unfavourable rainfall regime. Though a crop like wheat has a remarkable adaptation to low moisture regimes, but the level of production will inevitably be lower than in more favourable agro-climatic zones.

There are two main wheat growing seasons, March to June and October to January. During these periods 268mm and 292 mm of rainfall are received respectively. The potential evapotranspiration is 363.75 mm and 380.25 mm for the two seasons, which means that the rate of water loss through evaporation and transpiration is higher than the rate of water supply.

According to Eijanatten, C.L.M. (1977), the estimated average water requirement for wheat in season I is 322 mm and 324 mm in season II, which according to the above statistics is never met. Thus, it would

appear that this region requires fast growing and drought tolerant plant species.

In addition to crop growing, this area is most suited to livestock rearing on ranches, since land sizes are not as limiting as in other parts of the District.

4.9 MIDLAND ZONES

The midland zones are characterized by generally high temperatures and a diverse moisture availability zones. At an altitude between 1500 - 1850 m the temperatures range from 18 - 20°C and climatic classification is normally humid with 1100 - 2700mm of rainfall per annum. The climatic classification is further referred to as semi-humid to semi-arid when the average annual rainfall obtained falls between 600 - 1100 mm. The midland zones occupy much of the area below the slopes of the Aberdares and Mt. Kenya. The zone covers the whole of Mukurweini Division and some parts of Tetu, Mathira and Othaya. Hence, the micro-climatic variations due to the diverse physiographic features is expected to be high. For this reason two sites located about 30 km from each other but on the same zone were selected to be representative of

this zone. These are Tumutumu and M.O.W. Meteorogical stations.

4.10 NYERI M.O.W. METEOROLOGICAL STATION

The site is located at 0° 26'S, 36° 57' E on 1829m altitude. The mean annual temperature is about $17.35^{o}C$. The mean maximum and mean minimum annual temperatures is $19^{o}C$ and $14.9^{o}C$, respectively. A distinctly bimodal rainfal regime is encountered. The rainfall maximum occurring at the time of the equinoxes and the minimum at the beginning and in the middle of the year. The first maximum occures at or around April and May which forms a climatically humid period of about 61 days and wet conditions which may last for 91 days or more when we take the soil water storage capacity into consideration.

The second maximum occurs in the period from October to December, with a peak in November which is barely humid. The humid and the sub-humid conditions may last for about 52 days.

These two moist periods are seperated by periods of three and four dry months, respectively.

The mean annual rainfall of 886 mm is divided into 394 mm and 267 mm for the long and the short rain season, respectively, while the remaining

225 mm (or 25%) falls mainly between June to August (in what is commonly referred to as the "Gathano" rains). The amounts that are experienced in January-February have little significance to agriculture but help in pasture development.

The potential evaporation is highest in the early months of the year January-March and lowest in the middle months of the year and then rises again to the end of the year. Thus the Potential Evapotranspiration has a bimodal pattern.

WATER BUDGET M.O.W. STATION NYERI (MONTHLY AVERAGES FOR THE PERIOD 1940-1946)

LOCATION: 0° 26' S, 36° 57'E ALTITUDE, 1829M A.S.L.

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
P(MM)	49	46	62	167	165	27	32	39	32	81	104	82	886
E_T	133.7	139.8	133.7	115.5	100.3	91.2	72.9	91.2	112.5	121.6	100.3	103.3	1316
$P-E_P$	-84.7	-93.8	-71.7	51.5	64.7	-64.2	-40.9	-52.2	-80.5	-40.6	3.7	-20.3	
GST				51.5	100	35.8					3.7		
GCH				51.5	48.5	-64.2	-35.8				3.7	-3.7	
WD	84.7	93.8	71.7				5.1	52.2	80.5	40.6	17.6		446.2
WS					16.2								16.2
E_p	49	46	62	115.5	100.3	91.2	67.8	39	32	81	100.3	85.7	869.5
R_o					16.2								
P/E_o	0.27	0.27	0.35	1.09	1.20	0.23	0.34	0.33	0.22	0.49	0.78	0.57	
E_p/E_o	0.27	0.27	0.35	0.75	0.73	0.77	0.72	0.33	0.22	0.49	0.75	0.59	

E_T = Potential Evapotranspiration (0.75 x Pot. Evaporation E_o) in mm.

P = Precipitation in mm (E_o Pan Evaporation or Calculated values)

WD = Water deficit

WS = Water Surplus

GCH = + Ground water charge or - Ground water discharge

GST = Ground Storage (maximum assumed 100mm)

R_o = Runoff (Surplus after 100mm ground charge)

E_p = Effective Rainfall ie, $E_p = P-R_o - GCH$

P/E_o = Water availability ratio without ground water reserves (Climatic Hygroperiod)

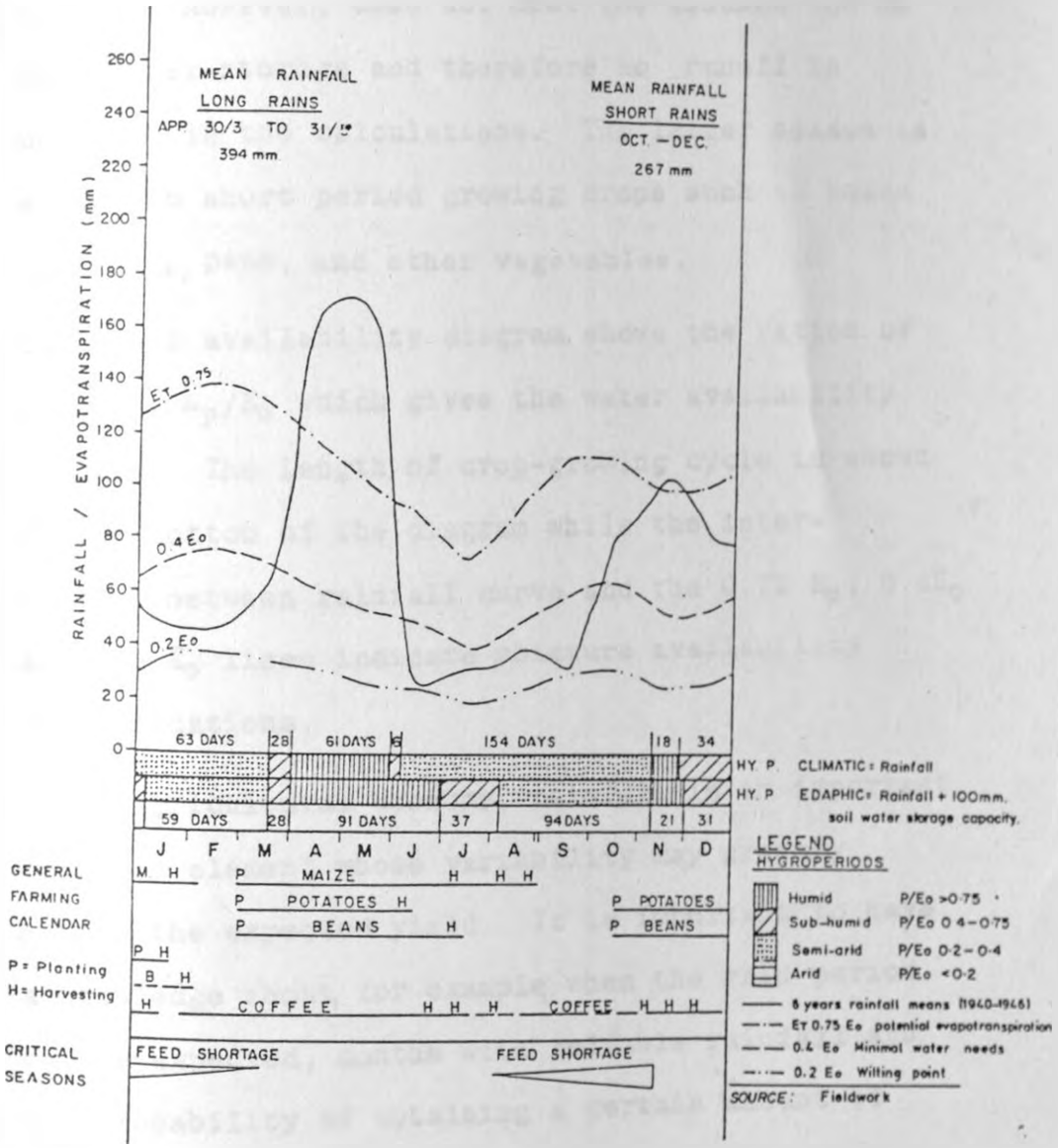
E_p/E_o = Water availability ratio with ground water reserves (Edaphic Hygroperiod)

TABLE 4.8

Fig. 4.4: WATER AVAILABILITY DIAGRAM (monthly data)
NYERI: MoW STATION

LOCATION 0° 26' S, 36° 57' E
ALTITUDE 1829 m

MEAN ANNUAL RAINFALL 886 mm (1940–46)
MEAN ANNUAL POTENTIAL EVAPOTR. 1316 mm



Precipitation exceeds potential evapotranspiration in April, May and November, resulting in a water surplus in May. The surplus water experienced in November however, does not meet the assumed 100 mm soil water storage and therefore no runoff is expected in the calculations. The latter season is suited to short period growing crops such as beans, potatoes, peas, and other vegetables.

The water availability diagram shows the ratios of P/E_o and E_p/E_o which gives the water availability classes. The length of crop-growing cycle is shown at the bottom of the diagram while the intersection between rainfall curve and the 0.75 E_o, 0.4E_o and 0.2 E_o lines indicate moisture availability classifications.

In an agricultural economy, rainfall is an important climatic element whose variability may greatly affect the expected yield. It is important to have a knowledge about, for example, when the rain period can be expected, months with reliable rainfall and the probability of obtaining a certain amount of rainfall over a given period.

In order to estimate the probability that a certain amount of rainfall is exceeded during a season or

month, the method of ranking the seasonal or monthly rainfall as described by H.M.H. Braun (1977) was used for both Nyeri M.O.W. and Tumutumu Meteorological data records.

The table below shows the results of the unranked and ranked monthly totals for March-May and October-December for M.O.W. station. The average and the median is calculated for two seasons. In March-May period the median is slightly higher than the average rainfall. The interpretation to this is that, there are more March-May seasons with above average rainfall than with below average rainfall. The October-December period, the median is lower than the average, which means below-average rainfall is occurring more often than above average rainfall. the probability values are given in the next table. From ranked totals per season it can be seen that the probability that 50, 100, 150, 200, 250, 300 and 350 mm of rainfall will be exceeded in the first season is 93.3%, 73.3% 26.7%, 10%, and 0% respectively. And the probability that the same amounts will be exceeded in the second season is 86.7%, 30%, 6.7%, 3.3%. 3:3%, 3.3% and 0%, respectively. This implies that for crops with 90 days of growing cycle and requiring more than 100 mm of rainfall

the growth can be assured at 73.3% in the long rains and at only 30% in the short rains.

Climatic classifications that would seem to tarry with the parameters provided are:

(1) Jaetzold's UM2 or UM3 main to marginal coffee zone with a medium cropping season and a short cropping season

(2) Koppen's "AW" Savanna, two wet seasons 4-8 dry months

(3) F.A.O. Major Climate "2" Moderately cool tropics or tropical highlands with less than 120 days of growing period.

Coffee is the main cash crop for the area while maize, beans, /potatoes, sweet potatoes constitute /irish the staple food crops. Whether this area is marginal for coffee growing or not is a fact that cannot be easily established. According to W.M.O. EA. 1973) Coffee has nowhere been completely controlled by ecological or climatic conditions", mainly because of the high value of the crop thus it has often been established in areas far from climatically ideal, or even suited to the crop". According to this source the most productive areas for coffee will be found within 1500-2300 mm above sea level

with mean annual rainfall of 900 - 1300 mm.

Dairy farming is another form of land use that is widely practised in this area, but as shown on the general farming calendar, low rainfall at some times of the year creates problems of seasonal shortage of animal feed.

TABLE 4.9

THE SEASONAL RAINFALL (in MM) AT M.O.W. STATION NYERI

FROM 1931 TO 1960

YEAR	MARCH-MAY	OCT-DEC	RANKED MARCH-MAY	NO.	OCT.-DEC.
1931	145.3	86.7	40	1	20
1932	167	94	42	2	41.7
1933	40	318	75	3	46
1934	165	65.7	79	4	47
1935	107	141	88.7	5	58
1936	133	41.7	91.3		64
1937	194.7	119.7	91.7	7	65.7
1938	79	106.3	95.3	8	67
1939	120	47	100.3	9	68
1940	147	80	107	10	68.3
1941	122	104.7	112.3	11	74.7
1942	175	80	115	12	79.3
1943	91.7	68	120	13	80
1944	88.7	99.3	122	14	80
1945	112.3	85.3	130.7	15	80.7
1946	75	80.7	133	16	85.3
1947	244.7	68.3	133	17	86.7
1948	91.3	74.7	144	18	93
1949	42	67	144.7	19	94
1950	152	46	145.3	20	97
1951	206	161.7	146	21	99.3
1952	95.3	20	147	22	10
1953	100.3	97	152	23	106.3
1954	144.7	93	165	24	112.3
1955	133	112.3	167	25	114.3
1956	146	58	175	26	119.7
1957	201.3	140	194.7	27	140
1958	130.7	79.3	201.3	28	141

YEAR	MARCH-MAY	OCT-DEC	MARCH-MAY	NO	OCT-DEC
1959	144	114.3	206	29	161.7
1960	115	64	244.7	30	318
AVERAGE	130.3	93.12	130.3		93.12
MEDIAN			131.85		83

MARCH-MAY, THE PROBABILITY TO RECEIVE MORE THAN:

50	100	150	200	250	300	350(MM)
28:30	22:30	8:30	3:30			
93:3%	73.3%	26.7%	10%			

OCTOBER - DECEMBER, THE PROBABILITY TO RECEIVE MORE THAN:

50	100	150	200	250	300	350(MM)
26:30	9:30	2:30	1:30	1:30	1:30	
86.7%	30%	6.7%	3.3%	3.3%	3.3%	

4.11 NYERI, KARATINA, TUMUTUMU METEOROLOGICAL STATION

The site is located on 0° 29'S, 37° 05' E at 1814 m above sea level. The mean annual temperature is 16.7^{o}C. The rainfall pattern is bimodal with one distinct dry season as indicated by the intersection between the rainfall curve and the $0.2E_{o}$ line.

The mean annual rainfall of 1087 mm is divided into 611 mm and 292 mm in the long rains and the short rains respectively. Water surplus is experienced in the months of April, May and November. The assumed 100 mm of soil water shortage is met in the first season creating conditions favourable for enhanced runoff.

The water availability periods are shown in fig.45 as 70 - humid - days in the long rains and 35 humid days in the short rains when no consideration of soil water storage is taken into account. Similarly there are 56 days which under the present classification can be said to be arid and 107 days semi-arid. However, when soil water storage capacity is taken into account the growing cycle in the first period becomes 130 days and in the second period 65 days.

The critical periods on the farm are in the months of Jan-Feb to the first half of March just before the long rains and in August and September. These are times when there is shortage of animal feed and human food.

The rainfall probability figures were calculated as in the previous case for M.O.W. Nyeri. Like in the former station the median in the first season exceeds the average rainfall, which indicates that there are more months in the first season with above-average rainfall than with below average rainfall.

WATER BUDGET TUMUTUMU, KARATINA, NYERI MONTHLY AVERAGES FOR THE PERIOD

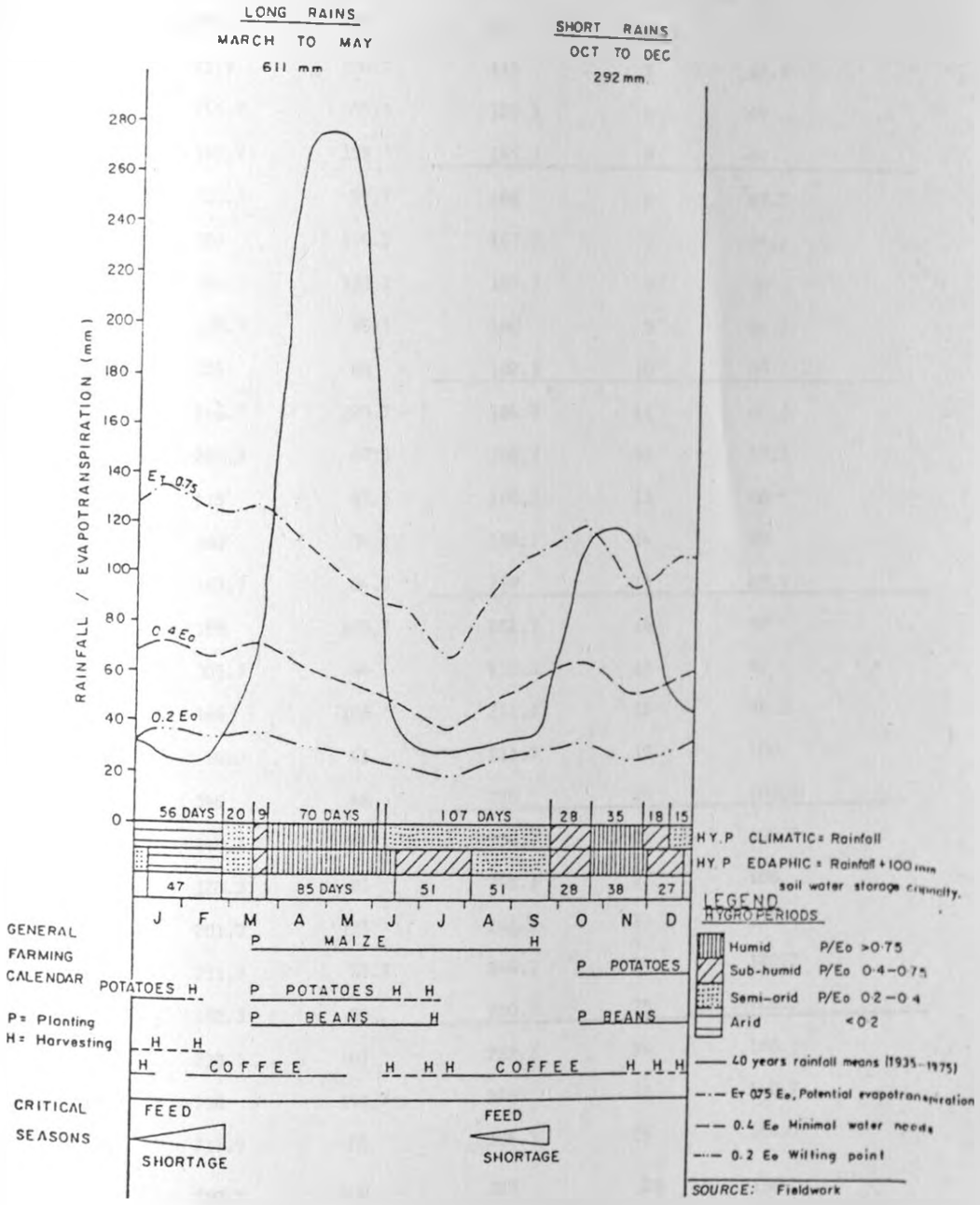
LOCATION		J	F	M	A	M	J	J	A	S	O	N	D	
0° 29'S	P(MM)	27	24	68	274	269	37	29	31	36	115	117	60	1087
37° 05'E	E_T	135	126.75	127.5	111	94.5	87	66.75	93	109.5	120	97.5	106.5	1275
ALT.1814M	$P-E_T$	-108	-102.75	-59.5	163	174.5	-50	-37.75	-62	-73.5	-5	19.5	-46.5	
	GST				100	100	50	12.25				19.5		
	GCH				100		-50	-37.75	-12.25			19.5	-19.5	
	WD	108	102.75	59.5					49.75	73.5	5		27	425.5
	WS				63	174.5								237.5
	E_P	27	24	68	111	94.5	87	66.75	43.25	36	115	97.5	79.5	849.5
	R_o				63	174.5								
	P/E_o	0.15	0.14	0.4	1.85	2.13	0.32	0.33	0.25	0.25	0.72	0.9	0.42	
	E_{P/E_o}	0.15	0.14	0.4	0.75	0.75	0.75	0.75	0.35	0.25	0.72	0.75	0.56	

E_T = Potential Evapotranspiration (0.75 x Pot. Evaporation E_o) in MM.
P = Precipitation in MM (E_o Pan Evaporation or Calculated values)
WD = Water Deficit
WS = Water Surplus
GST = Ground water storage (maximum assumed 100 mm)
GCH = + Ground water charge or water ground discharge
R_o = Runoff (Surplus after 100mm ground charge)
E_P = Effective Rainfall ie $E_P = P-R_o - GCH$
P/E_o = Water availability ratio without ground water reserves (Climatic Hygro period
E_P/E_o Water availability ratio with ground water reserves (Edaphic Hygro period)

TABLE: 4.10

Fig 45: WATER AVAILABILITY DIAGRAM (monthly data)
NYERI: TUMUTUMU, KARATINA

LOCATION 0° 29'S, 37° 05'E
ALTITUDE 1814 m
MEAN ANNUAL RAINFALL 1087 mm
MEAN ANNUAL EVAPOTR 1275 mm



SOURCE: Fieldwork

TABLE 4.11

THE SEASONAL RAINFALL (in mm) AT TUMUTUMU NYERI FROM 1931 TO 1960

YEAR	MARCH-MAY	OCT.-DEC.	RANKED MARCH-MAY	RANKED NO.	RANKED OCT-DEC
1931	186.3	91	21.7	1	41
1932	198.3	89	96.3	2	45
1933	21.7	106.7	115	3	62.3
1934	246.7	85.3	120.3	4	64
1935	145.7	159	145.7	5	67
1936	210.3	89.7	166	6	67.3
1937	327	146.3	167.3	7	74.3
1938	184.7	128.7	167.7	8	76
1939	185.7	96.3	180	9	84.7
1940	226	88	182.3	10	85
1941	246.7	128.3	184.7	11	85.3
1942	262.3	87.3	185.7	12	87.3
1943	115	67.3	186.3	13	88
1944	180	74.3	198.3	14	89
1945	167.7	84.7	199	15	89.7
1946	199	120.7	201.7	16	90
1947	305.3	64	210.3	17	91
1948	166	108	211.3	18	96.3
1949	96.3	41	211.7	19	100
1950	349	45	226	20	100.3
1951	240.3	192.3	238.7	21	106.7
1952	120.3	90	240.3	22	108
1953	201.7	115	246.7	23	115
1954	211.3	62.3	246.7	24	120.7
1955	182.3	76	250.7	25	128.3
1956	238.7	67	262.3	26	120.7
1957	266	140.7	266	27	140.7
1958	211.7	85	305.3	28	146.3
1959	250.7	100	327	29	159
1960	167.3	100.3	349.7	30	192.3
AVERAGE	203.7		203.7		97.6
MEDIAN	204.7		204.7		89.9

March-May, the probability to receive more than:

50	100	150	200	250	300	350
29:30	28:30	25:30	15:30	6:30	3:30	-
96.7%	93.3%	83.3%	50%	20%	10%	-

October - December, the probability to receive more than:

50	100	150	200	250	300	350
28:30	12:30	2:30	-	-	-	-
93.3%	40%	6.7%	-	-	-	-

Unlike the M.O.W. station rainfall amounts is more assured in the long rains for a variety of crops, than in the second season. Assuming other factors constant such as surface runoff it can be shown that the area can support crops requiring over 200 mm of rainfall per growing cycle with a high probability to maturity in the long rains. However, in the second season the crop variety that can be grown with a high certainty to maturity are only crops with a short life cycle or plants with a fairly developed drought resistance. Alternatively improved agricultural practices such as mulching techniques may help in extending the period of soil water storage and thus increased plant growth period.

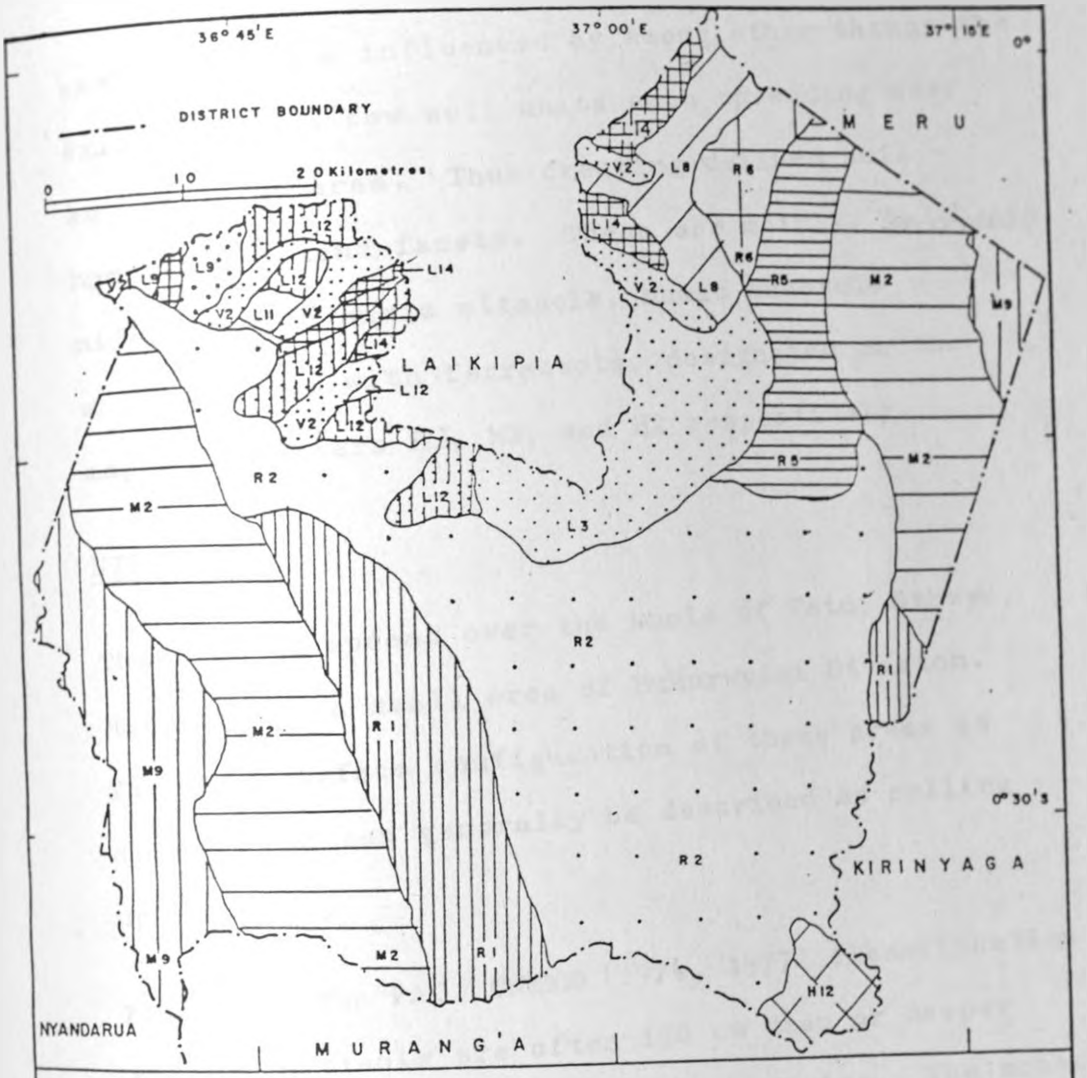
This site could be related to: (1) Jaetzeld's Agro-ecological zone UM2 (M+S/M) Main coffee zone with medium cropping season and a short to medium one. (2) Koppen's "AW" Savanna, two wet seasons 4-8 dry months. (3) F.A.O. Major Climate "2" Moderately Cool tropical highlands.

The type of farming system found in this area is mainly mixed farming based on crop/animal economy. The main cash crop is coffee which is grown on sole stand whereas subsistence crops such as maize, beans, potatoes and vegetables are often found inter-cropped and are rarely grown on sole stands.

4.12 SOIL TYPES AND THE FARMING SYSTEMS

According to the soil classification system of the Kenya Soil survey (1982) there are thirteen different soil units in Nyeri District which can be grouped into five general categories depending on the land surface configuration namely:(1) Mountain soils (2) Hill soils (3) Plateau soils (4) Footridges soils and (5) Valley soils. For the purpose of this study however, only three basic soil units found in the sample area which was confined to Othaya, Tetu, Mukurweini and Mathira Division, will be examined.

As noted in an earlier chapter, the choice of the



KEY

H12— Cambisols with ferralsols

L3— Ortho-luvic phaeozems

L8 — Verto-luvic Phaeozems

L9— Phaeozems with eutric planasol

L11— Pellic vertisols

L12— Pellic vertisols and verto-luvic phaeozems

L14— Eutric planasols

M2— Humic Andosols

M9— Dystric histosols with lithosols

R1 — Ando-humic nitisols and humic nitisols

R5 — Nito-ferric luvisols with humic nitosols

R6— Verto-luvic phaeozems

R2 Humic nitisols

MAP 2: SOIL MAP OF NYERI DISTRICT

Source: Kenya Soil Survey 1982.

sample area was influenced by among other things the existence of a few soil units each spreading over an expansive area. Thus creating defined soil - homogeneous land facets. These are mainly: Ando-humic nitosols with humic nitosols, Humic andosols and Cambisols with ferralsols, designated on the map with letters R1, M2, and H2 respectively.

NITOSOLS

These soils spread over the whole of Tetu, Othaya, Mathira and a small area of Mukurweini Division. The land surface configuration of these areas is diverse but can generally be described as rolling uplands.

Following the FAO / UNESCO (1974, 1977) classification system, nitisols are often 150 cm deep or deeper and have diffuse soil horizon boundaries. The moisture holding capacity is high throughout the profile and roots easily penetrate to very great depth. (Sombroek, W.G. 1977). They show a marked structure stability which enables them to be cultivated even on moderately steep gradients (Nyandat, N.N. 1983). They are friable rather than firm when moist, but hard to very hard when dry (Sombroek G.W. 1977). The chemical properties of these soils vary widely, but they are known to have a high degree of phosphorous absorption (Ekberg, N. et al 1982). The cationic exchange capacity by the top soil has been

known to vary from 13me% to as high as 40me% (Nyandat N.N. 1976). A high Cationic exchange capacity rate indicates that the soil is better able to supply and store positively charged ions (Ca,K, Mg.)

Nitisols have other notable positive attributes such as high porosity and favourable moisture and aeration conditions. However, the fact that these soils have a high phosphorous absorption capacity (forming compounds (F_2O_3) which cannot be readily available to plants) limits the efficiency of uptake of the soil applied phosphorous fertilizers.

The areas in Nyeri Disttrict occupied by nitisols range from 1500 m to 2750 m in altitude with maximum temperatures of 20°C to 26° and a minimum of about 6°C to 14°C. The amount of rainfall is adequate (for a variety of crops) in most of these areas being greater than 750 mm to less than 1750 mm.

The combined effects of relatively fertile soils with a favourable climate makes large areas suited for cultivation of a variety of crops such as tea, pyrethrum, maize, beans bananas, sweet potatoes, Irish potatoes, pineapples, tobacco and so on.

From the foregoing discussion, it can be seen that the natural soil type is not a limiting factor to

plant growth. Thus, existence of a particular crop/animal system is therefore dependent on climatic, socio-economic and to certain extent institutional factors.

FERRALIC CAMBISOLS WITH RHODIC OR ORTHIC FERRALSOLS

This is the soil unit designated with the letters H12 found mainly in the south eastern part of Mukurweini Division (Gumba and Kariara area). It is said to be somewhat excessively drained, moderately deep, red, very friable, sandy clay loam to sandy clay and in some places rocky (Kenya Soil Survey, 1982)

The area in which this soil grid occupies ranges from 1200 mm to 1500 mm above sea level. The maximum temperature can be as high as 26°C and the minimum about 14°C. The annual average rainfall is between 800 mm to 1400 mm. The predominance of such a highly permeable soil coupled with low average annual rainfall could be a great constraint to crop production.

According to Hussain, S.A. (1982) Ferral soil has a clay content of at least 15% of which around 90% is kaolinite having a low cationic exchange capacity (estimated by Nyandat, N.N. 1976 to be less than 16 me%.) this limits the stock of nutrients to a crop. Hussain adds, that this soil type contains few weatherable minerals which further limits its fertility.

These soils are also said to show a high degree of phosphorous fixation and the available nitrogen is also said to be low.* Thus this soil type unlike the nitisols described above, are relatively infertile.

The total effect of infertile, excessively drained soils, low rainfall and high evapotranspiration is the resultant limited number of crops that can be grown in this area.

The main crops grown here as shown by the current survey are pineapples, beans, maize, sugarcane and sweet potatoes. Although coffee is grown, the area has been known to be marginal for coffee growing, [Ministry of Agriculture & Livestock Development (M.O,A.L.D. 1983).]

OTHER SOIL RELATED PROBLEMS

There is little documented information on the seriousness of soil erosion in the study area. However, some general statements regarding erosion hazards associated with different farming systems appear to be gaining general acceptance.

In the Highland areas where steep slopes are under cultivation the rate of soil erosion may be expected

*Wamicha W.N. (1983) (KSS) Personal Communication.

to be high. However, the excellent physical properties of many of these deep, red, porous and friable soil developed over volcanic lavas and ashes may reduce the intensity of it (Ahn, P.M. 1977). It has also been noted that perennial crops such as coffee and tea give greater protection to soils than annuals (D.B. Thomas, 1982).

The National Environment Secretarial mapped most of the areas in the District which have limited use over time due to the high levels of soil erosion. Mukurweini Division was found to be having the greatest area with very serious limitations.

It is beyond the scope of this paper to go into the details on the subject of soil erosion and conservation but it is important to note in passing that the future productivity of the land will highly depend on the methods used today to retain and conserve the soil resource base.

In sum this section has identified a number of soil related limitations to crop production. The soil problem unlike climatic related problem can be overcome by physical, mechanical or chemical means depending on the origin of the limitation.

This description, however,has been very general,

since it has not addressed itself to the micro-variations that vary from farm to farm or from one section of the farm to the next. It is hoped that broad as it is, it will help to clarify some of the statements made with regard to the other technical elements and their relationship to farming activities.

4.13 SLOPE GRADIENT VARIATIONS AND THE DISTRIBUTION OF CROPS

In the previous sections an attempt was made to relate the various farming activities to climate while limitations and potentials pertaining to the soil types were noted. In this section a brief outline is given on the relationship between slope gradient and cropping patterns.

Secondary data was employed in this exercise to assist in the identification of crops grown at varying degrees of slope gradients. The information is presented below in figures 4.6 and 4.7.

As it is evident from the bar-graphs a clear trend is visible for some crops such as tea, coffee and pyrethrum. It is however, difficult to draw conclusive statements for other crops such as maize, beans and potatoes. Tea is a crop that best utilizes steep slopes giving high returns per unit of employed resources, while at the same time protecting the soil from erosive agents of water and wind.

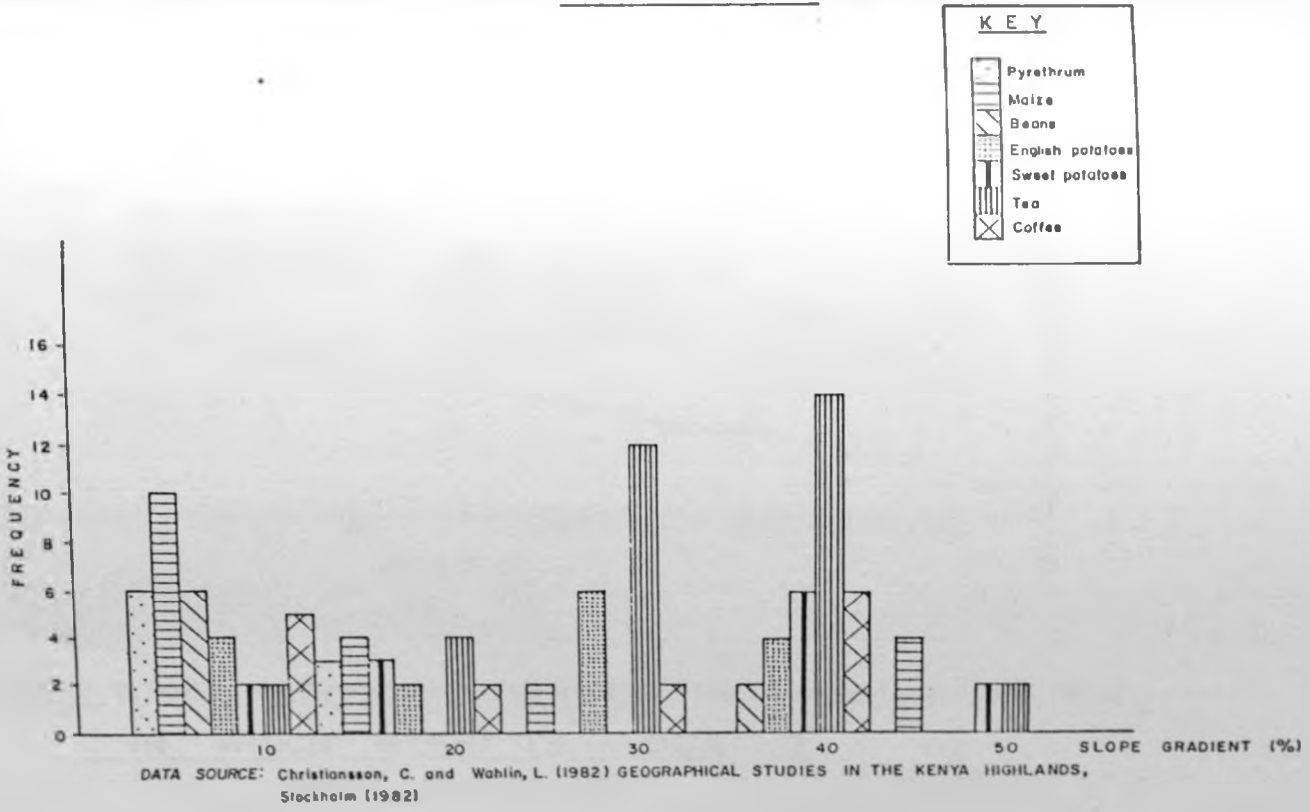
Although coffee is equally grown on steep slopes, the number of cases at very steep gradients is relatively lower than that of tea.

Pyrethrum which is the third most important cash crop in the District is rarely grown on steep slopes. Its most common occurrence is on slope gradients less than 20%.

Sweet potatoes is an important cover crop which is often grown on steep to very steep slopes. However, it is also grown on lesser steep ground.

In conclusion, it has been shown in this and the previous sections of this chapter that it is somewhat difficult to isolate a single factor and relate it to the existing farming without including the other associated factors which work together to determine the existence of a farming system.

Fig. 4·6: SLOPE GRADIENT (%) AND THE FREQUENCY OF CROPS GROWN AT EACH SLOPE GRADIENT IN OTHAYA AND ENDARASHA LOCATIONS, NYERI DISTRICT



DATA SOURCE: Christiansson, C. and Wahlin, L. (1982) GEOGRAPHICAL STUDIES IN THE KENYA HIGHLANDS, Stockholm (1982)

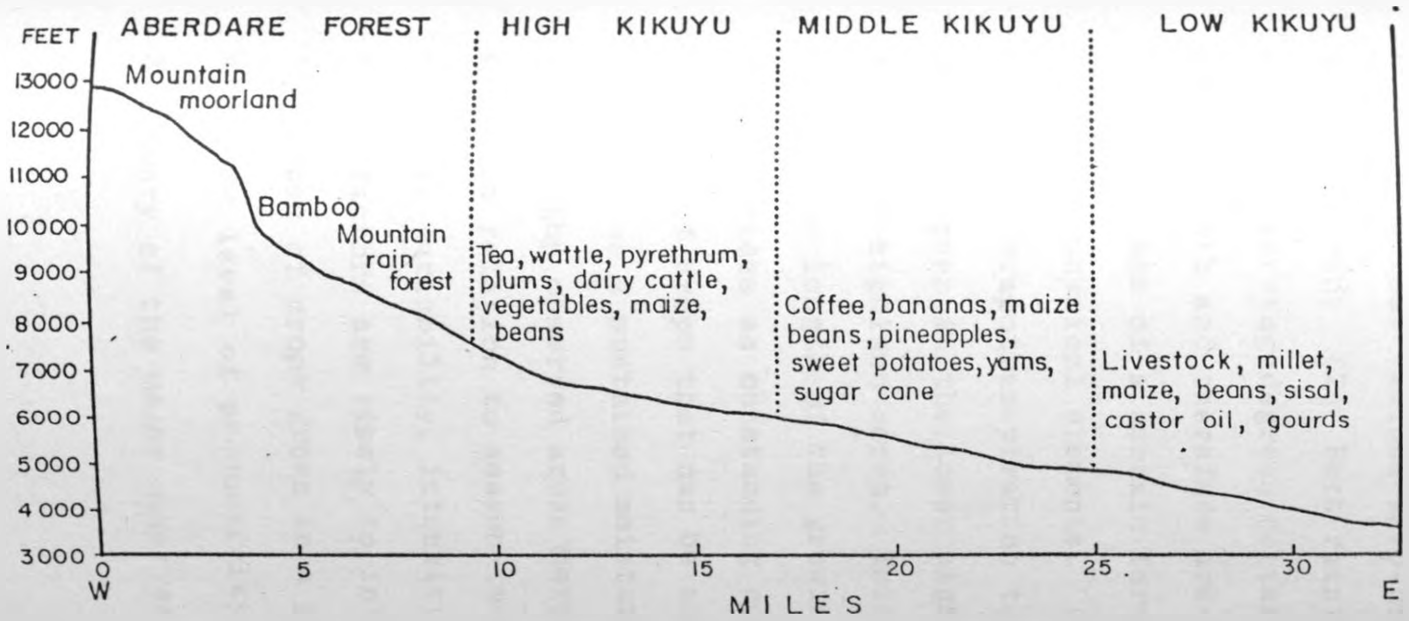


Fig. 4.7: AGRICULTURAL CROSS-SECTION OF THE KIKUYU PLATEAU, IN WHICH NYERI IS LOCATED

SOURCE: Taylor, D.R.F. (1969)

4.14 SUMMARY AND CONCLUSIONS

With regard to the discussion contained in this chapter four basic observations have been made: (1) There is a conspicuous difference in climatic elements across various agro-climatic zones in Nyeri District (2) Both rainfall and temperatures offer to varying degrees certain limitations to plant growth and therefore are likely to influence the existence of a certain farming system more than the other physical elements. (3) The ratio of potential evapotranspiration to precipitation is always higher in the lower highlands zones than in the upper highland zones. This element tends to reduce the length of the growing season and therefore provides an outstanding condition for the variety of crops that can be assured growth to maturity on a sustained moisture level. (4) Finally, for all the observed areas there are certain differences in relation to season-to-season, year-to-year rainfall variability, intensity and probability. These factors are likely to influence not only the types of crops grown in a particular area but also the level of productivity.

A summary of the major observed characteristics in

the five selected areas is given in the table 4.12 below. Whereas in the upper zones low temperatures are the system constraints, rainfall is a major obstacle in the lower zones. For example, in the Kiandongoro area crops can be grown all the year round in a normal year since there is no clear dry period. On the other hand the Nyeri municipality area experiences short growing periods and long dry periods. Therefore in both places the range of crops that can be grown is limited by either rainfall or temperature acting singly or together.

The available information is not enough to verify the previously stated hypothesis since a number of other factors have been held constant and neither is it convincing enough to help us make broad statements on the magnitude of the variations. Therefore additional qualitative and quantitative information is required.

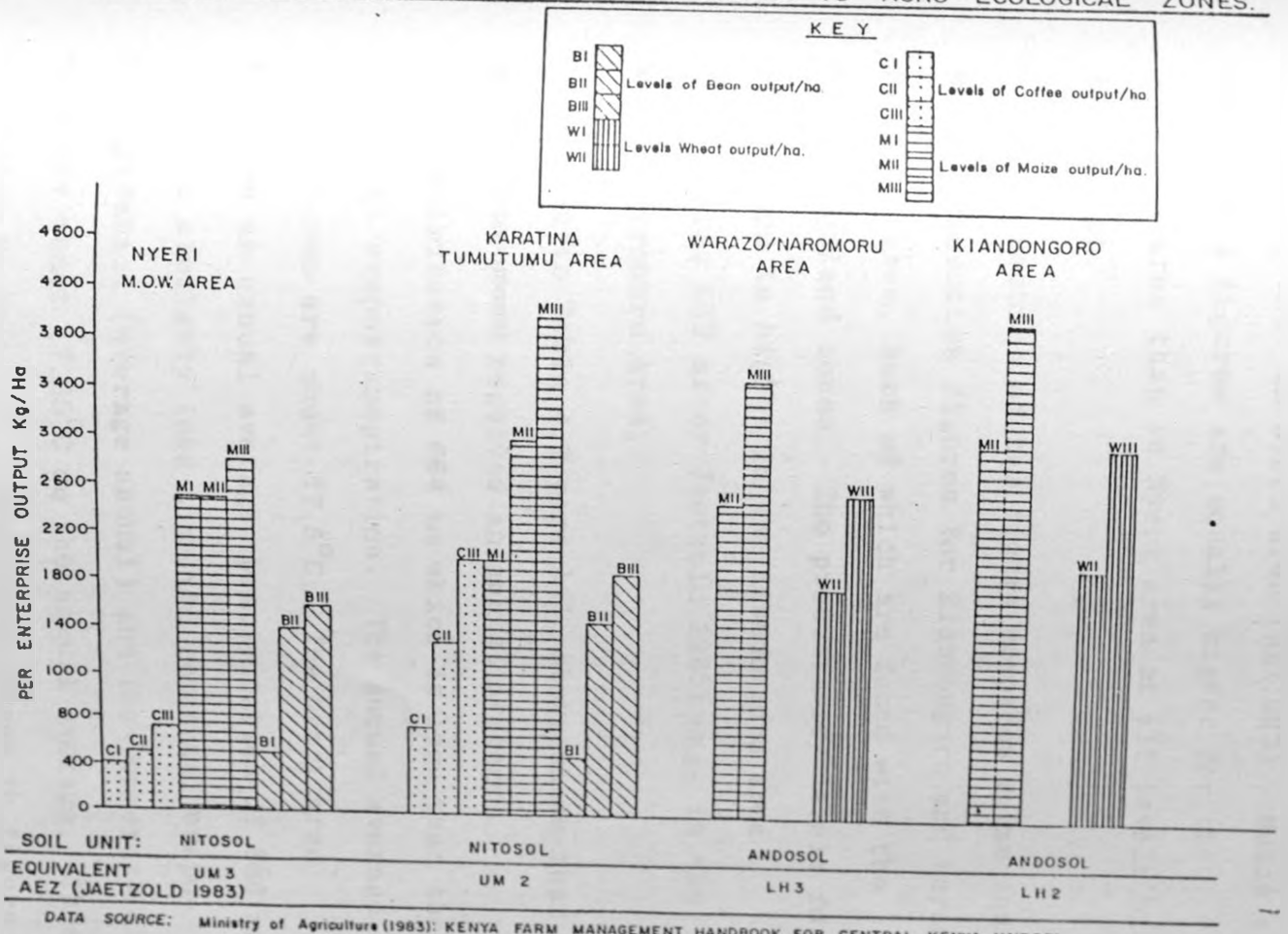
Land productivity expressed in enterprise output per hectare according to the selected climatic areas is given in Fig. 4.8. It was felt that these comparisons would give a better picture since similar soil units exist at each level of comparison.

The figure shows that there exists great differences

A summary of the observed characteristics in the survey area

LOCALITY	AVERAGE ANNUAL PREP(MM)	AVERAGE ANNUAL TEMP. °C	POT. EVAPT. (MM)	GROWING PERIOD LR	GROWING PERIOD SR	PERIOD OF DRY SEASON	CROP FARMING SYSTEM	SYSTEM CONSTRAINTS
WANDARE GATE 2400M. A.S.L.	1177.3	12.5	1412	165 DAYS	176 DAYS	NONE	Peas, Potatoes, cabbages, Maize pyrethrum	Low temperatures Occasional Frosts
KIANDONGORO 2378M	1795	13.7	1040.37	ALL YEAR ROUND		NONE	Cabbages, Potatoes Peas, Maize, Beans Pyrethrum, wheat	Low temperatures
WARAZO NAROMORU 2130M.	664	17.5	948	82 DAYS	84 DAYS	136 DAYS	Wheat, Barley, Beans Maize, Potatoes, Cabbages, Pigeon peas	Long dry period short growing period, Low moisture availability
NYERI M.O.W. 1829M	886	17.35	1316	95 DAYS	52 DAYS	217 DAYS	Coffee, Maize, Beans Irish Potatoes, Sweet potatoes, cassava	Short growing period Long dry period
KARATINA 1814M	1087	16.7	1275	84 DAYS	81 DAYS	178 DAYS	Coffee, maize, beans, potatoes Irish potatoes	Short growing season Long dry spells

Fig. 48: LAND PRODUCTIVITY ACCORDING TO AGRO—ECOLOGICAL ZONES.



in crop productivity between the four climatic areas. Coffee has higher productivity in the Karatina area (AEZ: UM2) than in Nyeri area (AEZ:UM3). Maize and bean yield figures are equally higher for the Karatina area than in Nyeri area at all levels of production.

The next section of the figure compares maize and wheat production figures for Kiandongoro and Warazo/ Naromoru area, both of which are found with the Upper Highland zones. The productivity levels for both crops is higher in the Kiandongoro area (designated LH2 after Jaetzold 1983) than in the Warazo/Naromoru area.

Reference to Table 4.7 page 141 above shows that Warazo/Naromonu receives an annual average precipitation of 664 mm which is less than the potential evapotranspiration. The annual average temperatures are about 17.5^{o}C. The Nyeri area receives an annual average precipitation of 886 mm which is similarly less than the potential evapotranspiration (average annual) and the temperatures are about 17.35^{o}C on the annual average. These according to the statistics given in figure 4.8 page 175 are the areas that show relatively lower

output of various crops per hectare. We can therefore accept the hypothesis that "Variations in farming system types are directly related to the variations in monthly and annual average precipitation and temperatures, soils and land surface configurations.

So far the analysis has been on productivity based on physical factors. However, national estimates by J.D. Acland (1975) show that low national average yields of various crops are mainly due to poor husbandry practices as shown in the table below comparing average yield and the expected yield with good husbandry.

CROP	AVERAGE YIELD	YIELD EXPECTED WITH GOOD HUSBANDRY
Tea	1300 kg/Ha	2500 kg/Ha
Coffee	600 kg/Ha	2.5 tonnes/Ha
Pyrethrum	280 Kg/HA	1350 Kg/Ha
Maize	1000 kg/Ha	8520 Kg/Ha
Potatoes	5 kg/Ha	40 tonnes/Ha
Beans	220 kg/Ha	1000 Kg/Ha

As a supplement to the above analysis chapter five examines some socio-economic and institutional constraints that could possibly explain further some of the reasons that create cross-sectional differences in productivity levels between and among

different groups of small holder farmers.

CHAPTER FIVE

ANALYSIS OF NYERI SMALL HOLDER FARMING SYSTEMS

In chapter four an attempt was made at highlighting upon some natural environmental factors that may limit agricultural potential in various agro-ecological zones in Nyeri District. These factors alone, however, are unlikely to offer a fuller explanation of the farm to farm variations in product output performances. Other factors such as accessibility to external sources of finance, the technology employed, availability of information on farm management practices and other related aspects, which may be endogenous or exogenous to a farmer may play a significant role in determining the levels of output attained.

This chapter addresses some of the above aspects with a view to offering explanations on the most significant factors that may result in cross-sectional differences in product output performances among smallholder farmers, as revealed by the sample population. It is divided into three main sections. The first examines general characteristics of the Nyeri small holder farming system - thus addressing resource utilization and maintenance of soil fertility.

Section two attempts to define at a rather broad front, the interrelationships between crop farming and livestock economy. The ecological and socio-economic constraints pertaining to these practices are also discussed. Finally the farmers' production priorities with respect to his needs, perception and the institutional support accorded him are generally examined. The last section subjects the gathered data into analytical tests in order to verify the truthfulness or falsehood of the hypotheses stated in chapter one. The chapter closes with a brief summary of the findings, thus paving the way to the next and final chapter on the summary of findings, conclusions and recommendations.

5.1 FARM CHARACTERISTICS

An important aspect to note in relation to farm management systems in the traditional setting is the size of the farm that a farmer operates on. Farm size, however, cannot be used as a measure of land productivity, since it does not incorporate an element of land quality. Paucity of concrete data could not allow us to carry out an intensive investigation into the micro-variations in land quality hence, farm size *per se* was taken without attempting any further analysis. Also examined as a way of indicating the extent to which farm size may pose

immediate and future limits to increased agricultural productivity (under a constant level of technology) are: (1) the prevalent levels of informal land subdivision (2) External sources of cultivable land and (3) farm management practices in current use.

Table. 5.1 FREQUENCY DISTRIBUTION OF FARMS SURVEYED BY SIZES:

Farm size in Hectates	Number of Cases	Percentage of the total number of cases in the sample %	Cumulative Frequency %
0 - 0.25	1	0.6	0.6
0.26 - 0.40	3	1.8	2.4
0.41 - 0.65	9	5.4	7.8
0.70 - 1.00	23	13.9	21.7
1.09 - 1.50	36	25.7	43.4
1.51 - 2.50	54	32.5	75.9
2.51 - 4.00	34	20.5	96.4
4.09 - 6.00	5	3.0	99.4
6.09 - 8.00	1	0.6	100.0
Total	166	100.0	100.0

Source: Fieldwork

The measures of central tendency, that is mean, mode and median are 1.3 Ha; 2.05 Ha and 1.5 Ha respectively, indicating that the sample was fairly

distributed. It is notable, however, that 75.9% of the farms are within 1.51 - 2.50 hectares, which indicates at the outset that the greater majority of the community under investigation own relatively small plots of land which may pose great management problems with increased human population as shown in the subsequent section.

FARM INFORMAL SUBDIVISIONS

Although the Government policy on land has always aimed at discouraging subdivisions of land into uneconomic units, it has not been possible to exercise control on the informal farm subdivisions, taking place at the farm level. Following the survey responses the following levels of farm informal subdivisions were recorded.

Table 5.2 FREQUENCY OF FARM INFORMAL SUBDIVISIONS IN THE SURVEY AREA

Farm size in Hectares	Number of Subdivisions	Number of Cases	Percentage of total number of cases in the sample
4.09 - 6.00	2	29	17.5
2.51 - 4.00	3	12	7.2
1.51 - 2.00	4	7	4.2
1.09 - 1.50	More than 4	2	1.2
0.25 - 1.00	None	116	69.9
Total		166	100.0

Source: Fieldwork

The figures above show that at least 30.1% of the surveyed farms were informally subdivided twice or more times, whereas 69.9% were not. The latter were often very small in size and this may have deterred further subdivision. However, with the rapidly rising population (estimated at 4% per annum) coupled with the family land inheritance system, informal farm subdivision is likely to continue.

Land subdivisions creates management problems (since decision-making is no longer centralized) limits application of capital intensive methods of farming and reduces the attractiveness of these farm holdings to the main financing agencies.

AVAILABILITY OF EXTERNAL SOURCES OF CULTIVABLE LAND

With the rising population and diminishing sizes of family farms, a situation may arise whereby the farm families may not be able to meet their food, cash, space and other basic requirements. To relieve this pressure on the family land some people may choose to hire or purchase land elsewhere, either within or outside the immediate community. The consequential result of which would be a large number of people owning more than one piece of land, in some cases widely distanced. This is likely to result in a lot of management problems, manifested in long distance travels and waste of valuable man-hours

which could otherwise be spent on gainful production. This may not augur well with the objective of increased food production and alleviation of rural poverty. In this particular survey 46.4% of the respondents were found to be managing more than one piece of land and 26.5% of them had freehold title deeds for them. If such trend continues land fragmentation is likely to become a formidable land and farm management constraint in the District. A constant review of the land consolidation policy is therefore deeming necessary.

5.2 PREVAILING METHODS OF SOIL FERTILITY MAINTENANCE.

FALLOWING

One natural method of maintaining soil fertility for long practised in Africa and elsewhere in the Tropics, is shifting cultivation - a practice which involves leaving a piece of land fallow for a length of time to allow regeneration of lost soil nutrients. This practice has been rendered impossible in many parts due to population pressure, institutionalised land tenure system and diminishing farm sizes.

Today in the survey area, a farmer may leave land fallow for a period of time either consciously to

to recapture lost soil nutrients or unconsciously do so due to other bottlenecks say labour. Only 34.9% of the surveyed farmers were found practising these variant types of land fallowing. The period in which land was maintained fallow varied as shown in the table below:

Table 5.3 FREQUENCY DISTRIBUTION OF FALLOW PERIODS IN THE SURVEY AREA

Period of Fallow	Number of Cases	Percentage of the total number of cases in the sample
One season of fallow	8	4.8
One year of fallow	13	7.8
Two years of fallow	5	3.0
Three years of fallow	5	3.0
Four years of fallow	6	3.6
Over five years of fallow	20	12.0
None at all	109	65.7
Total	166	100.0

65.7% of the farmers surveyed did not engage in any form of fallow cultivation. This may indicate the intensity of land use among smallholder farmers in Nyeri District.

CROP ROTATION

Crop rotation is practised in the survey area in

one form or another. The practice, however, does not take a clearly definable pattern, so that it is common to have one of the crops in the combination repeated during each rotational period. In short the practice only avoids repetition of an identical cropping pattern to the previous one. Farmers were also found to be alternating pastureland with cropland. These different practices were observed in 60.8% of the farms surveyed.

The following data shows the frequencies of crop rotation periods that were recorded.

Table 5.4 FREQUENCY DISTRIBUTION OF ROTATIONAL PERIODS

Crop Rotation Period	Number of Cases	Percentage of the tot No . of cases in the Sample
1 season of rotation	17	10.2
2 seasons of rotation	27	16.3
3 seasons of rotation	18	10.8
Rotation period of 2 years	13	7.8
Rotation after a long period	31	18.7
None at all	60	31.6
Total	166	100.0

Source: Fieldwork

From the figures above 31.6% of the surveyed farmers were not practising crop rotation at all, and only 26.5% were involved in short duration rotational periods. This shows that most farmers have tended to use the same piece of land for similar crops for a long time. The consequences of which would be possible infection of crops by pests and diseases, and/or reduced productivity in the absence of artificial fertilizers.

USE OF CROP RESIDUES

The crop residues are other sources of soil organic matter, that constitute part of the soil nutrients available to the plant. Crop residues may be maintained on the farm where they decompose to form manure or may be fed to animals which in turn provide farm manure through animal droppings. 88% of the farmers surveyed fed crop residues directly to the animals, 6% maintained them in the fields, 1.8% sold them to their neighbours and only 0.6% burned them in the fields. As discussed later in this chapter, the crop/animal sub-systems on the small holder farms are highly integrated, whereby the by-products of one sub-system are used as an input in the other, thus reducing the costs of inputs.

USE OF CHEMICAL FERTILIZERS

Among the farm inputs that have become important in increasing agricultural production is fertilizers. In the survey area 85.5% of the farmers used fertilizers. The 14.5% who never used chemical fertilizers were constrained by the following factors:

Table 5.5 FACTORS LIMITING FARMERS' USE OF CHEMICAL FERTILIZERS

Factor	Number of Cases	Percentage of the total No. of cases in the sar
High cost of chemical fertilizers	6	3.6
Supplier too far	4	2.4
Farm too small	4	2.4
Applied manure	11	6.6
No response	141	85.0
TOTAL	166	100.0

Source: Fieldwork

Therefore, the main reason why most farmers do not apply chemical fertilizers is the price and the distribution system. A farmer whose farm is small feels that the cost of any additional inputs cannot be justified by his level of output.

Again application of chemical fertilizers is not evenly distributed to all the crops that a farmer

grows. The following data show the differences in the frequency of use of chemical fertilizers on the various crops that a farmer grows.

Table 5.6

FREQUENCY DISTRIBUTION OF CHEMICAL FERTILIZER USE ON VARIOUS CROP ENTERPRISES

Crop Enterprise	Number of Cases	Percentage of the total number of cases in the sample
Cash crops	23	13.9
Subsistence crops	9	5.4
Horticultural crops	3	1.8
Cash crops/subsistence crops	78	47.0
Hortic. Crop/subsistence crops	4	2.4
Horticultural, cash and subsistence crops	5	3.0
On all crops	22	13.3
None at all	22	13.3
Total	166	100.0

Source: Field Work

The use of chemical fertilizers is more predominant on cash crop plots and less in horticultural crops. Probably because horticultural crops are often grown around the homestead and therefore more farm yard manure is used as opposed to chemical fertilizers.

Cash crop growers (as will be discussed later) have the advantage of obtaining chemical fertilizers on credit basis from the co-operative societies or in the case of tea growers from Kenya Tea Development Authority (KTDA). This credit which is recovered from the sales of the commodity helps farmers who have no other sources of capital to purchase their inputs.

5.3 HOUSEHOLD CHARACTERISTICS AND AVAILABILITY OF LABOUR FOR FARM WORK

The average small holder household in the survey area had an average of nine members, of whom more than half were under the age of twelve years. The mean number of male adults living on the farm per household was two, however, only one male adult on average was available full time for farm work per household. On the other hand on average three female adults were living on the farm and two were available for full time farm work.

Only 7.8% of children over the age of twelve were available fulltime for farm work. The remaining 74.1% were available only during the school holidays. Hence, they were never available during the labour peak periods in the months of January to March and

September to November. (Refer to Table 5.7)

62% of the interviewed farmers indicated that they experienced labour shortage during the peak labour demand periods, and an equal percentage hired labour to assist in the various activities on the farm during the year. Only 16.9% had permanent labour employed.

5.4 ·ACTIVITIES ON THE FARM AND THE USE OF HIRED LABOUR

Since agricultural activities in most parts of the District depend on the use of human labour, the household production size is determined in part by the availability of both domestic and hired labour. However, as indicated above, domestic labour is not always available at the time farm operations demand higher labour inputs. Hence, some families are involved in hiring external labour to supplement their own. In this section, we examine the main activities that utilize hired labour, and the periods in which the labour demand is highest.

The main activities that occupy the farmer and his family throughout the year are: Land preparation, planting, weeding, harvesting, spraying and pruning (coffee) and transporting. These tasks, however,

have varying labour demands, and therefore, the busiest periods on the farm also vary. The table below shows the busiest moths of the year and the activities performed by the hired labour.

Table 5.7

PEAK LABOUR PERIODS AND PERCENTAGE OF RESPONSES

	Jan Feb	March -May	June -Aug.	Sept. -Oct	Nov. -Dec.
BUSIEST PERIOD. NO. OF RESPONSES	15	65	21	3	61
NOT THE BUSIEST PERIOD. -No. OF RESPONSE	151	101	145	163	105
Work done by hired labour during these periods	Land preparation	Planting Weeding	Harvesting Weeding	Land Preparation	Planting Harvesting

Source: Field work

The busiest periods of the year are March-May and November to December, when the farmers are busy planting, weeding and harvesting.

Among the farmers interviewed, 45.8% indicated that these tasks were never completed on time, a possible cause of low yields - due to late planting and harvesting. It is clear that availability of labour during these periods is limited and this constitutes a major constraint to crop production.

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5.5 CAPITAL INVESTMENT AND FARM IMPLEMENTS

As noted in an earlier section, Nyeri small holder farming systems are characterized by existence of small plots which do not attract the use of heavy capital equipment such as tractor ploughs and mechanized harvesters. Therefore, much of the farm capital investment is in the form of simple tools and equipment. Investments on farm structures such as stores, water tanks and other related structures is also low.

The distribution of farm implements and structures in the survey area is as shown: (Table 5.8)

Table 5.8

OWNERSHIP OF FARM IMPLEMENTS AND STRUCTURES

Farm Implements and Structures	Number of respondents in possession of each item.	Percentage of the total number of respondents in possession of each item
i. Stores	117	70.5
ii Hand hoes	161	97.0
iii Ox-Plough	2	1.2
iv Tractor plough	4	2.4
v Pangas	161	97.0
vi Harrows	12	7.2
vii Wheel barrows	98	59.0
viii Spraying pumps	119	71.7
iv Water pipes	59	35.5
x Water tanks	74	44.6

Source: Field work

Investment on items such as spraying pumps, wheel barrows, hand hoes and pangas has a higher score relative to others, excluding stores. Most farmers who grow cash crops such as coffee are eligible to loans from the co-operative societies and can therefore afford most of these equipments. The poorer farmers who have no access to credit or loan are

most likely capable of purchasing low-cost items such as handhoes and pangas - hence the high score of percentage attached to these items.

5.6 LOANS AND CREDITS

In the absence of domestic sources of investable funds, loans and credits extended to farmers help build up the farmers' capital outlays. Lack of such, on the other hand, may reduce the farmers' purchasing power for certain important farm inputs such as fertilizers, chemical sprays and other essential inputs.

In the survey area, 74.1% of the farmers had, at one time or another obtained a loan or credit, whereas 25.9% had not. The following were the recorded sources of both credits and loans. (Table 5.9)

Table 5.9

MAIN SOURCES OF CREDITS AND LOANS

Loan/Credit Source	Number of Recipients In the sample	Percentage of the Total number of Recipients in the Sample
AFC	21	12.7%
Co-operatives	45	27.1%
Banks	9	5.4%
AFC/Co-operatives	27	16.3%
Banks/AFC	9	5.4%
KTDA	11	6.6%
None	42	25.3%
Total	166	100%

Source: Field Work

Co-operatives as a source of farm credits and loans ranks highest followed by Agricultural Finance Corporation (AFC) and the Kenya Tea Development Authority (KTDA) holds the third position. The percentage of farmers who obtain credits or loans from banks is low. It is also notable that very few farmers obtain credit from both Banks and AFC. Therefore in the absence of either the Co-operatives or KTDA both of which mostly cater for cash crops growers, the number of farmers who benefit from other sources

of loanable and creditable funds is very low.

At this point one may pause to question why it has become difficult for some farmers to benefit from certain sources of finance. Among the farmers interviewed, 4.2% expressed lack of security which is required by most financing agencies as collateral. 13.3% lacked proper guidance, 72.9% feared their farms would be auctioned in case of loan default and only 3.0% said they had enough domestic savings to finance their farm operations.

To allow more farmers to benefit from the available sources of loanable funds, a number of changes are required, both at the farmer's and institutional levels. Information on the use of loans is required while the stringent requirements of some financing agencies need to be loosened.

5.7 AGRICULTURAL EXTENSION SERVICES

Agricultural services extended to farmers are aimed at improving the levels of management skills and know-how among farmers. Distribution of these services may in certain circumstances lead to highly differential levels of farm output. In areas where the farmers have no other way of obtaining information related to farm management, a failure to offer the right or ample advice may keep some farmers at

low levels of production through employing traditional methods of crop and animal husbandry.

The nature of advice extended to the producer may also bias production possibilities open to him/her. Whether a farmer manages a coffee plot better than a maize plot may depend on the nature of advice, his/her knowledge level on management and probably, the income expected from the sale of the crop - or any other production objective or priority a farmer may have.

In the survey area, majority of the farmers (i.e. 95.2%) were aware of the existence of Government Agricultural Services. A clear indication that they appreciated or would be willing to avail themselves of this service. However, 23.3% of the farmers interviewed were never visited at all by the locational agricultural extension officer. The remaining 76.7% were visited at varying frequencies as shown below. (Table 5.10)

Table 5.10 FREQUENCY OF AGRICULTURAL EXTENSION VISITS TO THE INTERVIEWED FARMERS

Frequency of visits	Number of Cases
Visit once a week	11
Visit once a month	35
Visit after 6 months	39
Visit once a year	37
Visit after a long period of time	7
No visit at all	37
TOTAL	166

Source: Field work

The mean frequency of visit was once a year, which may or may not coincide with the times a farmer is making a decision on what to produce and how much to produce. However, examining the figures above one can note that at least the frequency of visits is fairly distributed.

NATURE OF EXTENSION ADVICE

As noted above, the nature of extension advice is more important than the number of visits a farmer is accorded by the agricultural extension officer. Since the agricultural extension officers are the

the main vehicles that carry information on research findings from the research institutes to the farmers, the nature of the advice they give is an important factor that may influence positively or negatively the farmer's production repertoire.

The table below shows the frequency of agricultural extension advice given to farmers on the various farm enterprises.

Table 5.11

FREQUENCY OF AGRICULTURAL EXTENSION ADVICE ON VARIOUS FARM ENTERPRISES

Farm Enterprise	Number of cases	Percentage of the total NO. of cases in the sample
Cash crops	79	47.6
Livestock	1	0.6
food crops	1	0.6
Horticultural crops	3	1.8
Cash crops/Livestock	6	3.6
Cash and food crops	10	6.0
All farm enterprises	25	15.5
None at all	41	24.7
Total	166	100

Source: Field work

5.8 FARMERS TRAINING CENTRES

The other source of technical information on farm management practices is the farmer training centres or field days organized by officers of the Ministry of Agriculture and Livestock Development. At the farmer training centres farmers are given short duration courses on various aspects of farm management. 49.4% of the respondents had never attended a farmer training, which means they had to depend on other sources of farm management information, which as shown above is also limited.

5.9 THE CROP PRODUCTION SYSTEM

CROPPING ACTIVITIES

The cropland is cultivated on permanent basis, twice a year following the bimodal rainfall pattern that is experienced in most parts of the District during the months of March-May and October-December.

The main cropping activities involve the growing of both food and cash crops. Coffee, tea and pyrethrum are the main cash crops grown. Local sale of the surplus food crops is also common.

Land preparation takes place at or before the onset of the rainy season,. Simple hand implements such

as pangas, forks, jembes and handhoes are the most common tools used in tilling the ground.

Apart from the main cash crops, most other crops are grown in mixtures. This practice commonly referred to as intercropping is the dominant cropping pattern. The spatial arrangement of components (crops) in this system may appear at times irregular and haphazard on some farms and well-patterned conforming to certain recommended spacing patterns on others. However, one may not fail to notice the intimate relationships between and among these components.

In the survey area 63.3% of the farmers were engaged in one form of intercropping or another. Although this cropping pattern is in contrast to what is normally recommended by the agricultural extension officers, farmers have got their own reasons for maintaining it. 28.9% of the farmers indicated that the practice enabled them to use lesser labour inputs per crop grown, 10.2% felt that it increased the variety of crops grown per unit area, 24.1% considered intercropping as a traditional practice but did not see it to be detrimental to their crop output. The table below shows the frequency of intercropping

practices with respect to farm size.

Table 5.12

FREQUENCY OF INTERCROPPING PRACTICES WITH RESPECT TO FARM SIZE

Farm Size in Hectares	Intercropping no.of cases	Percentage of of the total No. of cases in the sample	No-Intercropping no. of cases in the sample	Percenta of the total No of cases in the sample.
0 - 0.25	1	0.6	0	0
0.26-0.40	3	1.8	0	0
0.41-0.65	8	4.8	I	0.6
0.70-1.00	20	12.9	3	1.8
1.09-1.50	26	15.7	12	7.2
1.51-2.50	32	19.3	20	12.0
2.51-4.09	15	9.0	19	11.4
4.09-6.00	2	1.2	3	1.8
TOTAL	107	64.5	59	35.5

Source: Field work

From the above table it can be seen that there is a relationship between farm size and intercropping practice. There are fewer cases of intercropping at farm size of less than 0.41 ha and greater than 4.09 ha. The next table compares farm size and the various reasons given by farmers for engaging in this cropping pattern.

TABLE 5.13 FREQUENCY OF REASONS GIVEN FOR ENGAGING IN INTERCROPPING PRACTICES WITH RESPECT TO FARM SIZE

Farm Size For Intercropping in Ha.	Saves Labour		Higher Crop Variety		Tradition		None Response	Percentage of the total No. of cases in the Sample
	No. of Cases	Percentage of the total No. of cases in Sample	No. of Cases	Percentage of of the Total No. cases in Sample	No of Cases	Percentage of the total NO. of cas cases in Sample		
0-00.25	0	0	1	0.6	0	0	-	-
0.26 - 0.40	1	0.6	2	1.2	0	0	-	-
0.41 - 0.65	2	1.2	2	1.2	0	0	-	-
0.70 - 1.00	9	5.4	5	3.0	6	3.6	-	-
1.09 - 1.50	12	7.2	5	3	10	6.0	-	-
1.51 - 2.50	19	11.4	2	1.2	10	0.00	-	-
2.51 - 4.09	4	2.4	2	1.2	9	5.4	-	-
4.09 - 600	1	0.6	0	0	2	1.2	-	-
Total response	48	28.8	19	11.40	37	16.2	62	37.35

Source: Field Work

Within the 0.- 0.65 ha farm size group intercropping practices are more popular for allowing the farmer to reap a greater variety of crops than either as a way of saving the amount of labour input per level of output. The farms are so small that the available family labour is enough to carry out most of the farm activities in crop production without hiring extra hands.

THE CASH CROP ENTERPRISE

The cash crop economy in the District has been acquiring an upward trend since its initiation on the small-holder "African farms" in the 1950s. The fact that cash crops provide an ensured source of constant income has attracted more farmers into this farm enterprise. The table shows the number and percentage of farmers engaged in cash crop growing during the survey period.

Table 5.14

FREQUENCY OF CASH CROP GROWERS IN THE SURVEY AREA

Crop Grown	Number of Cases	Percentage of the total NO. of cases in the sample (%)
Coffee	135	81.3
Tea	73	44.0
Pyrethrum	9	5.4

Source: Field Work

Growing of pyrethrum has been discouraged by low and irregular payments of the produce by the Pyrethrum Board of Kenya.*

The presence of cash crops on the farm, however,

* - D.A.O. Nyeri - Personal Communication

results in competion over the existing resources of labour, land, capital and management.

The data below compares the proportion of land taken up by cash crops, food crops and livestock husbandry at each level of farm size.

Table 5.15

LAND RESOURCE UTILIZATION IN THE STUDY AREA

Farm size Allocation in HA / Farm Enterprise	0-0.25	0.26 -0.40	0.41 0.65	0.70 -1.00	1.09 -1.50	1.51- 2.50	2.51- 4.0	Totals
FOOD CROPS No of responses	33	55	26	34	13	3	0	166
Percentage of the total NO of response	19.9	33.1	15.7	20.5	9.0	2.0	0	100%
CASH CROPS No of responses	21	43	29	44	13	16	0	166
Percentage of the total NO of responses	12.7	25.9	17.5	24.1	7.8	9.6	0	100%
LIVESTOCK NO. of responses	59	38	17	17	10	9	6	153
Percentage of the total NO, of responses	35.5	22.9	10.2	10.2	6.0	3.6	0.6	78.8%

Source: Field work

The present ratios of cash crops; food, crops and livestock are expected to grow in favour of cash crops in the near future, a development which is likely to erode even further the production base for food and livestock. This is supported by the fact that while only 7.8% and 16.9% of the farmers indicated that they would be willing to increase area under food and livestock, 41.6% indicated a

a need for future expansion of the area under cash crops.

CULTIVATION OF OTHER CROPS

A list of crops currently grown by farmers in the survey area is given below which illustrates the overwhelming preference for maize,, Irish potatoes, and beans as food crops. Local sale and purchase of food crops was reported during the survey. 63.7% reported sale of surplus food crops and 69.9% reported buying of either additional foods to supplement their own production or after exhausting their own supplies.

Table 5.16

FREQUENCY OF CROPS CULTIVATED OTHER THAN THE MAIN CASH CROP

Crops	Number of Cases	Percentage of the total number of cases in the sample
Maize	165	99.4
Beans	163	98.2
English Potat.	151	91
Sweet Potat.	107	64.5
Peas	33	19.9
Cabbages	88	53
Tomatoes	44	26.5
Carrots	37	22.3
Bananas	127	76.5
Yams	37	22.3
Arrowroot	62	37.3
Fruits	63	38
Cassava	27	10.3
Sorghum	8	4.8
Sugar cane	49	29.5
Fodder crops	106	63.4
Pineapples	25	15.1
Tobacco	58	34.9

Source: Field work

5.10 PRODUCTION GOALS IN THE SMALL HOLDER FARMING SYSTEMS

Small-holder production goals are more difficult to analyse than would be the case for large scale monocultural production systems. This is due to the fact that decisions geared towards production for the market and for domestic consumption are strongly interwoven and cannot possibly be divorced in any form of analysis. In this study the farmers' production goals were divided into three main areas, that is, cash crop and food crop production, and livestock development. This was done to enable the resercher at least to tentatively separate those goals that are purely designated to production for market and those that are likely to be more for domestic consumption.

Thus, farmers' production goals in respect to these farm enterprises were investigated and the following table shows the farmers' responses to their planned avenues for future development.

Table 5.17

FREQUENCY OF RESPONSES FOR:

Farm Enterprise	Cash Needs	Food Needs	Food & Cash needs	Others	Totals
Cash crops	41.6	-	-	-	41.6
Hortic. Crops	-	-	11.4	-	11.4
Livestock	-	-	18.7	-	18.7
Food crops	-	10.2	-	-	10.2
Others	-	-	-	18.1	
Totals	41.6	10.2	30.1	18.1	100%

Source: Field work

The values are in percentages of responses.

The figures show the apparent importance attached to cash income as opposed to food production. This is in contradiction to the expectation that a farmer's production priority is given to the satisfaction of the family's food needs. A further investigation revealed that, the cash crop enterprise has received undue emphasis by the agricultural extension officers. 47.6% of the extension advice given to a farmer is on cash crop growing. This aspect as stated earlier may bias the farmer's production priorities.

In several interviews farmers were asked why they

intend to increase the hectarage under cash crops, and the following were the responses.

Table 5.18

FREQUENCY OF RESPONSE GIVEN FOR EXPANDING CASH CROP HECTARAGE

Reasons for expanding cash crop area	Number of cases	Percentage of the total No. of respondents in the Sample
Prices of cash crops are good	11	6.6
Cash crop is a future asset	45	27.1
Prices of other crops are low	4	2.4
Cash crop growers get loans	8	4.8
No response	98	59.0
	166	100.0

Source: Field work

27.1% of the farmers in the sample population expressed an intention to expand the area under cash crops because cash crops are seen to contribute to the farmers stock of future assets. But only 4.8% expressed the need to expand cash crop hectarage, because cash crop growers have access to loanable funds.

The assembled information so far, partially allows us to conclude that, "The current land use system in the District is one in which the dominance of cash crop growing is so structured as to reduce

food crop production". Refer to table 5.17 on page - 211

5.11 THE LIVESTOCK ECONOMY

The small holder farmer in Nyeri District maintains various types of domestic animals on the farm besides crop cultivation. The two enterprises have mutual inter-dependence, which may be direct or cyclic. This section addresses itself to the animal rearing sector singly and then together with the crop farming sector.

The commonly reared domestic animals in the investigated area are, cattle, sheep, goats and pigs. Small livestock such as poultry and rabbits are also kept, but their management as business concerns is less widespread. Thus, the latter were less emphasized in this study.

Cattle which were found to be the most popular domestic animals in the study area are normally kept for milk production and for sale when large sums of money are required for domestic expenses. Sheep and goats are kept as security animals which can be sold in times of emergency or when the flock is too big to maintain economically. Pig rearing on the other hand is geared to the market (in this case the Upland Bacon Factory in Limuru) where they are bought in

bulk.

No substantiative statistical information was obtained to help us relate statistically those factors that encourage or discourage the keeping of certain livestock types but extensive discussions were carried out between the researcher and the respondents. The information thus collected was recorded in the field notebook. This information reveals that pig rearing as an enterprise had become unattractive to most farmers due to the high cost of "concentrates" for feeding pigs and lack of other market openings.

The following is a summary table showing the frequency of occurrence of domestic animal types kept by the farmers in the survey area during the period of research.

Table 5.19

DISTRIBUTION OF LIVESTOCK NUMBERS IN THE SAMPLE

	Cattle	Sheep	Goats	Pigs
Total NO. of animals	501	287	88	21
Total No.of farms with each animal type	161	86	35	8
Average NO.of each animal type per farm	3	3	2.5	2.5

Source: Field Work

On average each of the farms surveyed had at least a combination of two of the four different types of livestock, of which cattle appeared more frequently in each of the combinations.

Selling of domestic animals is a common practice -the number of animals sold largely depends on the size of the herd. 78% of the farmers interviewed

had sold one or more units of cattle, 35% had sold sheep, 17% had sold goats and only 4% had pigs to sell. The fewer number of pigs sold is a reflection of the limited number in which they are kept as the table above shows.

ANIMAL GRAZING

The principal methods of feeding the animals that were in common use were: free-grazing and zero-grazing or a combination of both. 48.8% of the farmers practised free-grazing, 10.9% zero-grazing and 30.1% a combination of both. Free-grazing requires large areas of land to make it eonomically and ecologically feasible, whereas zero-grazing has greater economy of space, but is more capital intensive. These figures, may give an erroneous impression that small-holder farmers in Nyeri District have large areas of land under pasture. However, little mentioned is road-side grazing which is quite common and was included in the category of free-grazing. Table 5.16 shows that the percentage area allocated to animal-grazing vis-a-vis crop production is relatively lower. Therefore, to make livestock farming a scientifically sound system that does not result in over-grazing and hence soil degradation, zero-grazing would

be the most viable animal feeding system. However, natural grassland is always cheap and in the absence of scientific advice and capital it is the easiest to manage. As indicated in table 5.11 page 200 only 0.6% of the farmers interviewed had received advice on livestock development during the survey period from the agricultural extension officers.

Whether a farmer practices free-grazing or zero-grazing, feeding of animals with additional foodr in the "boma" is commonly observed. Farmers purposefully plant fodder crops along the farm boundaries or set aside a lot of land for this purpose. Referring to table 5.17 page 211 above 63.4% of the farmers interviewed had maintained permanent fodder crops on their farms.

CONSTRAINTS TO LIVESTOCK DEVELOPMENT

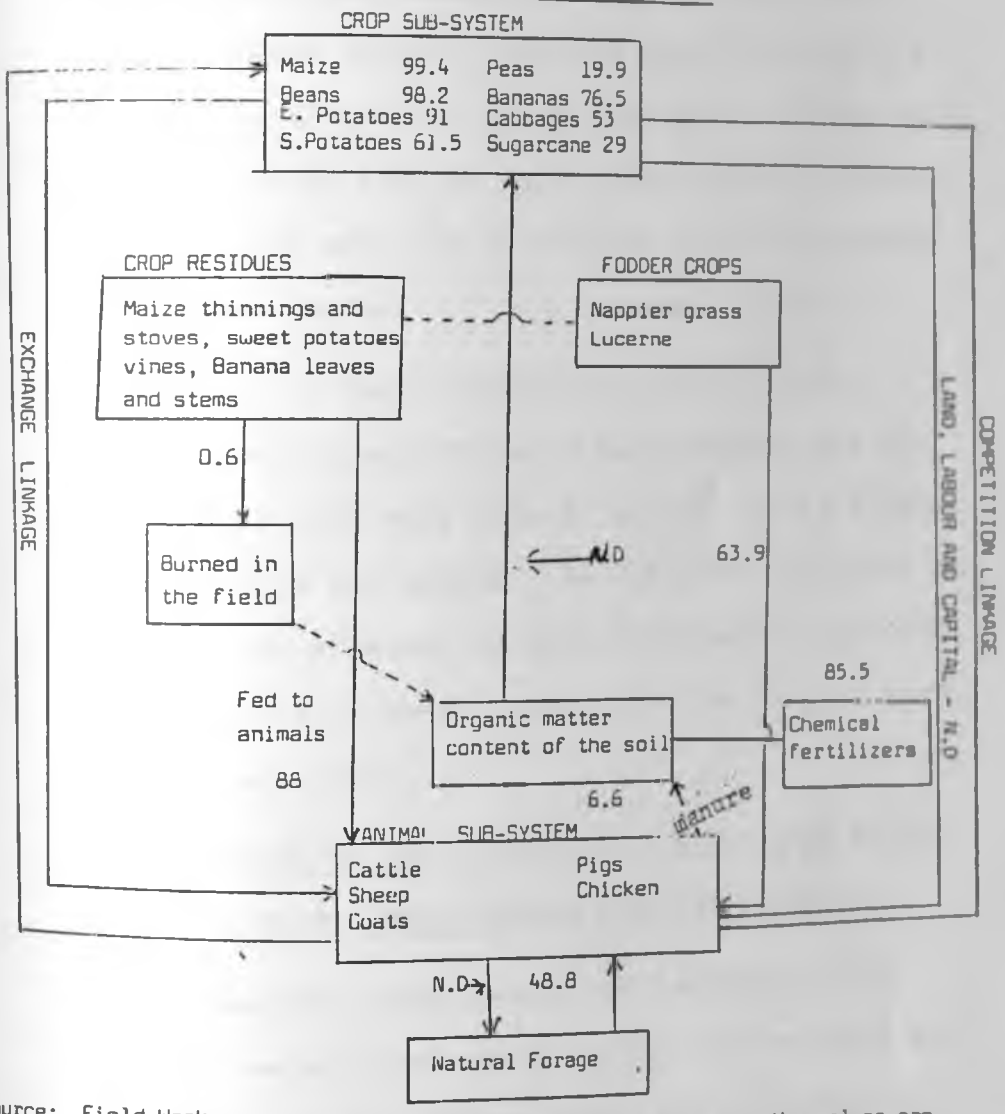
Development of livestock economy on the small-holder farms in the District is confronted with a number of limiting problems which slows the rate of growth in animal production. Shortage of grazing land and dry season animal feed are the most pre-dominant problems encountered. However, there are others which feature less prominently such as lack of veterinary services. These production

constraints are examined in greater details in following section which combines both crop cultivation and animal husbandry.

5.12 INTERACTION BETWEEN CROP CULTIVATION AND ANIMAL PRODUCTION

As mentioned in the introduction to this section the small-holder farmer maintains animals on the farm as a complementary activity to crop farming. This creates an integrative system which may be direct, cyclic or competitive. For example there is a direct and intimate interaction between fodder crops and animals on the farm. The animal droppings provide a source of farm manure while the fodder crops provide a resourceful source of animal feed. These associations may be illustrated in a kind of systems model shown below. (Figure 5(a).)

FIG 5(a) DIRECT AND INDIRECT CROP/ANIMAL ASSOCIATIONS



Source: Field Work

_____ unbroken lines indicate strong linkages

------ Broken lines indicate weaker linkage

N.D indicate absence of data

. 63.9 - the values are percentages of responses

The figure above shows the various identified linkages between the two subsystems. 1.8% of the farmers sold their crop residues to others and therefore, this was counted as a loss to the system. 0.6% of the farmers burned crop residues in the field and hence the linkage was weaker. There is a strong linkage however, between crop residues fed to animals, the manure deposited either in the "boma" or in the field and the soil organic matter content. All these are positive attributes that contribute to an intergrated farming system.

In addition to the positive attributes, there is bound to be a competitive linkage between the two subsystems. The most notable is the use of farmers land, capital and labour. No data was available to indicate the strength of this relationship and thus the inclusion of these factors in the diagram were mainly descriptive.

5.13 SUMMARY OF THE IDENTIFIED CONSTRAINTS WITHIN THE NYERI SMALL HOLDER FARMING SYSTEMS

In this section, the identified constraints to crop and animal production systems are summarized and the interrelationships among them elaborated. The purpose of which is to give comprehensive

insights into the possible linkages that may exist between the identified parameters and the small - holder agricultural production systems. Causal diagraming as an analytical tool to facilitate understanding of the complex causal relationships among the variables within the farming system is employed. However, for the purpose of clarity complex diagrams have been avoided.

In the survey area, agricultural production was seen to be limited by both natural and socio-economic conditions. Some of these aspects are summarized in the table below. (Table 5.20)

TABLE 5.20

PERCEIVED FARMING SYSTEMS PRODUCTION CONSTRAINTS AND THE RELATIVE IMPORTANCE ATTACHED TO THE CAUSAL FACTORS.

Farming system Production Contraint	Causal Factor (S)	Relative importance Attached to the causal Factor (s)	
		Number of respondents in the sample	Percentage of the total number of respondents in the sample
Low crop productivity	Too much rains	2	1.2
	long dry spells	13	7.8
	Insects, pests and diseases	30	18.0
	Flooding and erosion	5	3.0
	Winds	7	4.2
	Weeds	17	10.2
	Supply of seeds too late	23	13.9
	Prices of seeds to high	43	25.9
	Others	26	15.8
	TOTALS	166	100%
Low animal Productivity	Shortage of grazing lands	85	51.2
	Seasonal shortage of animal feed	32	19.3
	High cost of concentrates	25	15.0
	Others	24	14.5
	TOTALS	166	100%
Low animal Reproduction Rate	High calf mortality rate	25	15.0
	Lack of Veterinary Services	31	18.6
	Others	110	66.4
SOURCE: FIELD WORK	TOTAL	166	100%

The above statistics brings out the relative importance of each of the production constraints as identified subjectively by the producers themselves. This is in line with the argument that the subjective perception of the producers define the constraints operating in the production system.

The overall productivity of a farming system, however, reflects an interplay of different constraints and therefore, it is important that they are brought together in a single causal-functional model as shown in figure 5(B).

It can be seen from the model that the prevalent farming systems suffer from low productivity in crop as well as livestock due to some of the outlined production constraints, which act singly and/or together. Among the farmers interviewed 69.9% reported lack of self-sufficiency in their food requirement and therefore had to purchase additional food for the family to supplement their own farm production.

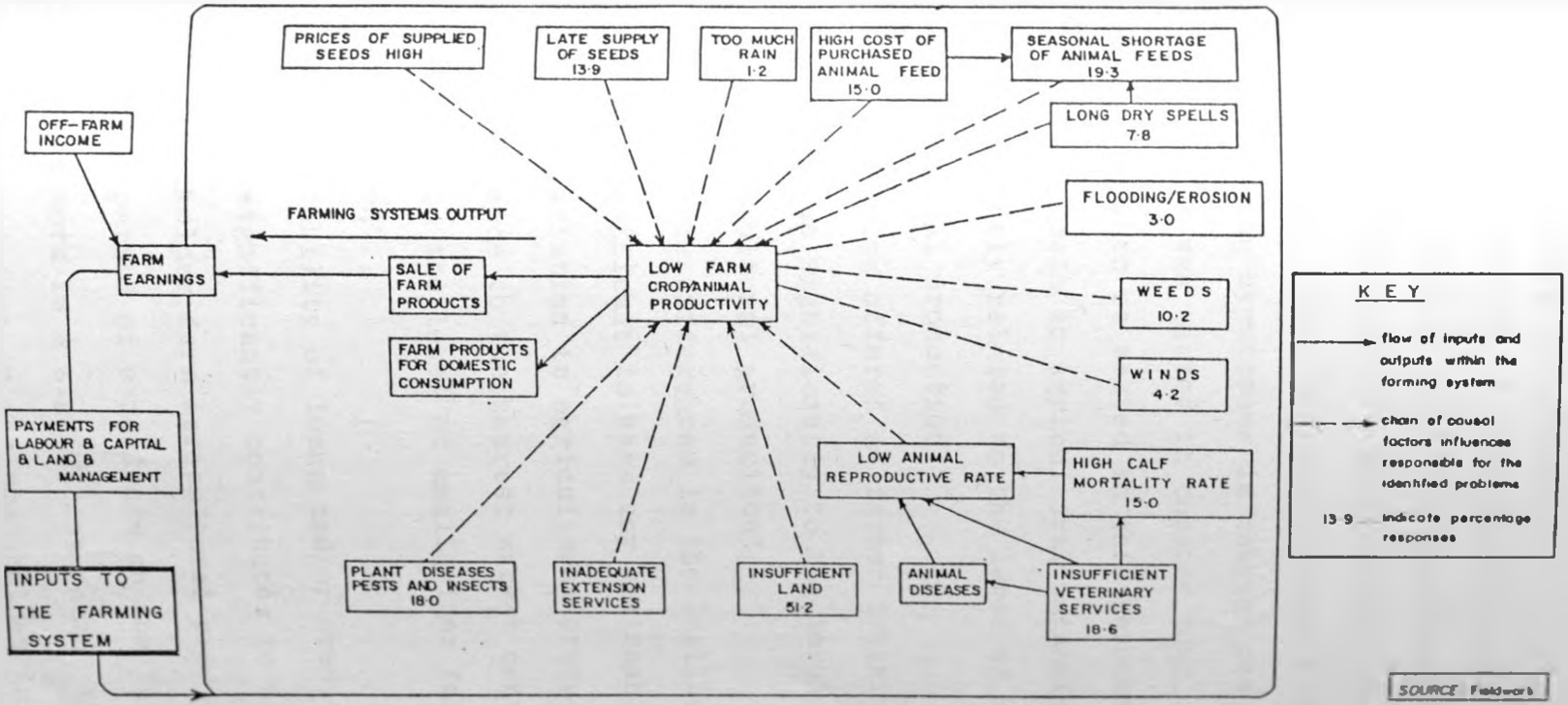


Fig. 5B: COMBINED INPUT–OUTPUT AND CAUSAL FACTORS DIAGRAM FOR SMALL-HOLDER FARMS

5.14 THE ANALYTICAL MODEL

The first section of this chapter examined statistics related to some general characteristics of the smallholder farmer resource availability, utilization and constraints. This section concerns itself mainly with testing hypotheses in chapter one. The first hypothesis was tested in chapter four. The other hypotheses to be tested in this chapter are:

1. "The growth in agricultural extension services is significantly related to the level of smallholder agricultural production."
2. " Training offered at farmer training institutes contributes significantly to the level of smallholder farm agricultural produciton".
3. "The size differences in the smallholder farms are too insignificant to have any noticeable contribution to the variation in agricultural production".
4. "Distance to the nearest market centre significantly relates to the level of smallholder farm agricultural production".
5. "Availability of loans and/or credits to smallholder farmers significantly contributes to the variation in smallholder farm agricultural production".
6. "The period of experience on the farm and farm related work is a significant factor that contributes to the variation in the smallholder farm agricultural production".

It was not possible to examine statistically production responses in all the crops cultivated by an individual farmer, hence a few crops were chosen for the purpose of analysis. These were, coffee, tea, maize, and beans. The former two represent the farmer's cash crops whereas the latter two represent the farmer's food crops. The respective yields of these crops were analyzed with respect to six selected independent variables. The choice of these latter variables was influenced by the researcher's own experience on the farm and written works of research based in other areas. An examination into the past research work done on farm production economics shows various deliberate efforts put by research workers in an attempt to explain variations in small holder (or large scale) farms production performances. There has not been, however, a general concensus as to the commonly shared denominators. It is, therefore, in order here to outline the main variables examined in this study.

The dependent variables were the respective crop yields, whereas the independent variables were the following:

X_{127} - Farmers' period of experience on the farm

X_{113} - Distance from the farm to the nearest market centre

X_{122} - Frequency of agricultural extension visits

X_4 - Farm size

X_{125} - Frequency of availability of loans and/or credits.

X_{79} - Frequency of attendance to farmer training institutes.

In order to determine the relative importance of the selected independent variables to agricultural production (based on the respective crop yields), regression models drawn from computer programs contained in the statistical package for Social Sciences (SPSS) were used. This is an integrated System of Computer programs designed for the analysis of Social Science data. Its attractiveness in data analysis lies mainly on its considerable flexibility in the format of data.[1]

The SPSS subprogram REGRESSION performs a multiple regression analysis discussed in chapter three. This is the main analytical model used in the present analysis. It would have been ideal to present other analytical models, but this was not

1-Nie, N.H. et al (1975) Statistical Package for Social Sciences.

possible due to financial and time constraints.

The general form of this analytical model (discussed also in Chapter three) is:

$$Y = B_o + B_1X_1 + B_2X_{21} + B_3X_{31} + B_pX_{p1} + E_1$$

where Y = the dependent variable

B_o = intercept term along Y axis

B = 1--P the model regression parameters referred to as the partial regression coefficients.

E_1 = random disturbance or error term.

5.15 EMPIRICAL RESULTS AND ANALYSIS OF THE MODEL

As indicated above the model was aimed at testing the hypotheses advanced in chapter one, which in general terms stated that, the respective crop yields varied from farm to farm in accordance with factors that are basically endogenous and exogenous to the farm. Although the number of variables chosen in each case is few, it is hoped that the results of this analysis will give us some indications of the relative contribution of each independent variable to variation in crop yield singly and together with others.

The results of the multiple linear regression

TABLE: 5.23 SUMMARY TABLE OF REGRESSION ANALYSIS ON COFFEE YIELDS

VARIABLE	R	R^2	RSQ	SIMPLE	B	BETA
X_{127} -FARMERS PERIOD OF EXPERIENCE ON THE FARM	0.06102	0.00372	0.00372	0.06102	-0.69971	-0.01223
X_{113} - DISTANCE TO THE NEAREST MARKET CENTRE	0.17535	0.03075	0.02702	-0.17031	-2.64120	-0.14390
X_{122} -FREQUENCY OF AGRICULTURAL EXTENSION VISITS	0.31783	0.10102	0.07027	0.27713	5.41398	0.28906
X_4 - FARM SIZE	0.33211	0.11030	0.00928	0.13794	3.80464	0.08583
X_{125} - FREQUENCY OF AVAILABILITY OF LOANS AND/OR CREDITS	0.35033	0.12273	0.1243	0.10844	3.25994	0.09625
X_{79} - FREQUENCY OF ATTENDANCE TO FARMER TRAINING INSTITUTES	0.36249	0.13140	0.00866	0.05286	-2.53444	-0.09941
CONSTANT:					48.06989	

SOURCE: COMPUTER PRINTOUT

for the first dependent variable - that is, the available data on coffee yields, based on an examination of 135 smallholder farmers are as given in tables 5.21 and 5.22.

Table 5.21 gives the multiple correlation coefficient R, the coefficient of multiple determination R^2, the amount of change in R^2, the simple correlation coefficient of each variable, the regression coefficient for each variable and the beta weight.

The multiple correlation coefficient R indicate the strength of relationship between coffee yields and the six independent variables taken together. The latter are arranged in accordance with their significance in the regression equation and are also cumulative. This relationship can therefore, be illustrated algebraically as: Y=a+.363X, which shows a positive relationship between coffee yield and the selected independent variables.

The coefficient of multiple determination R^2 shown in column 2 of table 5.21 indicate the proportion of variance in the dependent variable accounted for by the six independent variables separately and jointly. This is given as R^2= .13140, meaning that 13.14% of the variation in the levels of

coffee yield is explained by the six independent variables operating jointly. These variables, therefore, do not explain 86.86% of the variation in coffee yield. This result was unexpected. The low influence of these variables to variation in coffee yield is explained by the fact that none of the selected independent variables were seen to vary tremendously from one farm to the other, as shown by the descriptive statistics provided earlier in this chapter. Again, a series of key factors have not been included in the model such as use of chemical fertilizers, capital investments, labour availability and bio-physical characteristics.

RSQ change given in column 3 of table 5.21 show the amount of variation in the dependent variable accounted for by each of the independent variables singly, - that is, the contribution of each variable to total variation explained by the six independent variables as shown:

R^2= .00372 + .02702 + .07027 + .00928 + .01243 + 00866 = .13140.

From these figures, it is shown that there is no single variable that contributes enormously to the variation in the dependent variable.

The prediction equation of the multiple linear regression is derived from column 5 of table 5.21 which contains the coefficients of the multiple regression equation. The derived equation is given as:

$$\bar{Y} = 48.0699 - 0.6997\ X_{127} - 2.6412\ X_{112} + 5.4139\ X_{122} + 3.8046\ X_4 + 3.2599\ X_{125} - 2.5344\ X_{79}$$

where:

$\bar{Y}$ = estimated coffee yield

X_{127} = farmers period of experience on the farm and farm related activities

X_{113} = Distance to the nearest market centre

X_4 = Farm size

X_{125} = Frequency of availability of loans and/or credits

X_{79} = Frequency of attendance to farmer training institutes.

X_{22} Frequency of agricultural extension visit

If one assumes that these factors were independent of each other - an assumption which is implicit in the use of multiple regression technique - a positive change in variables X_{127}, X_{113} and X_{79} would have a negative influence on the level of coffee yield, whereas a similar change in variables X_{122}, X_4 and X_{125} would have the opposite effect. The linear regression equation does not tell us

how significant each of the independent variables have been in explaining the variation in the dependent variable. The following section looks at this latter aspect.

ANALYSIS OF VARIANCE AND TEST OF SIGNIFICANCE

Analysis of variance is a technique used in relating a dependent variable, measured on an interval or ratio scale to a mutually exclusive classification of the observations, which acted as the independent variable[1]. This analytical procedure indicates what proportion of the variation in the dependent variable is accounted for by the classification as discussed above. The parametric 'F' - test which was used in the analysis of variance indicate the probability of the difference observed in the sample that were also present in its parent population.

The purpose of significance testing is to determine whether the observed parameters of the regression equations have a statistically significant effect. That is, to determine whether all the observed parameters are likely to have the same sign, and perhaps magnitude as well, in the population.

In this analysis all the values were tested at 0.01 level of significance. The summary table showing the various levels of analysis is provided below table 5.22

Johnston, R.J. (1978) Multivariate Analysis in Geography.

TABLE; 5.2.2

ANALYSIS OF VARIANCE FOR COFFEE YIELDS

VARIABLE	B	BETA	STANDARD ERROR B	"F" RATIO
X_{127}- FARMERS PERIOD OF EXPERIENCE ON THE FARM	-0.69971	-0.01223	4.63742	0.023
X_{113}- DISTANCE TO THE NEAREST MARKET CENTRE	-2.64120	-0.14390	1.37904	3.668
X_{122}- FREQUENCY OF AGRICULTURAL EXTENSION VISITS	5.41398	0.28906	1.45575	13.831
X_4- FARM SIZE	3.80464	0.08583	3.55291	1.147
X_{125}- FREQUENCY OF AVAILABILITY OF LOANS AND/OR CREDITS	3.25994	0.09625	2.61656	1.552
X_{79}- FREQUENCY OF ATTENDANCE TO FARMER TRAINING INSTITUTES	-2.53444	-0.09941	2.01242	1.586
CONSTANT	48,06989		19.43212	6.119

SOURCE: COMPUTER PRINTOUT

The critical value of 'F' at 0.01 level of significance with 6/159 degrees of freedom = 2.16. A parameter is taken to be significant if the actual value exceeds or equals to the critical 'F' - value.

The tabulation indicates that, only two of the six variables were significant in the regression equation. These were X_{113}, Distance to the nearest market centre and X_{122}, Frequency of agricultural extension visits. However, the following variables were not significant.

X_{127} = Farmers period of experience on the farm

X_4 = farm size

X_{125} = Frequency of availability of loans and/or credits

X_{79} = Frequency of attendance to farmer training institutes.

The lack of significance in explaining variation in coffee yield in variables X_{127}, X_{125} and X_{79} was unexpected. When this study was being proposed a number of guiding assumptions were made with respect to the selected independent variables. First, the farmer's period of stay on the farm was to be an indicator of cumulative knowledge and experience about all aspects related to farming, the frequency

of availability of loans and/or credits was seen to be an important differentiating factor relative to a farmer's ability to purchase capital inputs, hire labour and initiate technical changes on the farm, and the frequency of attendance to farmer training institutes was viewed as an important source of information related to farm management and organisation. However, these factors have been shown to be insignificant in as far as coffee production is concerned.

The insignificance embodied in these three factors could have arisen out of default in data collection. The data collection was based solely on the responses of the farmers according to the questionnaire. Since the farmers were asked to recall past events, this could have been a possible source of error.

The period of stay on the farm does not seem to have a significant influence on the level of coffee yield. This is not a traditional crop and therefore, the experience of the farmer is often surpassed by the accumulated coffee management knowledge in research stations and elsewhere. Hence, a farmer's receptivity to new ideas on coffee management such as pruning cycle, spraying and application of fertilizers could have greater impact on production levels than the

period of experience working on the farm.

Frequency of availability of loans and/or credits may have failed to show a significant influence on the variation in coffee yield due to the fact that, most of the coffee growers (74.7%)had accessed themselves loans or credits from the local co-operative societies. It happens that all small holder coffee growers are members of the co-operative societies which also markets the product for them.

It was found out that very few farmers ever attended courses at the local farmer training centre, and those who ever did, it was recorded did so after a long period of time. Hence, most of the small holder farmers did not keep abreast with teachings on how best to improve farm management activities provided by the farmer training institutes. Therefore, it can be seen why attendance to farmer training institutions failed to show a significant contribution to the variation in coffee yield. Again those farmers who frequented these training institutes may not necessarily be getting knowledge on how to improve coffee yield alone, and thus time spent at farmer training centres only adds negatively to the yield of this crop by withdrawing labour which otherwise could be employed tendering the crop.

Farm size is another factor that was found to be insignificant in explaining variation in coffee yield. Probably areas under the crop could have been more important in explaining the influence it has on variation in coffee yield rather than the gross farm size. This result was, however, expected. The results of the multiple linear regression for the second dependent variable - that is the available data on tea yields, based on an examination of 13 smallholder farmers is as shown in tables 5.23 and 5.24. Table 5.23 provides the following results:

$R = .42734$

$R^2 = .18262$

The former parameter indicates a positive relationship between the dependent variable (that is tea yields) and the independent variables (elucidated above). The latter parameter shows that 18.3% of the variation in tea yields is explained by the six independent variables operating jointly. 81.7% of the variation in the dependent variables is unexplained. This is partly due to the homogeneity of the distribution of these factors and partly due to the existence of a number of variables which could not be quantified , such as micro-variations in soil types, social, economic and cultural factors. This explan-

ation also applies to the variation observed above in coffee yield.

The contribution of each independent variable to the total variation in the dependent variable is as shown below:

$R^2 = 0.0768 + 0.04850 + 0.03019 + 0.01549$

$+ 0.00919 + 0.00245 = .18262$

As in the case of coffee yield, there is no single factor that is dominant in accounting for the variation in the dependent variable.

The prediction equation of the multiple linear regression is:

$\bar{Y} = 63.91448 + 4.4004 \text{ X } 127 - 4.7288 X_{113} + 3.0269 X_{122} - 2.0882 X_4 + 4.0975 X_{125} - 3.1307 X_{79}$

where

$\bar{Y}$ = Estimated tea yields and the Xs represent the six independent variables discussed earlier.

A positive change in variables X_{113}, X_4 and X_{79} would negatively influence the level of tea yields, whereas a similar change in variables X_{127}, X_{122} and X_{125} would have the opposite influence.

So far the results of the regression analysis performed on the respective yields of the two cash

TABLE: 5.2:3

SUMMARY TABLE OF REGRESSION ANALYSIS ON TEA YIELDS

VARIABLE	R	R^2	RSQ CHANGE	SIMPLE R	B	BETA
X_{127}- FARMERS PERIOD OF EXPERIENCE ON THE FARM	0.27713	0.07680	0.07680	0.27713	4.40035	0.23494
X_{113}- DISTANCE TO THE NEAREST MARKET CENTRE	0.35397	0.12529	0.04850	-0.23700	-4.72878	-0.18906
X_{122}- FREQUENCY OF AGRICULTURAL EXTENSION VISITS	0.39431	0.15548	0.3019	0.14811	3.02691	0.17774
X_4- FARM SIZE	0.41350	0.17098	0.01549	-0.17031	-2.08816	-0.11377
X_{125}- FREQUENCY OF AVAICABILITY OF LOANS AND/OR CREDITS	0.42441	0.18017	0.00919	0.13794	4.09746	0.09245
X_{79}- frequency OF ATTENDANCE TO FARMER TRAINING INSTITUTES	0.42734	0.18262	0.00245	-0.20994	-3.13066	-0.09913
CONSTANT					63.91448	

SOURCE: COMPUTER PRINTOUT

crops (coffee and tea) show that, the used variables explain little of the observed variation in yields. An attempt was made to determine the levels of significance embodied in these variables, in the above analysis of coffee yields. A similar analysis of variance and significance test is performed for the tea crop yield. This will help us determine whether there is a significant difference in the production responses to the selected variables in the former and latter crop yields. The 0.01 level of significance is maintained.

The critical 'F' value at 0.01 level of significance with 7/158 degrees of freedom = 2.76.

Looking at the tabulations given in table 5.26 three out of the six independent variables were significant in the regression equation. These were X_{127} - Farmers period of experience on the farm, X_{113} - Distance to the nearest market centre and X_{122} - Frequency of agricultural extension visits.

An attempt to explain the insignificant contribution made by variation X_4, X_{125}, amd X_{79} to variation in crop yields was given above when discussing coffee yield. The significance of variable X_{127} on tea yields and not on coffee yield is due to the

TABLE: 5.24

ANALYSIS OF VARIANCE FOR TEA YIELDS

VARIABLE	B	BETA	STANDARD ERROR B	"F" RATIO
X_{127} - FARMERS PERIOD OF EXPERIENCE ON THE FARM	4.40035	0.23494	1.39124	10.004
X_{113} - DISTANCE TO THE NEAREST MARKET CENTRE	-4.72878	-0.18906	2.08207	5.158
X_{122} - FREQUENCY OF AGRICULTURAL EXTENSION VISITS	3.02691	0.17774	1.23957	5.963
X_4 - FARM SIZE	-2.08816	-0.11377	1.34385	2.415
X_{125} - FREQUENCY OF AVAILABILITY OF LOANS AND/OR CREDITS	4.09746	0.09243	3.22608	1.613
X_{79} - FREQUENCY OF ATTENDANCE TO FARMER TRAINING INSTITUTES	-3.13066	-0.09913	3.11028	1.013
CONSTANT	63.91448		22.22840	

SOURCE: COMPUTER PRINTOUT

fact that tea unlike coffee does not require a lot of purchased inputs such as sprays and fertilizers. In fact the management component is more important in terms of prunning, picking the leaves on time and delivering the leaves to the collecting centre. So if we work with our assumption that the period one stays on the farm is an indicator of knowledge and experience about farm management practices, then we can accept the significance of this variable in explaining variation in tea yields.

The model has so far been examining the relationship between the farmers' main cash crops (coffee and tea) and the selected independent variables. A similar analysis is undertaken here with respect to maize and bean yields. These are the primary food crops grown by the farmers in the District.

The results of the multiple linear regression for the third dependent variable - the available data on maize yield based on an examination of 165 smallholder farmers are provided in table 5.25.

The multiple correlation coefficient R=.26491 and the coefficient of multiple determination R^2=0.07018. The R^2 value show that 7.0% of the variation in maize yield is explained by a joint operation of

TABLE: 5.25 SUMMARY TABLE OF REGRESSION ANALYSIS ON MAIZE YIELDS

SUMMARY TABLE OF REGRESSION ANALYSIS

VARIABLE	R	R^2	RSQ · CHANGE	SIMPLE R	B	BETA
X_{127} - FARMERS PERIOD OF EXPERIENCE ON THE FARM	0.11635	0.01354	0.1354	0.11635	3.17295	0.11957
X_{113} - DISTANCE TO THE NEAREST MARKET CENTRE	0.15509	0.02405	0.1051	-0.11521	-1.08566	-0.12748
X_{122} - FREQUENCY OF AGRICULTURAL EXTENSION VISITS	0.16399	0.06110	0.03705	0.16733	2.43180	0.20557
X_4 - FARM SIZE	0.18201	0.06733	0.00623	0.03356	1.35515	0.06589
X_{125} - FREQUENCY OF AVAILABILITY OF LOANS AND/OR CREDITS	0.18201	0.06733	0.00000	-0.01215	-0.58748	-0.03738
X_{79} - FREQUENCY OF ATTENDANCE TO FARMER TRAINING INSTITUTES	0.26491	0.07018	0.0284	0.0339	0.90436	0.10406
CONSTANT:					22.50912	

SOURCE: COMPUTER PRINTOUT

the six independent variables. This is a rather weak relationship which means that the selected independent variables have a very low contribution to the variation in the yield of this crop. The partial contribution of each independent variable to the total crop yield is as shown below.

$R^2 = 0.01354 + 0.01051 + 0.03705 + 0.00623 + 0.000 + 0.0284 = 0.07018$

None of these parameters has an outstanding influence on the dependent variable. Variable X_{125} has nil contribution. This was expected since most farmers obtain their loans and credits mainly from the co-operative societies - which is mainly meant for improving the cash crop production. In view of the importance attached to cash crop growing as discussed earlier, there is bound to be negligence on food crop growing.

The predictive multiple regression model that explains this relationship is:

$\bar{Y} = 22.50912 + 3.17295\ X_{127} - 1.08566\ X_{113} + .43180\ X_{122} + 1.35515\ X_4 - 0.58748\ X_{125} + 0.90436\ X_{79}$

Where: $\bar{Y}$ = estimated maize crop yield and the X_s are the independent variables outlined above.

VARIABLE	B	BETA	STANDARD ERROR B	"F" RATIO
X_{127} - FARMERS PERIOD OF EXPERIENCE ON THE FARM	3.17295	0.11957	2.22630	2.181
X_{113} - DISTANCE TO THE NEAREST MARKET CENTRE	-1.08566	-0.12748	0.66204	2.689
X_{122} - FREQUENCY OF AGRICULTURAL EXTENSION VISITS	2.43180	0.20557	0.96611	6.336
X_4 - FARM SIZE	1.35515	0.06589	1.70566	0.631
X_{125} - FREQUENCY OF AVAILABILITY OF LOANS AND/OR CREDITS	-0.58748	-0.03738	1.25614	0.219
X_{79} - FREQUENCY OF ATTENDANCE TO FARMER TRAINING INSTITUTES	0.90436	0.10406	0.69887	1.67
CONSTANT	22.50912		9.32884	5.822

SOURCE: COMPUTER PRINTOUT

A positive change in variables X_{113} and X_{125} would negatively influence the level of maize yields, whereas a similar change in variables X_{122} X_4 X_{127} and X_{79} would have the opposite effect.

Analysis of significance (at 0.01 level of significance with 6/159 degrees of freedom) indicate that three out of six variables were significant. These are X_{127} - Farmers period of experience on the farm, X_{113} - distance to the nearest market and X_{122} - frequency of agricultural extension visits. Other variables not significant are:

X_{125} = frequency of availability of loans and/or credit

X_4 = farm size

X_{79} = Frequency of attendance to farmer training institutes.

Explanations for lack of significance in the above variables is as given in relation to tea crop yields above.

It is worth noting at the outset, however, that a multiple regression analysis of the selected variables is not by any means sufficient to explain the observed variation in crop production performances. Other factors should also be taken into

onsideration. This study could not incorporate all the various factors that are likely to influence crop production performances in the analysis. A few variables were therefore selectively chosen. But from what we have found and assembled so far, it is becoming clear that the variables incorporated in this analysis should be looked upon as indicative of what is happening in this sector rather than sources of conclusive findings that could be used without further research and analysis as a base for future development of the agricultural sector. A discussion on the shortcomings of the model and the cautionary measures taken in the data interpretation appears in the last section of this chapter.

The results of the regression analysis for the fourth dependent variable - that is, the collected data on bean crop yield, based on a survey of 163 small holder farmers are as follows: (table 5.27)

$R = 0.27708$

$R^2 = 0.07677$

The multiple linear regression analysis, therefore, indicates that the six selected independent variables explain only 7.7% of the variation in the dependent variable. The value is slightly higher than was

contained in the analysis of maize crop yield. However, the relationship is still weak - which means that other variables rather than the ones incorporated in this analysis could possibly have had greater contribution in explaining the variation in the yield of this crop.

Each of the independent variables contributes partially to the total explained variation as shown:

R^2= 0.03749 + 0.02357 + 0.01152 + 0.00230 + 0.00096 + 0.00094 =.07677.

TABLE: 5.27 SUMMARY TABLE OF REGRESSION ANALYSIS ON BEAN YIELDS

VARIABLE	R	R^2	RSQ CHANGE	SIMPLE R	B	BETA
X_{127} - FARMERS PERIOD OF EXPERIENCE ON THE FARM	0.19361	0.03749	0.03749	0.1936	4.27372	0.19260
X_{113} - DISTANCE TO THE NEAREST MARKET CENTRE	0.24709	0.06105	0.02357	0.17845	-2.47247	-0.15184
X_{122} - FREQUENCY OF AGRICULTURAL EXTENSION VISITS	0.26939	0.07257	0.01152	0.12862	2.02744	0.12201
X_4 - FARM SIZE	0.27363	0.07487	0.00230	0.07962	-1.86103	-0.06642
X_{125} - FREQUENCY OF AVAILABILITY OF LOANS AND/OR CREDITS	0.27537	0.07583	0.00096	-0.0197	-1..28071	-0.03257
X_{79} - FREQUENCY OF ATTENDANCE TO FARMER TRAINING INSTITUTES	0.27708	0.07677	0.00094	0.04813	0.44493	0.02945
CONSTANT					22.56228	

SOURCE: COMPUTER PRINTOUT

TABLE 5.2M ANALYSIS OF VARIANCE FOR BEAN YIELDS

VARIABLE	B	BETA	STANDARD ERROR B	"F" RATIO
X_{127}- FARMERS PERIOD OF EXPERIENCE ON THE FARM	4.27372	0.19260	1.96699	4.721
X_{113}- DISTANCE TO THE NEAREST MARKET CENTRE	-2.47247	-0.15184	1.26957	3.793
X_{122}- FREQUENCY OF AGRICULTURAL EXTENSION VISITS	2.02744	0.12201	1.31434	2.379
X_4 - FARM SIZE	-1.86103	-0.06642	2.93836	0.401
X_{125}- FREQUENCY OF AVAILABILITY OF LOANS AND/OR CREDITS	-1.28071	-0.03257	3.04776	0.177
X_{79} - FREQUENCY OF ATTENDANCE TO FARMER TRAINING INSTITUTES	0.44493	0.02945	1.17106	0.144
CONSTANT	22.56228		21.05643	1.148

SOURCE: COMPUTER PRINTOUT

Variables X_{125} and X_{79} have a very low contribution. But overall no single variable has an outstanding contribution. The predictive linear multiple regression that explains this relationship is:

$$\bar{Y} = 22.56228 + 4.2737\ X_{127} - 2.4725\ X_{113} + 2.0274\ X_{122} - 1.8610\ X_{4} - 1.2807\ X_{125} + 0.4449\ X_{79}$$

where $\bar{Y}$ = estimated yield of the bean crop and Xs represent the selected independent variables. The B coefficients show that variables X_{127} X_{122} and X_{79} are important variables for increased yield of the bean crop. However, variables X_4 X_{113} and X_{125} show a negative contribution to the crop yield.

Table 5.30 show the results of the analysis of variance with 'F' ratios. The theoretical value of 'F' at 6/159 degrees of freedom tested at 0.01 level of significance = 216

From table 5.30 three out of the six variables are significant. These are : X_{127} - Farmers period of experience on the farm, X_{113} - Distance to the nearest market centre and X_{122} - frequency of agricultural extension visits. Variables X_4 - farm size X_{125} - frequency of availability of loans and/or credit and X_{79} - frequency of attendance to farmer training institutes were insignificant. These were

the same variables that were found to be insignificant relative to maize crop yield. Carefully interpreted one would say that in order to increase the level of food production in the District more agricultural extension officers should be deployed in the area. Referring back to the statistics, however, we find that most agricultural extension officers advise farmers mainly on how to cater for cash crops. Therefore, it must be ensured also that the farmers are equally advised on food crop production. Attendance to farmer training centre should be encouraged more so as to allow farmers to breakthrough into the modern methods of crop and animal husbandry. The Government scheme on seasonal credits should be expanded to cover most of the smallholder farmers who depend mainly on growing of food crops, and not limited to cash crop farmers.

In sum it is only through extending indiscriminantly the right advice and support to the smallholder farmers can the nation hope to meet the increased demand for food as the population burgeons.

5.16 A DISCUSSION AND SUMMARY OF THE MAIN FINDINGS

According to the objectives and the subsequent hypotheses advanced in this study, the analysis of the smallholder farming systems has two main

aspects: (1) the endogenous determinants of crop production performances - in which two factors were included in the analysis, that is farm size (X_4) and farmers' period of experience on the farm (X_{127}) (2) the influences of the exogenous factors on farm organization and production management. The exogenous factors were :(X_{113}). Distance to the nearest market centre (X_{122}) Frequency of agricultural extension visits, (X_{125}) Frequency of availability of loans and/or credits and (X_{79}) Frequency of attendance to farmer training institutes.

The multiple linear regression analysis revealed that: (1) Farm size is an insignificant factor in explaining the total variation in crop yield. This phenomenon was seen to apply for all the respective yields of crops subjected to the statistical analysis. Hence we accept the hypothesis that: "The size differences in the smallholder farms are too insignificant to have any noticeable contribution to the variation in agricultural production".
(2) Availability of loans and credits was also found to be insignificant and could not explain statistically the total variation in crop yield. An observation that applied to all crops under analysis. We therefore reject the null hypothesis that:

"Availability of loans and/or credits to smallholder farms significantly contribute to the variation in smallholder farm agricultural production".

(3) Frequency of agricultural extension visits was found to be an important factor in explaining total variation in crop yield. A factor that underscores the importance of agricultural extension services in influencing the level of agricultural development. As a result the hypothesis that; "the growth in agricultural extension services is significantly related to the level of smallholder farm agricultural production"is accepted.

(4) The analysis however, supported the hypothesis that:"the period of experience on the farm and farm related work is a significant factor that contributes to the variation in the smallholder farm agricultural production" in the analysis of tea, maize and beans yield data, but not coffee yield data. The possible reasons for this deviation were offered above.

(5) The other exogenous factors, that is, frequency of attendance to farmer training institutes and distance to the nearest market centre, were negatively supported by the analysis and thus we reject the hypothesis that:

(1) Distance to the nearest market centre significantly relates to the level of smallholder farm

agricultural production" and (2) "Training offered at farmer training institutes contributes significantly to the level of smallholder farm agricultural production" and accepted the alternative hypotheses that: (1) Distance to the nearest market centre does not significantly relate to the level of smallholder farm agricultural production and (2) "Training offered at farmer training institutes does not contribute significantly to the level of smallholder farm agricultural production".

However, as indicated above the quantitative analysis of the relationship between crop production performances and the various independent variables must be interpreted with caution. First the use of multiple linear regression analysis underlies some unrealistic assumptions putforward in chapter three, some of which are unlikely to be achieved in practice. The most limiting assumption, in the model assumes that the dependent and independent variables are numerical quantities which are observed without error. It is also implicit in the use of this model that, in order to derive statistical significance tests on the overall relationship among all the variables analysed on the individual coefficients, the random disturbance terms E_i are

normally distributed with mean zero and variance $\emptyset^2$; that is, E_i is $N(\emptyset, \emptyset^2 1)$. These conditions were unlikely to have been achieved due to: (I) the respondents were asked to recall some of the information contained in this study and therefore, there were greater chances of obtaining inaccurate information because of memory problems. (2) it was noted that some respondents were reluctant in answering some questions and (3) the subjective judgement of the situation by the interviewers may have influenced the results and information obtained.

Despite the shortcomings pertaining to the application of this model, the stated objectives were realised by seeking clarification from the descriptive statistics contained in the first section of this chapter and drawing heavily from secondary sources of information and data. In accordance with the available information the following conclusion can be safely stated.

Small holder farming systems in the District have proved to be capable of generating enough food and income, but due to the prevailing production constraints, full realisation of the land potential has been limited. Policy emphasis should therefore, aim at alleviating some of the identified production

constraints in these farming systems.

A summary of land utilization analysis showed that there are great variations in enterprise hectarage. This reflects in part the importance attached to each enterprise by the farmers - as influenced probably by the past and expected returns per unit area. According to the evidence we have gathered so far" cash crop production in the District holds an important place in the centre of the small holder production repertoire. This tendency will continue unless major changes in the relationship of agricultural support services occur, or new crop varieties that promise an equally high return per unit are introduced in the farming systems."

It was shown in the analysis also, that "the accumulated knowledge on farm management and organisation is an important factor that influences farm production economics. It is therefore safe again to conclude that the indigenous knowledge of the farmers play an important role not only in enhancing crop production but also in improvising structural changes on the farm." Therefore, this knowledge should be respected whenever any technical changes are recommended to farmer. That is, the farmer should always be involved

in the planning and development of new ideas and not to impose ideas on unfamiliar innovations that may be seen to alienate the farmer.

Development of infrastructural facilities is a strong commitment that the Government has in order to stimulate economic development in most parts of the country. This is a commitment with a substance. It was shown in this study that distance to the market centre is a factor that contributes to variation in farm production performances.

In sum, it was shown in this chapter that "development policies that aim at promoting rural development, particularly in the agricultural sector, must be based on a full understanding of the inter-relationships between crop-livestock systems, institutional arrangements and the socio-economic environment of the farming communities".

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSIONS & RECOMMENDATIONS

The study examined the Nyeri smallholder farming systems with a view to identifying physical and socio-economic constraints to increased farm production. The original intention was to combine socio-economic and ecological factors into one comprehensive analytical model. However, due to lack of adequate and accurate data this was not possible and therefore, the two aspects were examined separately with a limited attempt to incorporate both in the analysis.

The second objective was to determine the influence of some selected exogenous and endogenous factors to variations in farm production performances. To this end working hypotheses were formulated and subjected to statistical analysis. It was thus possible to establish the relative importance of each to crop production.

The study also sought to identify the interactions between animal and crop subsystems, in order to determine the nature of these associations.

Specific problems with respect to these two systems

were also highlighted. Interactive models were used to explain the identified problems, relationships and possible areas of interventions. Paucity of data again could not allow us to measure the exact magnitudes involved.

This chapter contains a summary of all the identified farm production problems and potentials, plus an outline of recommendations for future lines of research and planning as revealed by the research findings. It is divided into four main sections. Section one discusses the main findings and conclusions of the thesis, directing special attention to physical and socio-economic determinants of the farming systems. Section two looks at possible areas of intervention by both the Government and Non-Government organizations in order to enhance food production and generation of higher farm income among small holder farmers and consequently improved standards of living and social eocnomic welfare. Section three is a brief outline on further lines of research for scholars, and section four carries the main conclusions that emerge out of this study.

6.1a SUMMARY OF THE MAIN RESEARCH FINDINGS & CONCLUSIONS

On the basis of the available evidence assembled and discussed in the preceeding chapters, the following

aspects were noted.

There exist considerable differences in climatic elements between regions in the District. The most notable being rainfall amounts, its distribution, intensity and probability of occurence. The meteorological data examined showed rainfall amounts and temperature to vary with altitude. The probability of receiving a given amount of rainfall was also seen to be higher in the long rains than in the short rains period while the other parameters varied between months and places. The ratio of potential evapotranspiration to precipitation was seen to be higher in the lower highland and midland zones than in the upper highland zones. This phenomenon tends to influence the length of the growing season per zone and therefore, is an outstanding determinant of the types of crops that can be assured growth to maturity on a sustained moisture availability level.

The major soil types described in this study following the Kenya Soil Survey (1982) classification system, has led us to conclude that, generally the District enjoys a rich fertile soil that is well-suited to the growing of a variety of crops. Nitisols for instance, which cover much of Tetu, Othaya, Mathira and a small area of Mukurweini Division, show

a marked structure stability which enables cultivation on moderately steep gradients. They have a high moisture holding capacity and a high cationic exchange capacity (CEC). The only limitation that is seen in them is high phosphorous absorption capacity - a limitation that is easily overcome by the application of phosphate fertilizer. These soil qualities coupled with an adequate and evenly distributed rainfall (in some areas) makes some parts of this District agriculturally productive holding other factors in place, - such as soil erosion, micro-variations in soil fertility and other environmental constraints alluded in this thesis.

A small area of the survey area, however, has a ferralic cambisol soil type, which is excessively drained, has a low CEC with weatherable minerals which limit its fertility and productivity. The annual precipitation is low and the potential evapotranspiration high. The total effect being limited number of crops that can be grown in the area.

Following our findings in literature and actual field work we were able to identify the major farming system types found in the District. These can be summarized as described below. Farming System

I Where pyrethrum, wheat and dairy farming are

the dominant agricultural land use type. This type of farming is typically found in areas of higher elevation usually between 2000-2400 mm above sea level. On average these areas receive sufficient amount of rainfall for crop growth. Farming system 2: This second system is found in the next lower zone between 1950-2100 mm above sea level. The common crops grown are tea, pyrethrum, maize and other subsistence crops. Dairy farming is also a dominant land use system in this zone. Farming system 3: this system is found in the transitional zone between the highlands and the midlands. Coffee, tea and dairy farming constitute the dominant crop/animal combination system. Farming System 4: This is normally found in the areas below 1800 mm of elevation. The system is dominated by the growing of coffee and subsistence crops such as maize, beans and potatoes. Farming system 5: Subsistence crops dominate this farming system, and livestock farming is limited to the rearing of either pure traditional or mixed breeds. Although coffee is also grown, it is in what one would call areas of marginal productivity.

At this point, it is important to direct our attention to the second task of this study, which was to

determine crop production performances with respect to the various chosen characteristics pertaining to the farm and the available agricultural support services. Factors that were thought to raise the chances of increased farm productivity were identified and analysed using a multivariate regression analysis. As we undertook to perform this task we cautioned at the outset against the use of the results of the analysis as substitute to observations and experiences acquired elsewhere in the field - in the process of planning for rural agricultural-based development projects. The obvious reasons for offering such cautionary note arose from some of the unrealistic assumptions implicit in the use of these models. However, we also justified its application in the present study as opposed to other available analytical methods.

To summarise our findings in this context it is imperative to at least give a brief outline of the variables included in the model, the results and the conclusions that emerged. Farm size and the farmer's experience on the farm were taken to be the direct (or endogenous) factors that could most likely bring about noticeable differences on the levels of farm productivity. The other variables

listed below were the indirect factors. These are: (1) Frequency of agricultural extension visits (2) Frequency of availability of loans and/or credits (3) distance to the nearest market centre and (4) frequency of attendance to farmer training institutes.

We have found the following factors to be significant determinants of farm production performances: that is (1) Frequency of agricultural extension visits

(2) distance to the nearest market centre

(3) farmer's period of experience on the farm

Other variables, that is (1) farm size

(2) frequency of attendance to farmer training institutes were insignificant.

After examining all these variables the following observations were made: (1) it appears that the period of experience on the farm and frequency of agricultural extension visits increases the chances of raised and sustainable farm production level. (2) Distance to the nearest market had a significant negative sign in the overall predictive equations. Hence we would conclude that accessibility to market services is an important aspect that must be considered when planning for agricultural sector.

(3) It was also noted that farm size is an insignificant variable that does not by itself influence the level of farm productivity. This suggests that land quality in terms of fertility and soil maintenance rather than size measured in hectares could be a more important factor in crop production. Elsewhere in this study we have shown that land as a natural resource continues to decline in the face of rising human population. The future trends show that little productive agricultural land will remain unused under these conditions. Therefore the solution lies not in extending cultivation to vulnerable marginal areas, but to intensify productivity per unit area of land. (4) it was an unexpected result that the frequency of availability of loans and/or credits has no significance to farm productivity. Consequently we were bound to agree with Miller, L.R.(1977)who says that the proponents of loans and credits as a valuable farm input that increases farm productivity and helps in the generation of higher income work under unjustified assumptions. To quote: (a) "they assume that agricultural research has developed improved technology which is clearly superior to the traditional methods (b) that farmers have seen practical

demonstrations of the new technology, understands it and are anxious to use it. (c) that farmers have confidence that the fertilizers, seeds, pesticides and equipment needed to adopt the new practice will be available at the proper time and in the amounts required. (d) that the necessary credit to purchase these inputs will be made available at the required time and (e) that the farmers have been assured there will be a market for the extra production at prices which will make the financial reward of adopting the improved technology well worth the weather, biological and market risks involved". He concludes that unless these conditions for the successful use of credit exist or are being created, extending credit to small farmers may be a disservice.[1]

(5) It was established that agricultural extension service is a fundamental service that can effectively demonstrate to a farmer better farming methods that will result in a significant increase in farm production. Although 76.7% of the interviewed farmers were visited by the agricultural extension personnel of the Ministry of Agriculture, it was found out that the technical advice was mainly meant to improve cash crop production. This is the chief factor that frustrates efforts towards production of food for

self-sufficiency. It is therefore likely that without instituting training programmes for the agricultural extension personnel with emphasis on food production, no significant increase in food production will be realised despite the Government's policies and guidelines aimed at making Kenya self-sufficient in food production.

The main problems affecting agricultural development in the present area of study were summarised in Chapter five. In passing these constraints could be grouped into three:

(1) Those originating from the natural physical and biological environment and therefore the farmer has no control over for example rainfall, and others such as insects and pests which a farmer can control.

(2) Institutional constraints - that is some of the procedures employed by these institutions that prempt the opportunities of the small holder farmers to avail themselves farm inputs, markets and other related services.

(3) Endogenous constraints - e.g. scarce labour and land resources, insufficient technical know-how and limited experience.

In sum, if the Kenyan agricultural sector is to meet

[1] Miller L.R. (1977) Agricultural Credit & Finance in Africa p.5

food needs for both the growing rural population and its urban counterparts, some structural and institutional changes will be required. The nature and the form they will take depends a lot on our accumulated knowledge about general farming systems and the agricultural institutional support arrangements. Hence these two are bound to be major areas of policy concern and therefore open avenues for future research.

6.1b SUMMARY OF THE MAIN CONCLUSIONS

This thesis has focussed on various aspects related to smallholder farming systems. A number of problems and potentials for increasing agricultural production have been discussed with special emphasis on physical and socio-economic variables. In closing, therefore, we may pass on a brief summary of the main conclusions that have emerged from our research findings.

After a careful examination of the main physical factors included in our analysis it was finally appreciated that the natural environment resources to a high degree influence and condition the type of farming activities that are to be found in an area. These are important determinants of the farming system types and are a major differentiation denominators. Whereas some of these constraints can be overcome using advanced science-based technology others cannot, and therefore the only option left to the land users is to synchronize farming activities with the natural pattern of phenomenal occurences.

On the socio-economic and institutional front, it was established that: (1) the supply of

farm input is usually a constraint, a problem manifested in low effective supply distribution system. (2) The indigenous knowledge of the farmers on farming activities is an important attribute that should always be considered when planning for the agricultural sector. (3) The existing agricultural extension personnel is inadequate to offer an appreciable coverage of the smallholder farmers in the district, which is a major constraint to development of better farm management techniques (4) besides other infrastructural facilities, the development of better roads and easily accesible markets would give a great boost to agricultural production in the district. (5) Lack of loanable funds from both private and public money lending institutions is a major constraint limiting agricultural development on the smallholder farms. A better system of reaching the majority of farmers in the rural areas must be instituted if this important sector of the economy will achieve the desired levels of agricultural production. (6) The sizes of the farms though they do not appear to result in noticeable economic differentiation, are a major limitation to application of capital intensive technology and also a major disincentive to financing agencies.

Thus, if agricultural production among the smallholder farms are to be increased it seems that more attention needs to be paid to other sources of funds for the smallholder farmers.

The overall policy implications of our research findings are that planners in both the Government and non-Governmental instituitons need to recognise the various characteristics embodied in different farming systems and thus develop policy guidelines that will encourage a more efficient use of land resources as outlined in the subsequent sections.

6.2 RECOMMENDATION TO PLANNERS: THE LONG TERM AGRICULTURAL DEVELOPMENT FOCUS

As a policy objective the Kenya Government has a strong commitment towards alleviating rural poverty and uplifting the standards of living in the rural areas. The development proposal presented here, therefore, focusses on issues that have been addressed before as is evidenced in the National Development plans. However, we hope to stress a few highlights that may reveal important socio-economic indicators required to initiate and sustain long-term agricultural development. As we have emphasized before in this thesis, resource and institutional support services are two important factors that if well managed and focussed, could

bring substantial changes in overall development of the economy. The term resource is used mainly to refer to land and labour which are the main factors of production employed by the small scale farmers. The way a farmer organizes these resources in the absence of external support services heavily determines his level of output and income. However, nothing so far would make us believe that farm development would keep abreast with the increased demand for food and cash without a strong external support - the latter term refers to the exogenous support services that are directed and planned for by the Government. These services come in form of credits, advisory services and improved infrastructural facilities.

The main avenues that the Government uses to communicate information on new research findings and the agricultural policy framework are the agricultural extension officers. It has emerged from our research that not only are there inadequate field personnel but also the few who are there offer teachings that are mostly focussed on cash crop growing. Two possibilities can be discerned (1) that the agricultural extension officers are inadequately trained

to handle competently technical development in other crops and (2) that their approach on teaching farmers is one that is highly biased to cash crop farming. If the national objectives of tackling the relative food supply problems is to be achieved, the agricultural extension officers will have to be retrained in areas that are relevant to this objective.

In view of the current rapid population growth rates, the country will continue experiencing shortage of potentially arable land and massive rural unemployment and under-employment. Review of the current study findings indicate that already there is a tremendous rate of land informal subdivisions in the survey area. It was also evidenced that rental or purchase land is no longer available. The consequential effects of these tendencies will be rapid out migration either into urban areas or lesser (often marginal agricultural lands) populated districts. This phenomenal change will only excerbate the population pressures experienced in urban areas and aggravate environmental degradation in the marginal lands. These are formidable problems which cannot be addressed purely

by focussing on the development of the fragile resource base. They call for integrated rural development packages. Thus although greater attention will be paid on intensifying agricultural production through extended teachings on new farm management skills, alternative avenues should be created to relieve the land of the existing pressures. Here we have in mind

(1) initiating rural agri-based small scale businesses that employs agricultural raw materials as inputs such as, weaving, handicraft industries, and small scale processing industries.

(2) the Government on its current emphasis on technical skills development should encourage and facilitate technical graduates to concentrate on making simple farm implements in support of agriculture. This line of development has two-fold advantages:

(1) development of small scale agricultural-based processing industries may lead to diversification of farm production thus reducing the apparent overdependence for cash-earnings on mainly coffee and tea.

(2) by encouraging technical graduates to come together in support of agriculture the rate of

rural unemployment may lessen at the same time farmers will be able to purchase and have their farm tools repaired locally.

STEPS TOWARDS A PARADIGM FOR SOCIO-ECONOMIC DEVELOPMENT

The Kenya Government has always aimed at helping the rural communities to achieve lasting changes in their social and economic conditions through promotion of rational development policies that encourage the use of local capital, including human and land resources. As a way of reinforcing and fastening the process of rural development the following planning principles are recommended in this study.

(1) The Government should aim at assisting and promoting those activities that support capital formation in the agricultural sector; these may include increased land productivity and external sources of income earning.

(2) Agricultural project planning and design should be able to build on existing acitvities in a given geographic locale, in order to bring about development synergisms through physical and strategic linking of two or more activities. For example an existing agricultural project may be complemented by a project that processes

and markets the produce. In principle this approach may reduce wastage and duplication of efforts by allowing say one agency to plan and implement an integrated programme, and calling on the services of other agencies to provide their specialized component parts as and when needed.

In sum in all cases, therefore, agricultural projects should be encouraged if they in concert with other ongoing development efforts, help create the necessary critical mass of inputs and services needed for self-sustaining development.

The above recommendations come at the time when the Kenya Government is embarking on a major planning shift from centralized to decentralized planning and implementation functions. Thus this study has reinforced efforts that are already being put by the Government in streamlining rural development activities.

6.3 FURTHER LINES OF RESEARCH FOR SCHOLARS & OTHER RESEARCHERS

This study had the immediate aim of describing and analysing the physical and socio-economic constraints and potentials to increased agricultural production. But as we have indicated above, the study has had its own shortcomings and gaps which need to be

bridged by conducting further research along similar lines.

Our research concentrated more on small-holder farmer production problems. We have tried to show how lack of agricultural support services could result into differences in crop production performances. We failed however, to give a comprehensive analysis on the livestock development. This was partly due to time and financial constraints and partly because we had not fully appreciated the role of the livestock economy in the farming systems at the onset of the study. A further study could bridge this gap by bringing the two agricultural activities more closely in the analysis.

From the onset of this study we have tried to show how the development of the cash crop economy may negatively influence food crop production. We have suggested ways in which food production for domestic consumption and local sale could be increased. But we did not include in our analysis factors such as input price changes and the effect these may have on production costs - neither did we offer alternatives to purchased agricultural inputs whose prices are likely to go up and hence limit their use.

We also assumed that increased food and cash production on the small holder farmers would finally alleviate rural poverty and unemployment. We did not however, relate a number of factors e.g. food production and population growth or even fluctuations in the international commodity prices. We are in this section recommending further studies not only on how best we can increase agricultural production, but also, how we can use income drawn from this sector to start small scale income generating activities in the rural areas. - such as production centres that will be involved in repairing of farm implements and possibly production of simple but improved farm implements. A further study is also recommended that will identify locally available materials that could be used in place of fertilizers and other expensive agricultural inputs. For instance development of ox-ploughs may reduce the farmers labour bottleneck and hence discourage the application of purchased herbicides, while research into other better methods of farming may curb loss of soil fertility and eventually lead to lesser use of fertilizer. Investigation into the feasibility of zero-grazing on the smallholder farms in view of the diminishing farm sizes,

labour bottlenecks and the need to intensify agricultural production would positively contribute to further development of the rural areas.

While we addressed some of these aspects in this study in passing, further and more comprehensive studies are needed, that will eventually lead to an accumulation of useful information that will aid planners and decision makers to develop and initiate development programs and projects that rewards the small-holder farmers by offering the right advice and support system.

TOWARDS AN INTEGRATED AGRICULTURAL RESEARCH FOCUS

The vital role of small holder farming systems in the overall development of the national economy has been emphasized throughout this thesis. The dominant agricultural activities were identified broadly and the underlying physical, economic and institutional potential and constraints discussed. It was shown that the farming system production economics is a reflection of complex and highly interrelated factors that are not easily discernible. Hence, no single study can successfully address these multivariate problems without an equal support from other relevant studies and disciplines.

As such a fuller understanding of the farming systems require a multi-disciplinary approach. It is only through such an approach that we can hope to unearth with appreciable success the potentials and constraints facing the small holder farmers.

In support of our recommended approach, Fendru, I. (1980) states that "past research activities have failed to give fruitful recommendations on how best to improve the lives of the rural poor because most of them were concentrated on cash crop improvement through taxonomic and botanic investigation, varietal screening, breeding and application of modern husbandry production techniques, while there has been no serious systems approach to agricultural research. That is each crop was viewed as a separate entity and not as a community of crops and a farmstead or as a single farm enterprise. He continues to add that, very little attempt was made to integrate crop with animal production nor was much effort made to transform smallholding into viable economic units --- economic and social consideration were not taken into account in formulating and executing agricultural research policy.[1]

A World Bank paper quoted by the same author states that"common failure of researchers is to treat

small scale farming as a system of cultivation that demands a comprehensive on farm approach for technical improvements. An important reason for this is that research goals are generally formulated within disciplines .. rather than between and/or among them". All what this means is that an integrated approach to the farming system questions is the key to a fuller understanding of these systems.

It was the initial intention of this study to come out with a well articulated research methodology and findings that would comprehensively combine all the aspects outlined above, however, at the end of it all we found ourselves inadequately equipped with appropriate techniques, data and scientific information that could assist us in accomplishing this task. We therefore recommend further studies to be carried out in future in order to help us gain more useful knowledge and understanding through which it would be possible to examine the influence on the system of physical and socio-economic factors and hence serve as a useful guide for further investigation and development strategies for improving small holder agriculture in Kenya.

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APPENDIX I

RECORDING SCHEDULE

SURVEY FORM NUMBER----------

NAME OF THE FARMER----------

DIVISION----------

LOCATION----------

SUB-LOCATION----------

DATE----------

LAND TENURE AND FARM SIZE

1. What is the size of this farm? .....Hectares

   1. less than 0.25 hectares
   2. 0.25 to less than 0.40 hectares
   3. 0.40 to less than 0.65 hectares
   4. 0.65 to less than 1.00 hectares
   5. 1.00 to less than 1.50 hectares
   6. 1.50 to less than 2.5 hectares
   7. 2.50 to about 4 hectares
   8. 4.00 to about 6.5 hectares
   9. 6.50 to about 10 hectares

2. Is this farm informally subdivided? .....

   1. Yes
   2. No
   3. N.A.

3. If YES, into how many subdivisions? .....

   1. 2
   2. 3
   3. 4
   4. more than 4
   5. N.A.

4. Do you have additional land elsewhere? .....

   1. Yes
   2. No
   3. N.A.

5. If Yes, what is the ownership status? .....

   1. Freehold
   2. Co-operative farm
   3. Clan land
   4. Not surveyed
   5. In dispute

6. Is land available for renting or purchasing?

   .....

   1. Yes
   2. No
   3. N.A.

7. Do you leave any part of your land fallow?

   .....

   1. Yes
   2. No
   3. N.A.

8. If YES, over what period of time? .....

   1. One season
   2. One year
   3. Two years
   4. Three years
   5. Four years
   6. Over five years

Crop Enterprises

9. Which of the following crops do you grow on your farm?

Crops	Estimated Yield
Coffee	.....
Tea	.....
Pyrethrum	.....
Maize	.....
Beans	.....
Irish Potatoes	.....
Sweet Potatoes	.....
Peas	.....
Cabbages	.....
Tomatoes	.....
Carrots	.....
Bananas	.....
Yams	.....

Arrowroot .....

Cassava .....

Sorghum .....

Sugar cane .....

Pineapples .....

Fodder crops .....

10. What area of your land is under food crops ..... hectares/Acres?

1. less than 0.25 hectares
2. 0.25 to less than 0.40 ha
3. 0.40 to less than 0.65 ha
4. 0.65 to less than 1.00 ha
5. 1.00 to less than 1.5 ha
6. 1.5 to less than2.50 ha
7. 2.50 to less than 4 ha
8. 4.00 to less than 6.5 ha
9. 6.5 to less than 10 ha.

11. Do you sell some of your farm produce besides the man cash crops?.....

1. Yes
2. NO
3. N.A.

12. Do you also buy farm produce from other sources to supplement your farm produce? .....

1. Yes
2. No
3. N.A.

13. Which are/is your main cash crop? .....

1. Tea
2. Tea/coffee
3. Coffee
4. Pyrethrum
5. Tea/Pyrethrum
6. Tea/Coffee/Pyrethrum
7. Others (specify)
9. N.A.

14. What area of your land is under cash crop?

1. less than 0.25 hectares
2. 0.25 to less than 0.40 ha
3. 0.40 to less than 0.65 ha
4. o65 to less than 1.00 ha
5. 1.00 to less than 1.50 ha
6. 1.50 to less than 2.50 ha
7. 2.50 to less than 4 ha
8. 4.00 to less than 6.5 ha
9. 6.50 to less than 10 ha.

15. Do you intend to add more to the existing cash crop/s? .....

    1. Yes
    2. No
    3. NA

16. If yes, what induces you to do so? .....

    1. Prices are good
    2. Cash crops are a good future asset
    3. Prices of other farm produce are low
    4. Others (specify)
    5. N.A.

17. If NO, which of the following farm enterprises do you envisage to encourage more on your farm in future?

    1. Horticultural crops
    2. Livestock fodder
    3. Food crops
    4. Livestock fodder
    5. Others (specify)
    6. N.A.

18. Do you practice crop rotation on your farm?..

    1. Yes
    2. No
    3. N.A.

19. If YES, in what sequence? .....

1. After every season
2. After two seasons
3. After one year
4. After two years
5. After a long period
6. N.A.

20. What did you do with crop residues after harvest? .....

1. Burned them in the field
2. Fed them to animals
3. Maintained them for manure
4. Sold to my neighbour
5. Others (specify)
6. N.A.

21. On the same subject of crops, what in your opinion has been the major cause of crop failure in the past? .....

1. Too much rain
2. long dry spells
3. insects, pests and diseases
4. wind destroys them in the field
5. Others (specify)
6. N.A.

LIVESTOCK ECONOMY

22. Which of the following animals do you keep on the farm? Cows, sheep, goats and pigs

1. All of the above
2. Three of the above
3. Two of the above
4. One of the above
5. None

23. Number of cows? .....

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8
9. 9
10. above 10
11. N.A.

24. Number of sheep? .....

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8
9. 9
10. Above 10
11. N.a.

25. Number of goats? .....

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. Above 6
8. N.A.

26. Number of Pigs? .....

1. 1
2. 2
3. 3
4. 4
5. above 5
6. N.A.

27. For feeding your animals do you depend on:

1. Free grazing
2. stall feeding
3. both
4. N.A.

28. What area of the land is purposefully fenced for livestock? .....

1. Less than 0.25 ha
2. 0.25 to less than 0.40 ha
3. 0.40 to less than 0.65 ha
4. 0.65 to less than 1.00 ha
5. 1.00 to less than 1.50 ha
6. 1.50 to less than 2.50 ha
7. 2.50 to less than 4.00 ha
8. 4.00 to less than 6.5ha
9. 6.50 to less than 10 ha.

29. Which of the above animals have you sold this year? .....

1. Cows .....
2. Sheep .....
3. Goats .....
4. Pigs .....
5. None .....

30. Number of cows sold .....

1. 1
2. 2
3. 3
4. Above 4
5. N.A.

31. Number of Goats sold .....

1. 1
2. 2
3. 3
4. above 4
5. N.A.

32. Number of sheep sold .....

1. 1
2. 2
3. 3
4. above 4
5. N.A.

33. Number of pigs sold .....

1. 1
2. 2
3. 3
4. above 4
5. N.A.

34. How much milk do your cows produce per day?..

1. less than 1 gallon
2. 1 to less than 2 gallons
3. 2 to less than 3 gallons
4. 3 to less than 4 gallons
5. 4 to less than 5 gallons
6. Over 5 gallons

35. What specific problems do you face in relation to the livestock enterprise? .....

1. shortage of grazing land
2. high prices of animal feed
3. shortage of animal feed
4. high calf mortality
5. others (Specify)

FARM INPUTS

36. What type of maize seeds to you use for planting? .....

1. Hybrid
2. Katumani composite
3. Local variety
4. Others (specify)

37. What are the advantages of the variety used compared to the others? .....

1. early maturing
2. better yield
3. tastes better
4. does not fall with winds
5. others (specify)

38. If you buy your seeds from either K F A stores or other nearest suppliers, what are some problems with this variety compared to local variety? .....

1. supply comes late
2. prices are high
3. insects damage grain
4. does not resist drought
5. more weed problems
6. they do not do well without fertilizers
7. others (specify)

39. Do you use chemical fertilizers?

1. Yes
2. No

40. If YES, on which crops do you often use them?

1. cash crops
2. subsistence crops
3. Horticultural crops
4. cash crops and subsistence crops
5. horticultural and cash crops
6. horticultural and subsistence crops
7. on all crops.

41. If not, what limits you from applying fertilizer on your crops? .....

1. too expensive
2. supplier is far away
3. apply farm manure instead
4. farm too small
5. others (specify)

INVESTMENT

42. Please list all implements and structures on the farm that have resulted from farm income.

stores	handhoes
tractor plough	tractor
panga	harrows
wheel barrows	spraying equipment
others (specify)	

INFRASTRUCTURE

43. How far is your nearest market from your farm?

1. less than 1 mile
2. 1 to less than 2 miles
3. 2 to less than 3 miles
4. 3 to less than 4 miles
5. 4 to less than 5 miles
6. 5 to less than 6 miles

7. 6 to less han 7 miles
8. 7 to less than 8 miles
9. 8 to less than 9 miles
10. over 9 miles

44. What means do you use for transporting your farm produce to the market?

1. human labour
2. Bicycles
3. wheel barrows
4. hired vehicles
5. matatus
6. personal vehicle
7. drought animals
8. others (specify)

45. Are you aware of the existence of agricultural extension services?

1. Yes 2. No

46. If YES, how often have you been visited by the area agricultural extension officer?

1. once a week 2. once a month
3. once after 6 months
4. after a long period
5. N.A.

47. On what farm enterprises have you been advised on in the past, by the Government agricultural extension officer?

1. cash crops
2. Livestock
3. food crops
4. horticultural crops
5. cash crops, livestock and horticultural crops
6. cash and subsistence crops
7. on all farm enterprises

48. Have you ever obtained loan/credit for farm improvement?

1. Yes
2. No

49. (a) If Yes, how often have you obtained loan/credit for farm improvement in the last 10 years?

1. once
2. twice
3. 3 times
4. 4 times
5. 5 times
6. 6 times
7. 7 times
8. more than 8 times
9. none

49. (b) What are your main sources of credit/loan?

1. A.F.C.
2. co-operative societies
3. banks
4. A.F.C. and Co-operative societies
5. others (specify)

50. If NO, why is it becoming difficult for you to obtain loan/Credit?

1. lack of securities
2. lack of proper guidance
3. has no need for credit
4. others (specify)

LABOUR AND BACKGROUND OF THE FARMER

51. What is your age?

1. below 30 years
2. 31 - 40
3. 41 - 50
4. 51 and above

52. How many years have you been working on the farm?

1. 0 - 5 years
2. 5 - 10 years
3. 10 - 15 years
4. over 15 years

53. How often do you visit farmers Training Centres?

1. once a month
2. once after 3 months
3. once after 6 months
4. once after 1 year
5. once after 2 years
6. once after a long period
7. none at all
8. N.A.

54. Do you have off farm employment?

1. yes
2. No

55. How many male adults live on this farm?

1. 1
2. 2
3. 3
4. 4
5. 5
6. above 6
7. N.A.

56. How many female adults live on this farm?

1. 1
2. 2
3. 3
4. 4
5. 5
6. n.a.

57. How many children under 12 years live on this farm?

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. over 8

58. How many children of more than 12 years also live on this farm?

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8
9. 9
10. 10
11. more than 10

59. How many male adults work full time on the farm?

1. 1
2. 2
3. 3
4. 4
5. 5
6. more than 6

60. How many female adults work full time on the farm?

1. 1
2. 2
3. 3
4. 4
5. 5
6. more than 6

61. How often are the children available for farm work in a year?

1. full time
2. one month
3. two months
4. three months
5. none at all

62. Do you hire people to assist one the farm?

1. Yes
2. No

63. If Yes, of the hired labour how many are permanent?

1. 1
2. 2
3. 3
4. 4
5. 5
6. above 6
7. none

64. How many are temporary per season?

1. below 5
2. 5 - 10
3. 10 - 15

65. What activities do the hired people assist in?

1. land preparation
2. planting
3. harvesting

4. transporting

5. others (specify)

66. In what period of the year do you and your family have to work hardest?

1.	January		July
2.	February		August
3.	March		September
4.	April		October
5.	May		November
6.	June		December

67. What work is done in these months/periods?

Task	Usually completed on time
Land preparation	Y / N
Planting	Y / N
Weeding	Y / N
Harvesting	Y / N
Others (specify)	Y / N

68. During this period do you experience labour shortage?

1. Yes

2. No

69. Do you observe a strict intercropping pattern?

1. Yes
2. No

70. If Yes, what would you say is the chief benefit accrueing to it?

1. saves labour resources during land preparation, weeding and sowing
2. saves land resources by giving more output per unit land
3. crops grown in intercropping benefit from each other
4. it is a tradition
5. others (specify)

71. And finally, thanking you very much for your co-operation do you think farming is a:

1. profitable business
2. unprofitable
3. uncertain
4. others (specify)

ADDITIONAL INFORMATION SOUGHT FROM DISTRICT AND DIVISIONAL AGRICULTURAL OFFICERS

A. 1. What are the major problems facing farmers in your area of coverage _____

_____

2. What efforts are being put to help farmers overcome the problems you have identified above ----------

_____

3. With respect to small holder farmers who have less capital and other production resources, what is the existing policy design to help them boost productivity?

_____

4. Would you say that soil erosion is a problem in your area of coverage? ____

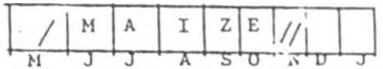
_____

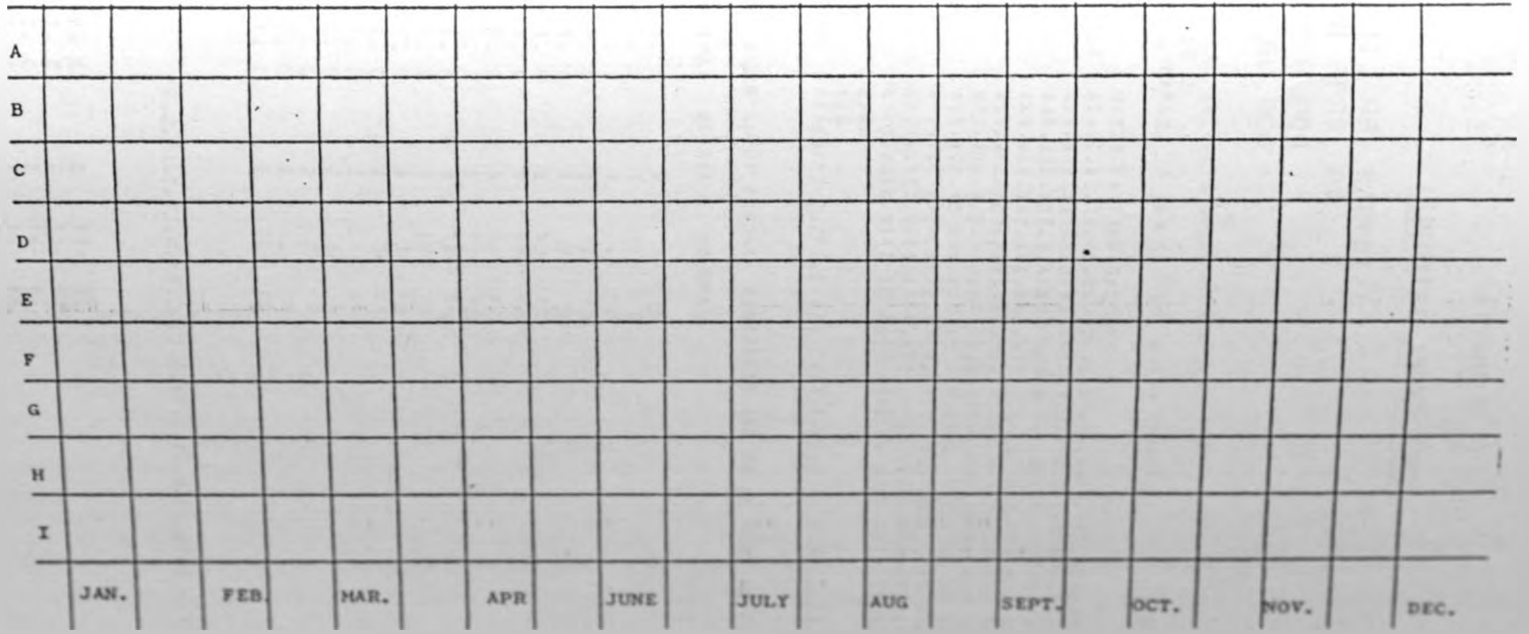
5. Any other comments

B. Could you please assist in filling the table below?

Agro-ecological zone (location	Crops grown

CROPPING PATTERN THROUGHOUT THE YEAR. INDICATE THE CROP AND THE GROWING SEASON BELOW. PUT / FOR START OF THE PLANTING SEASON AND // FOR THE CLOSE OF THE GROWING SEASON.





APPENDIX II

COMPUTER PROGRAMME

```
JOB RKOI, 66, KARERI
ICSNRUN SPSS, OV,
MAXTIME 6,000
VOLUME 60,000
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[illegible]AL PACKAGE FOR THE SOCIAL SCIENCES SPSSN - [illegible]
[illegible] IMPLEMENTATION - RELEASE 1
[illegible]SION IS DESIGNED TO SAVE PAPER.  A NEW CONTROL CARD, 'PAGING                    [illegible]
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RUN NAME          NYERI FARMING SYSTEMS
VARIABLE LIST     X1,X2,X3,X4,X5,X6,X7,X8,X9,X10,X11,X12,X13,X14,X15,X16
                  X17,X18,X19,X20,X21,X22,X23,X24,X25,X26,X27,X28,X29,X30
                  X31,X32,X33,X34,X35,X36,X37,X38,X39,X40,X41,X42,X43,X44
                  X45,X46,X47,X48,X49,X50,X51,X52,X53,X54,X55,X56,X57,X58
                  X59,X60,X61,X62,X63,X64,X65,X66,X67,X68,X69 TO X72,X73,X74
                  X75,X76,X77,X78,X79,X80,X81,X82,X83,X84,X85 TO X88,X89,X90
                  X91,X92,TO X94,X95 TO X99,X100,X101,X102 TO X112,X113,
                  X114 TO X121,X122,X123,X124,X125,X126,X127,X128,X129,X130
                  X131,X132,X133,X134,X135,X136,X137,X138,X139,X140,X141 TO
                  X145,X146,X147 TO X151,X152 TO X154,X155 TO X159,X160
INPUT MEDIUM      CARD
\ OF CASES        166
INPUT FORMAT      FIXED(F3.0,2F2.0,3F1.0/F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,
```

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE	FORMAT	RECORD	COLUMNS
X1	F 3. 0	1	1- 3
X2	F 2. 0	1	4- 5
X3	F 2. 0	1	6- 7
X4	F 1. 0	1	8- 8
X5	F 1. 0	1	9- 9
X6	F 1. 0	1	10- 10
X7	F 1. 0	1	11- 11
X8	F 1. 0	1	12- 12
X9	F 1. 0	1	13- 13
X10	F 1. 0	1	14- 14
X11	F 1. 0	1	15- 15
X12	F 1. 0	2	1- 1
X13	F 2. 0	2	2- 3
X14	F 1. 0	2	4- 4
X15	F 2. 0	2	5- 6
X16	F 1. 0	2	7- 7
X17	F 2. 0	2	8- 9
X18	F 1. 0	2	10- 10

F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,

X19	F 2. 0	2	11- 12
X20	F 1. 0	2	13- 13
X21	F 2. 0	2	14- 15
X22	F 1. 0	2	16- 16
X23	F 2. 0	2	17- 18
X24	F 1. 0	2	19- 19
X25	F 2. 0	2	20- 21
X26	F 1. 0	2	22- 22
X27	F 2. 0	2	23- 24
X28	F 1. 0	2	25- 25
X29	F 2. 0	2	26- 27

F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE	FORMAT	RECORD	COLUMNS
X30	F 1. 0	2	28- 28
X31	F 2. 0	2	29- 30
X32	F 1. 0	2	31- 31
X33	F 2. 0	2	32- 33
X34	F 1. 0	2	34- 34
X35	F 2. 0	2	35- 36
X36	F 1. 0	2	37- 37
X37	F 2. 0	2	38- 39
X38	F 1. 0	2	40- 40
X39	F 2. 0	2	41- 42
X40	F 1. 0	2	43- 43

F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,F1.0,F2.0,

X41	F 2. 0	2	44- 45
X42	F 1. 0	2	46- 46
X43	F 2. 0	2	47- 48
X44	F 1. 0	2	49- 49
X45	F 2. 0	2	50- 51
X46	F 1. 0	2	52- 52
X47	F 2. 0	2	53- 54
X48	F 1. 0	2	55- 55
X49	F 2. 0	2	56- 57
X50	F 1. 0	2	58- 58
X51	F 2. 0	2	59- 60

F1.0,F2.0,19F1.0/16F1.0/12F1.0/15F1.0/10F1.0/20F1.0

X52	F 1. 0	2	61- 61
X53	F 2. 0	2	62- 63
X54	F 1. 0	2	64- 64
X55	F 1. 0	2	65- 65
X56	F 1. 0	2	66- 66
X57	F 1. 0	2	67- 67
X58	F 1. 0	2	68- 68
X59	F 1. 0	2	69- 69
X60	F 1. 0	2	70- 70
X61	F 1. 0	2	71- 71
X62	F 1. 0	2	72- 72
X63	F 1. 0	2	73- 73
X64	F 1. 0	2	74- 74
X65	F 1. 0	2	75- 75
X66	F 1. 0	2	76- 76
X67	F 1. 0	2	77- 77
X68	F 1. 0	2	78- 78
X69	F 1. 0	2	79- 79
X70	F 1. 0	2	80- 80
X71	F 1. 0	2	81- 81

[illegible]

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE [illegible]

VARIABLE	FORMAT	RECORD	COLUMNS
X30	F 1. C	2	[illegible]
X31	F 2. C	2	[illegible]
X32	F 1. C	2	[illegible]
X33	F 2. C	2	[illegible]
X34	F 1. C	2	[illegible]
X35	F 2. C	2	[illegible]
X36	F 1. C	2	[illegible]
X37	F 2. C	2	[illegible]
X38	F 1. C	2	[illegible]
X39	F 2. C	2	[illegible]
X40	F 1. C	2	[illegible]

[illegible]

X41	F 2. C	2	[illegible]
X42	F 1. C	2	[illegible]
X43	F 2. C	2	[illegible]
X44	F 1. C	2	[illegible]
X45	F 2. C	2	[illegible]
X46	F 1. C	2	[illegible]
X47	F 2. C	2	[illegible]
X48	F 1. C	2	[illegible]
X49	F 2. C	2	[illegible]
X50	F 1. C	2	[illegible]
X51	F 2. C	2	[illegible]

[illegible]

X52	F 1. C	2	[illegible]
X53	F 2. C	2	[illegible]
X54	F 1. C	2	[illegible]
X55	F 1. C	2	[illegible]
X56	F 1. C	2	[illegible]
X57	F 1. C	2	[illegible]
X58	F 1. C	2	[illegible]
X59	F 1. C	2	[illegible]
X60	F 1. C	2	[illegible]
X61	F 1. C	2	[illegible]
X62	F 1. C	2	[illegible]
X63	F 1. C	2	[illegible]
X64	F 1. C	2	[illegible]
X65	F 1. C	2	[illegible]
X66	F 1. C	2	[illegible]
X67	F 1. C	2	[illegible]
X68	F 1. C	2	[illegible]
X69	F 1. C	2	[illegible]
X70	F 1. C	2	[illegible]
X71	F 1. C	2	[illegible]

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE	FORMAT	RECORD	COLUMNS	
X72	F 1. C	2	21-	22
X73	F 1. C	3	1-	1
X74	F 1. C	3	2-	2
X75	F 1. C	3	3-	3
X76	F 1. C	3	4-	4
X77	F 1. C	3	5-	5
X78	F 1. C	3	6-	6
X79	F 1. C	3	7-	7
X80	F 1. C	3	8-	8
X81	F 1. C	3	9-	9
X82	F 1. C	3	10-	10
X83	F 1. C	3	11-	11
X84	F 1. C	3	12-	12
X85	F 1. C	3	13-	13
X86	F 1. C	3	14-	14
X87	F 1. C	3	15-	15
X88	F 1. C	3	16-	16
X89	F 1. C	4	1-	1
X90	F 1. C	4	2-	2
X91	F 1. C	4	3-	3
X92	F 1. C	4	4-	4
X93	F 1. C	4	5-	5
X94	F 1. C	4	6-	6
X95	F 1. C	4	7-	7
X96	F 1. C	4	8-	8
X97	F 1. C	4	9-	9
X98	F 1. C	4	10-	10
X99	F 1. C	4	11-	11
X100	F 1. C	4	12-	12
X101	F 1. C	4	13-	13
X102	F 1. C	5	1-	1
X103	F 1. C	5	2-	2
X104	F 1. C	5	3-	3
X105	F 1. C	5	4-	4
X106	F 1. C	5	5-	5
X107	F 1. C	5	6-	6
X108	F 1. C	5	7-	7
X109	F 1. C	5	8-	8
X110	F 1. C	5	9-	9
X111	F 1. C	5	10-	10
X112	F 1. C	5	11-	11
X113	F 1. C	5	12-	12
X114	F 1. C	5	13-	13
X115	F 1. C	5	14-	14
X116	F 1. C	5	15-	15
X117	F 1. C	5	16-	16
X118	F 1. C	5	17-	17
X119	F 1. C	5	18-	18

NYERI FARMING SYSTEMS

[illegible]

ACCORDING TO YOUR INPUT FORMAT, VARIABLES ARE TO BE READ AS FOLLOWS

VARIABLE	FORMAT	RECORD	COLUMNS
X120	F 1. 0	5	19- 19
X121	F 1. 0	6	1- 1
X122	F 1. 0	6	2- 2
X123	F 1. 0	6	3- 3
X124	F 1. 0	6	4- 4
X125	F 1. 0	6	5- 5
X126	F 1. 0	6	6- 6
X127	F 1. 0	6	7- 7
X128	F 1. 0	6	8- 8
X129	F 1. 0	6	9- 9
X130	F 1. 0	6	10- 10
X131	F 1. 0	7	1- 1
X132	F 1. 0	7	2- 2
X133	F 1. 0	7	3- 3
X134	F 1. 0	7	4- 4
X135	F 1. 0	7	5- 5
X136	F 1. 0	7	6- 6
X137	F 1. 0	7	7- 7
X138	F 1. 0	7	8- 8
X139	F 1. 0	7	9- 9
X140	F 1. 0	7	10- 10
X141	F 1. 0	7	11- 11
X142	F 1. 0	7	12- 12
X143	F 1. 0	7	13- 13
X144	F 1. 0	7	14- 14
X145	F 1. 0	7	15- 15
X146	F 1. 0	7	16- 16
X147	F 1. 0	7	17- 17
X148	F 1. 0	7	18- 18
X149	F 1. 0	7	19- 19
X150	F 1. 0	7	20- 20
X151	F 1. 0	7	21- 21
X152	F 1. 0	7	22- 22
X153	F 1. 0	7	23- 23
X154	F 1. 0	7	24- 24
X155	F 1. 0	7	25- 25
X156	F 1. 0	7	26- 26
X157	F 1. 0	7	27- 27
X158	F 1. 0	7	28- 28
X159	F 1. 0	7	29- 29
X160	F 1. 0	7	30- 30

THE INPUT FORMAT PROVIDES FOR 160 VARIABLES. 160 WILL BE READ
IT PROVIDES FOR 7 RECORDS ('CARDS') PER CASE. A MAXIMUM OF [illegible] 'COLUMNS' ARE USED ON A RECORD.

VAR LABELS X1,CL.NC/X2,LOC./X3,AGRC.EC./[illegible],FA SIZE/X5,[illegible]/X6,[illegible]/
X7,ABC LAND/X8,OWNERSHIP/X9,LAND AVG/X10,FALLOW/X11,PERIP/
X12,COF/X13,YLD/X14,TE/X15,YLD/X16,PAM/X17,YLD/X18,IM/X19
YLD/X20,GE/X21,YLD/X22,IPO/X23,YLD/X24,IPO/X25,YLD/X26,PI
X27,YLD/X28,CAU/X29,YLD/X30,TM/X31,YLD/X32,CAA/X33,YLD/
X34,BAN/X35,YLD/X36,TAP/X37,YLD/X38,APR/X39,YLD/X40,FR/
X41,YLD/X42,CASS/X43,YLD/X44,[illegible]/X45,YLD/X46,[illegible]/X47,YLD
X48,FOB/X49,YLD/X50,PAP/X51,YLD/X52,TOL/X53,YLD/X54,[illegible]/
X55,SELL/X56,LUY/X57,MAIZE/X58,MAIZE/X59,[illegible]/X60,[illegible]/

11/06/84 PAGE 2

X61,WHY/X62,SEX/X63,SEX/X64,AGT/X65,SEX/X66,OCR/X67,SUCR
X68,TUCR/X69,CCFA/X70,SCCFA/X71,TCCFA/X72,FCCFA/X73,ARIM/
X74,NCC/X75,NOS/X76,NOS/X77,NCP/X78,MAF/X79,AFPL/X80,NOCC
X81,NCCS/X82,NOSS/X83,NCPS/X84,MPS/X85,LRP/X86,SLRP/X87,T
LRP/X88,FLRP/X89,ZMS/X90,SIMS/X91,TIMS/X92,ADV/X93,SADV/
X94,TADV/X95,PASS/X96,SPASS/X97,TPASS/X98,FPASS/X99,SUCR
X100,OWC/X101,LPTS/X102,STRS/X103,MH/X104,OPL/X105,TPL/
X106,FS/X107,MR/X108,LE/X109,SL/X110,TR/X111,SP/X112,ST
X113,ONM/X114,ML/X115,ECL/X116,SLT/X117,MW/X118,PET/X119,PT
/X120,PAPS/X121,MAEC/X122,WASC/X123,ERTAS/X124,CLAM/
X125,SCCAN/X126,CHNL/X127,AGE/X128,EXPF/X129,FTC/X130,IMP
X131,MACHF/X132,FADAF/X133,NCLT/X134,NCAT/X135,MMAF/X136
,MFAFF/X137,FCAVL/X138,MPFM/X139,PL/X140,TL/X141,AL/X142,
SAL/X143,TAL/X144,FAL/X145,FVL/X146,OPF/X147,SOPP/X148,SO
OOP/X149,TWOOP/X150,FWOOP/X151,FVWOOP/X152,TCCT/X153,SELL
X154,CSICR/X155,GENE/X156,SGENE/X157,TGENE/X158,FUENE/
X159,FUCENE/X160,FARMING

VALUE LABELS X2,(1) KLGURU (2) KAGITE (3) IKIAINI (4) KONYE
(5) KIRIMUKUYU (6) GIKONDI (7) GETHI (8) KUMITE (9) K.KUM
ITE (10) GTHAYA (11) GHINGA (12) KANIGA (13) THIGIRIRI
(14) TETU (15) AGUTHI (16) KUMGYAS/X3,(1) ONE SEVEN (2)
ONE SIX (3) ONE FIVE (4) ON FOUR (5) TWO SEVEN (6) TWO
SIX (7) TWO FIVE (8) TWO FOUR (9) TWO THREE (10) THREE SE
VEN (11) THREE SIX (12) THREE FIVE (13) THREE FOUR (14)
THREE THREE (15) FOUR FIVE (16) FOUR FOUR (17) FIVE FIVE/
X4 (1) UPTO 0.25 (2) 0.26 TO 0.40 (3) 0.41 TO 0.65 (4)
0.70 TO 1.00 (5) 1.05 TO 1.50 (6) 1.51 TO 2.00 (7) 2.51
TO 4.00 (8) 4.05 TO 6.00 (9) 6.05 TO 8.00/X5 (1) YES (2)
NO (9) N.A/X6 (1) 2 (2) 3 (3) 4 (4) MORE THAN 4 (9) N.A/
X7 (1) YES (2) NO (9) N.A/X8 (1) FREEHOLD (2) LEASEHOLD
(3) CLAN (4) NOT SURVEYED (5) IN DISPUTE (9) N.A/X9 (1)
YES (2) NO (9) N.A/X10 (1) YES (2) NO (9) N.A/X11 (1) ONE
SEASON (2) ONE YEAR (3) TWO YEARS (4) THREE YEARS (5) FOU
R YEARS (6) OVER FIVE YEARS (9) N.A/X12 (1) YES (2) NO/
X13 (1) UPTO 200 (2) 201 TO 400 (3) 400 TO 600 (4) 600 TO
800 (5) 800 TO 1000 (6) 1000 TO 1200 (7) 1201 TO 1400 (8)
1400 TO 1600 (9) 1600 TO 1800 (10) 1800 TO 2000 (11) 2000
TO 2200 (12) 2200 TO 2400 (13) 2400 TO 2600 (14) 2600 TO
2800 (15) 2800 TO 3000 (16) 3000 TO 3200 (17)3200 TO 3400
(18) 3400 TO 3600 (19) 3600 TO 3800 (20) 3801 TO 4000 (21)
4000 TO 4200 (22) 4200 TO 4400 (23) 4400 TO 4600 (24) 4600
TO 4200 (25) 4800 TO 5000 (26) 5000 TO 5200 (27) 5200 TO
5400 (28) 5400 TO 5600 (29) 5600 TO 5800 (30)5800 TO 6000
(31) 6000 TO 6200 (32) 6200 TO 6400 (33) 6401 TO 6600 (34)
6600 TO 6800 (35) 6801 TO 7000 (36) 7000 TO 7500 (37)7500
TO 8000 (38) 8000 TO 8500 (39) 8500 TO 9000 (99) N.A/X14
(1) YES (2) NO/X15 (1) UPTO 200 (2) 200 TO 400 (3) 400 TO
600 (4) 600 TO 800 (5) 800 TO 1000 (6) 1000 TO 1200 (7)
1200 TO 1400 (8) 1400 TO 1600 (9) 1600 TO 1800 (10) 1800
TO 2000 (11) 2000 TO 2200 (12) 2200 TO 2400 (13) 2400 TO
2600 (14) 2600 TO 2800 (15) 2800 TO 3000 (16)
3000 TO 3200 (17) 3200 TO 3400 (18) 3400 TO 3600 (19)3600
TO 3800 (20) 3801 TO 4000 (21) 4000 TO 4200 (22) 4200 TO
4400 (23) 4400 TO 4600 (24) 4601 TO 4200 (25)4800 TO 5000
(26) 5000 TO 5200 (27) 5200 TO 5400 (28) 5401 TO 5600 (29)
5600 TO 5800 (30) 5800 TO 6000 (31) 6000 TO 6200 (32)
6200 TO 6400 (33) 6401 TO 6600 (34) 6600 TO 6800 (35)6801
TO 7000 (36) 7001 TO 7500 (37) 7500 TO 8000 (38) 8001 TO
8500 (39) 8500 TO 9000 (99) N.A/X16 (1) YES (2) NO/X17 (1
) UPTO 200 (2) 201 TO 400 (3) 401 TO 600 (4) 601 TO 800

SYSTEMS

(5) 80C TO 100C (6) 100C TO 12... (7) 120C AND ABOVE (99)
N.A/X18 (1) YES (2) NO/X19 (1) UPT... (2) 0.25 TO 0.4C
(3) 0.4C TO 0.65 (4) 0.65 TO 1.0C (5) 1.0C TO 1.5C (6)
1.5C TO 2.5C (7) 2.5C TO 4.0C (8) 4.0C TO 6.5C (9) 6.5C
TO 10.0C (10) 10.0C TO 15.0C (11) 15.00 TO 20.0C (12) 20.
0C TO 25.00 (13) 25.0C TO 30.0C (14) 30.00 TO 35.0C (15)
35.0C TO 40.00 (16) 40.0C TO 45.0C (17) 45.0C TO 50.00
(18) 50.0C TO 55.0C (19) 55.0C TO 60.00 (20) 60.00 TO 65.
0C (21) 65 TO 7C (22) 7C TO 75 (23) 75 TO 8C (24) 8C TO
85 (25) 85 TO 9C (26) 9C TO 10C (27) 10C TO 12C (28) 12C
TO 140 (29) 140 TO 16C (2C) 16C TO 18C (31) 18C TO 2CC (99)
N.A/X20 (1) YES (2) NO/X21 (1) UPTO 0.25 (2) 0.25 TO
0.4C (3) 0.40 TO 0.65 (4) 0.65 TO 1.0 (5) 1.C TO 1.5 (6)
1.5 TO 2.5 (7) 2.5 TO 4.C (8) 4.C TO 6.5 (9) 6.5 TO 10
(10) 10 TO 15 (11) 15 TO 20 (12) 20 TO 25 (13) 25 TO 30
(14) 30 TO 35 (15) 35 TO 4C (16) 4C TO 45 (17) 45 TO 50
(18) 50 TO 55 (19) 55 TO 60 (20) 60 TO 65 (21) 65 TO 70
(22) 70 TO 75 (23) 75 TO 8C (24) 80 TO 85 (25) 85 TO 90
(26) 90 TO 95 (27) 95 TO 100 (28) 1CC TO 12C (29) 12C TO
14C (30) 140 TO 16C (21) 16C TO 18C (32) 18C TO 20C (99)
N.A/X22 (1) YES (2) NO/X23 (1) UPTO 0.25 (2) 0.25 TO 0.4C
(3) 0.4C TO 0.65 (4) 0.65 TO 1.C (5) 1.0 T 1.5 (6) 1.5 TO
2.5 (7) 2.5 TO 4.C (8) 4.C TO 6.5 (9) 6.5 TO 10 (10) 10
TO 15 (11) 15 TO 20 (12) 20 TO 25 (13) 25 TO 3C (14) 30
TO 35 (15) 35 TO 4C (16) 40 TO 45 (17) 45 TO 5C (18) 50
TO 55 (19) 55 TO 6C (20) 6C TO 65 (21) 65 TO 7C (22) 70
TO 75 (23) 75 TO 8C (24) 8C TO 85 (25) 85 TO 9C (26) 90
TO 95 (27) 95 TO 10C (3C) 1CC TO 12C (29) 12C TO 14C (30)
14C TO 16C (31) 16C TO 18C (32) 18C TO 20C (99) N.A/X24
(1) YES (2) NO/X25 (1) UPTO 0.25 (2) 0.25 TO 0.4C (3) 0.4
TO 0.65 (4) 0.65 TO 1.C (5) 1.C TO 1.5 (6) 1.5 T ... (7)
2.5 TO 4.0 (8) 6.5 AND ABOVE (99) N.A/X26 (1) YES (2) NO/
X27 (1) UPTO 0.25 (2) 0.25 TO 0.4 (3) 0.4 TO 0.65 (4) 0.65
TO 1.0 (5) 1.0 AND ABOVE (99) N.A/X28 (1) YES (2) NO/X29
(1) (1) UPTO 0.4C (2) 0.4 TO 1.C (3) 1.C TO 2.C (4) 2.0
TO 4.0 (5) 4.0 TO 6.0 (6) 6.0 TO 10.0 (7) 11 AND ABOVE
99) N.A/X30 (1) YES (2) NO/X31 (1) UPTO 100 (2) 100 TO
200 (3) 250 TO 300 (4) 350 TO 400 (5) 450 TO 500 (6) 550
TO 600 (7) 650 TO 700 (8) 750 TO 800 (9) 850 TO 1000 (99)
N.A/X32 (1) YES (2) NO/X33 (1) UPTO 100 (99) N.A/X34 (1)
YES (2) NO/X35 (1) UPTO 100 (99) N.A/X36 (1) YES (2) NO/
X37 (1) UPTO 1 (99) N.A/X38 (1) YES (2) NO/X39 (1) UP TO 1 (99)
N.A/X40 (1) YES (2) NO/X41 (1) UPTO 100 (99) N.A/X42 (1)
YES (2) NO/X43 (1) UPTO 1 (99) N.A/X44 (1) YES (2) NO/X4.
(1) UPTO 1 (99) N.A/X46 (1) YES (2) NO/X47 (99) N.A/X48
(1) YES (2) NO/X49 (99) N.A/X50 (1) YES (2) NO/X51 (99)
N.A/X52 (1) YES (2) NO/X53 (99) N.A/X54 (1) UPTO 0.25 (2)
0.25 TO 0.40 (3) 0.41 TO 0.65 (4) 0.70 TO 1.00 (5) 1.09
TO 1.50 (6) 1.51 TO 2.5 (7) 2.51 TO 4.0 (8) 4.01 TO 6.0
(99) N.A/X55 (1) YES (2) NO/X56 (1) YES (2) NO/X57 (1)
TEA (2) TEA COFFEE (3) COFFEE(4) PYRETHRUM (5) TEA PYRETH
RUM (6) TEA COFFEE PYRETHRUM (7) OTHERS (9) N.A/X58 (1)
TEA (2) TEA COFFEE (3) COFFEE (4) PYRETHRUM (5) TEA PYRET
HRUM (6) TEA COFFEE PYRETHRUM (7) OTHERS (8) N.A/X59 (1)
UPTO 0.25 (2) 0.26 TO 0.4C (3) 0.41 TO 0.65 (4) 0.7C TO
1.0C (5) 1.09 TO 1.5C (6) 1.51 TO 2.5 (7) 2.51 TO 4.C (8)
4.09 TO 6.C (9) N.A/X6C (1) YES (2) NO/X61 (1) PRICES GOO
D (2) FUTURE ASSET (3) OTHER CROPS DO NOT PAY (4) OTHERS
(9) N.A/X62 (1) HORTICULTURE (2) LIVESTOCK (3) FOOD CROPS
(4) FODDER (5) OTHERS (9) N.A/X63 (1) HORTICULTURE (2)

LIVESTOCK (3) FOOD CROPS (4) FODDER (5) OTHERS (9) N.A/
X64 (1) YES (2) NO/X65 (1) EVERY SEASON (2) In Two Seasons
S (3) ONE YEAR (4) TWO YEARS (5) LONG PERIOD (9) N.A/X66
(1) BURN IN FIELD (2) FED TO ANIMALS (3) MANURE (4) SOLD
(5) OTHERS (9) N.A/X67 (1) BURN IN FIELD (2) FED TO ANIMA
LS (3) MANURE (4) SOLD (5) OTHERS*(9) N.A/X68 (1) BURN IN
FIELD (2) FED TO ANIMALS (3) MANURE (4) SOLD (5) OTHERS
(9) N.A/X69 (1) TOO MUCH RAIN (2) LONG DRY SPELLS (3) INS
ECTS PESTS DISEASES (4) FLOODS EROSION (5) WIND (6) OTHER
(9) N.A/X70 (1) TOO MUCH RAIN (2) LONG DRY SPELLS (3) INS
ECTS PESTS DISEASES (4) FLOOD EROSION (5) WIND (6) OTHERS
(9) N.A/X71 (1) TOO MUCH RAIN (2) LONG DRY SPELLS (3) INS
ECTS PESTS DISEASES (4) FLOODS EROSION (5) WIND (6) OTHER
(9) N.A/X72 (1) TOO MUCH RAIN (2) LONG DRY SPELLS (3) INS
ECTS PESTS DISEASES (4) FLOODS EROSION (5) WIND (6) OTHER
(9) N.A/X73 (1) ALL (2) THREE (3) TWO (4) ONE (9) N.A/X74
(1) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6) 6 (7) 7 (8) 8 AND ABOVE
(9) N.A/X75 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6) 6 (7) 7 (8)
8 AND ABOVE (9) N.A/X76 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6)
6 (7) 7 (8) 8 AND ABOVE (9) N.A/X77 (1) 1 (2) 2 (3) 3 (4)
4 (5) 5 AND ABOVE (9) N.A/X78 (1) FREE GRAZING (2) STALL
FEEDING (3) BOTH (9) N.A/X79 (1) UPTO 0.39 (2) 0.40 TO
0.40 (3) 0.41 TO 0.65 (4) 0.70 TO 1.00 (5) 1.04 TO 1.50
(6) 1.51 TO 2.50 (7) 2.51 TO 4.0 (8) 4.05 TO 6.0 (9) N.A/
X80 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5 AND ABOVE (9) N.A/X81
(1) 1 (2) 2 (3) 3 (4) 4 (5) 5 AND ABOVE (9) N.A/X82 (1) 1
(2) 2 (3) 3 (4) 4 (5) 5 AND ABOVE (9) N.A/X83 (1) 1 (2) 2
(3) 3 (4) 4 (5) 5 AND ABOVE (9) N.A/X84 (1) LESS 1 GALLON
(2) 1.5 TO 2 GALLONS (3) 2.5 TO 3.0 GALLONS (4) 3.5 TO 4
GALLONS (5) 4.5 TO 5.0 GALLONS (6) 5.5 TO 6.0 GALLONS (7)
6.5 GALLONS AND ABOVE (9) N.A/X85 (1) SHORTAGE OF GRAZING
LAND (2) HIGH COST OF FEED (3) SHORTAGE OF FEED (4) HIGH
CALF MORTALITY (5) OTHERS (9) N.A/X86 (1) SHORTAGE OF GR
AZING LAND (2) HIGH COST OF FEED (3) SHORTAGE OF FEED (4)
HIGH CALF MORTALITY (5) OTHERS (9) N.A/X87 (1) SHORTAGE
OF GRAZING LAND (2) HIGH COST OF FEED (3) SHORTAGE OF FEE
D (4) HIGH CALF MORTALITY (5) OTHERS (9) N.A/X88 (1) SHOR
TAGE OF GRAZING LAND (2) HIGH COST OF FEED (3) SHORTAGE
OF FEED (4) HIGH CALF MORTALITY (5) OTHERS (9) N.A/X89 (1
) HYBRID (2) KATUMANI (3) LOCAL (4) OTHERS (9) N.A/X90 (1
) HYBRID (2) KATUMANI (3) LOCAL (4) OTHERS (9) N.A/X91 (1
) HYBRID (2) KATUMANI (3) LOCAL (4) OTHERS (9) N.A/X92 (1
) EARLY MATURE (2) BETTER YIELD (3) TASTE (4) NOT FALL (5
) EARLY MATURE (2) BETTER YIELD (3) TASTE (4) NOT FALL (5
) OTHERS (9) N.A/X93 (1) EARLY MATURE (2) BETTER YIELD (3
TASTE (4) NOT FALL (5) OTHERS (9) N.A/X94 (1) EARLY MATU
RE (2) BETTER YIELD (3) TASTE (4) NOT FALL (5) OTHERS (9)
N.A/X95 (1) SUPPLY IS LATE (2) PRICES HIGH (3) INSECTS DA
MAGE GRAIN (4) NOT DROUGHT RESISTANT (5) MORE WEED PROBLE
MS (6) DO NOT DO WELL WITHOUT FERTILIZERS (7) OTHERS (9)
N.A/X96 (1) SUPPLY IS LATE (2) PRICES HIGH (3) INSECTS DA
MAGE GRAIN (4) NOT DROUGHT RESISTANT (5) MORE WEED PROBLE
MS (6) DO NOT DO WELL WITHOUT FERTILIZERS (7) OTHERS (9) N.A
X97 (1) SUPPLY IS LATE (2) PRICES HIGH (3) INSECT DAMAGE
GRAIN (4) NOT DROUGHT RESISTANT (5) MORE WEED PROBLEMS (6
) NOT DO WELL WITHOUT FERTILIZERS (7) OTHERS (9) N.A/X98
(1) SUPPLY IS LATE (2) PRICES HIGH (3) INSECT DAMAGE GRA
IN (4) NOT DROUGHT RESISTANT (5) MORE WEED PROBLEMS (6)
NOT DO WELL WITHOUT FERTILIZERS (7) OTHERS (9) N.A/X99 (1
) YES (2) NO/X100 (1) CASH CROPS (2) SUBSISTANCE CROPS (3)

11/06/84

HORTICULTURE (4) CASH SUBSISTENCE (5) MOST. CASH CROPS (6
)HORTI. SUBSISTENCE CROPS (7) ON ALL CROPS (9) N.A/X101
(1) TOO EXPENSIVE (2) SUPPLIER IS FAR (3) APPLY MANURE (4
)FARM TOO SMALL (5) OTHERS (9) N.A/X102 (1) YES (2) NO/
X103 (1) YES (2) NO/X104 (1) YES (2) NO/X105 (1) YES (2)
NO/X106 (1) YES (2) NO/X107 (1) YES (2) NO/X108 (1) YES
(1) NO/X109 (1) YES (2) NO/X110 (1) YES (2) NO/X111 (1)
YES (2) NO/X112 (1) YES (2) NO/X113 (1) UPTO 1 MILE (2)
1.5 TO 2.0 (3) 2.5 TO 3.0 (4) 3.5 TO 4.0 (5) 4.5 TO 5.0
(6) 5.5 TO 6.0 (7) 6.5 TO 7.0 (8) 7.5 TO 8.0 (9) 8.5 TO 9
X114 (1) YES (2) NO/X115 (1) YES (2) NO/X116 (1) YES (2)
NO/X117 (1) YES (2) NO/X118 (1) YES (2) NO/X119 (1) YES
(2) NO/X120 (1) YES (2) NO/X121 (1) YES (2) NO/X122 (1)
ONCE A WEEK (2) ONCE A MONTH (3) ONCE IN SIX MONTHS (4)
ONCE IN A YEAR (5) AFTER A LONG PERIOD (6) NOT AT ALL (9)
N.A/X123 (1) CASH CROPS (2) LIVESTOCK (3) FOOD CROPS (4)
HORTICULTURE (5) CASH CROPS LIVESTOCK HORTICULTURE (6) CA
SH CROPS FOOD CROPS (7) ON ALL FARM ENTERPRISES (9) N.A/
X124 (1) YES (2) NO/X125 (1) AFC (2) COOPERATIVES (3) BAN
KS (4) AFC COOPERATIVE (5) BANKS COOPERATIVES (6) BANKS
AFC (7) KTDA & OTHERS (9) N.A/X126 (1) LACK OF SECURITY
(2) LACK OF GUIDANCE (3) HAS NO NEED FOR IT (4) OTHERS
(9) N.A/X127 (1) UPTO 30 YEARS (2) 31 TO 40 (3) 41 TO 50
(4) 51 TO 60 (5) 61 TO 70 (6) OVER 70/X128 (1) UPTO 5 YRS
(2) 6 TO 10 (3) 11 TO 15 (4) 16 TO 20 (5) OVER 20/X129 (1
) ONCE A MONTH (2) THREE MONTHS (3) SIX MONTHS (4) A YEAR
(5) TWO YEARS (6) LONG PERIOD (7) NOT AT ALL (9) N.A/X130
(1) YES (2) NO/X131 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6) 6
AND ABOVE (9) N.A/X132 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6)
6 AND ABOVE (9) N.A/X133 (1) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6
) 6 (7) 7 (8) 8 AND ABOVE (9) N.A/X134 (1) 1 (2) 2 (3) 3
(4) 4 (5) 5 (6) 6 (7) 7 (8) 8 AND ABOVE (9) N.A/X135 (1)
1 (2) 2 (3) 3 (4) 4 (5) 5 (6) 6 AND ABOVE (9) N.A/X136 (1
) 1 (2) 2 (3) 3 (4) 4 (5) 5 (6) 6 AND ABOVE (9) N.A/X137
(1) FULL TIME (2) ONE MONTH (3) TWO MONTH (4) THREE MONTH
(5) NONE AT ALL/X138 (1) YES (2) NO/X139 (1) 1 (2) 2 (3)
3 (4) 4 AND ABOVE (9) N.A/X140 (1) UPTO 5 (2) 6 TO 10 (3)
11 TO 15 (4) 16 TO 20 (5) N.A/X141 (1) LAND PREPARATION
(2) PLANTING (3) HARVESTING (4) TRANSPORTING (5) WEEDING
(6) SPRAYING AND PRUNING (9) N.A/X142 (1) LAND PREPARATIO
N (2) PLANTING (3) HARVESTING (4) TRANSPORTING (5) WEEDIN
G (6) SPRAYING AND PRUNING (9) N.A/X143 (1) LAND PREPARAT
ION (2) PLANTING (3) HARVESTING (4) TRANSPORTING (5) WEED
ING (6) SPRAYING AND PRUNING (9) N.A/X144 (1) LAND PREPAR
ATION (2) PLANTING (3) HARVESTING (4) TRANSPORTING (5) WE
EDING (6) SPRAYING AND PRUNING (9) N.A/X145 (1) LAND PREP
ARATION (2) PLANTING (3) HARVESTING (4) TRANSPORTING (5)
WEEDING (6) SPRAYING & PRUNING (9) N.A/X146 (1) PERIOD ON
E (2) PERIOD TWO (3) PERIOD THREE (4) PERIOD FOUR (5) PER
IOD FIVE/X147 (1) LAND PREP. (2) PLANTING (3) HARVESTING
(4) TRANSPORTING (5) WEEDING (6) SPRAYING AND PRUNING (9)
N.A/X148 (1) LAND PREP. (2) PLANTING (3) HARVESTING (4)
TRANSPORTING (5) WEEDING (6) SPRAYING AND PRUNING (9) N.A
X149 (1) LAND PREP. (2) PLANTING (3) HARVESTING (4) TRANS
PORTING (5) WEEDING (6) SPRAYING AND PRUNING (9) N.A/X150
(1) LAND PREP. (2) PLANTING (3) HARVESTING (4) TRANSPORTI
NG (5) WEEDING (6) SPRAYING AND PRUNING (9) N.A/X151 (1)
LAND PREP. (2) PLANTING (3) HARVESTING (4) TRANSPORTING
(5) WEEDING (6) SPRAYING AND PRUNING (9) N.A/X152 (1) YES
(2) NO/X153 (1) YES (2) NO/X154 (1) YES (2) NO/X155 (1)

SYSTEMS

SAVES LABOUR (2) SAVES LAND (3) CROP SYNBIOSIS (4) TRADITI
N (5) OTHERS (9) N.A/X159 (1) SAVES LABOUR (2) SAVES LAND
(2) CROP SYNBIOSIS (4) TRADITION (5) OTHERS (9) N.A/X157
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TRADITION (5) OTHERS (9) N.A/X158 (1) SAVES LABOUR (2) SA
VES LAND (3) CROP SYNBIOSIS (4) TRADITION (5) OTHERS (9)
N.A/X159 (1) SAVES LABOUR (2) SAVES LAND (3) CROP SYNBIOSI
S (4) TRADITION (5) OTHERS (9) N.A/X160 (1) PROFITABLE
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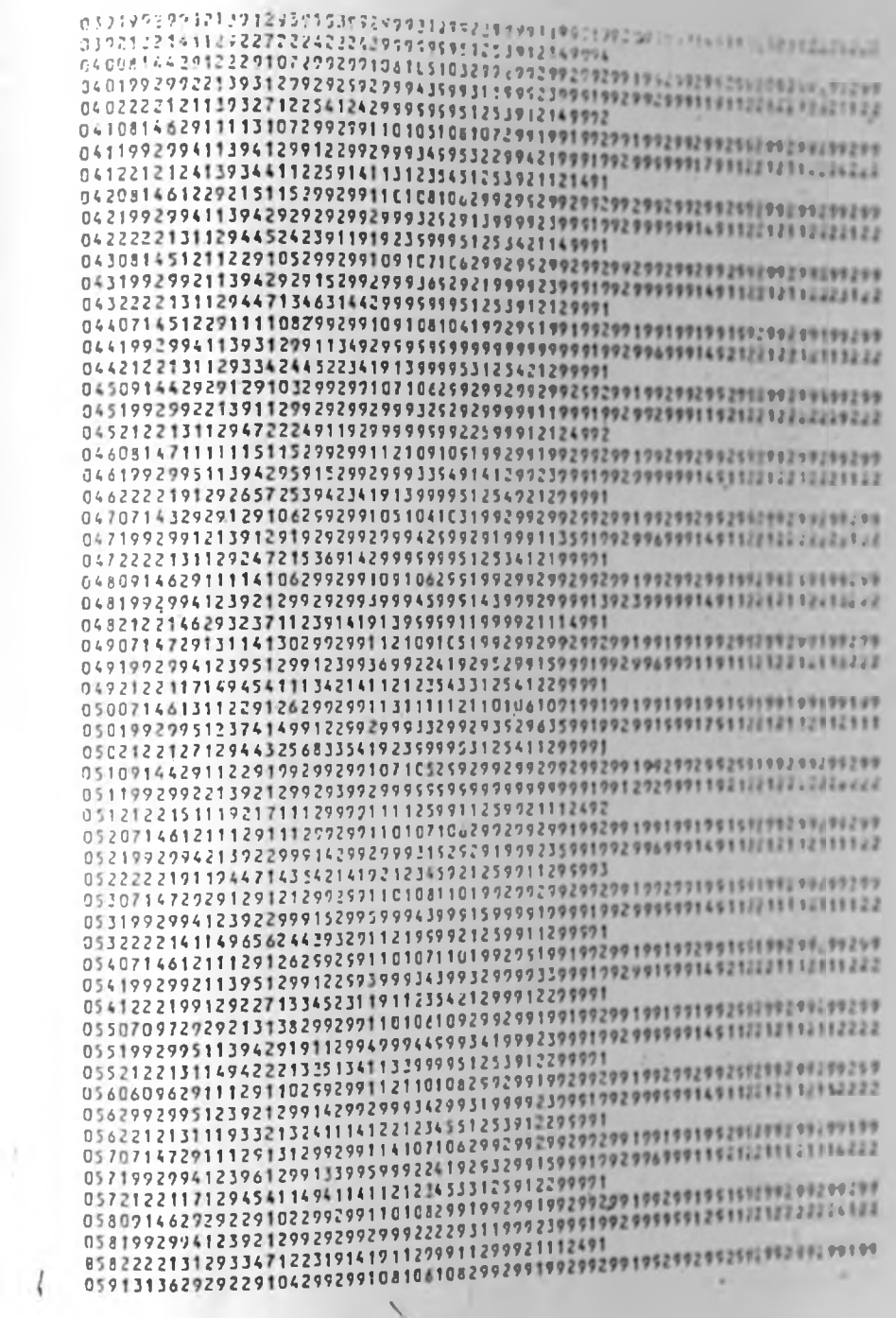

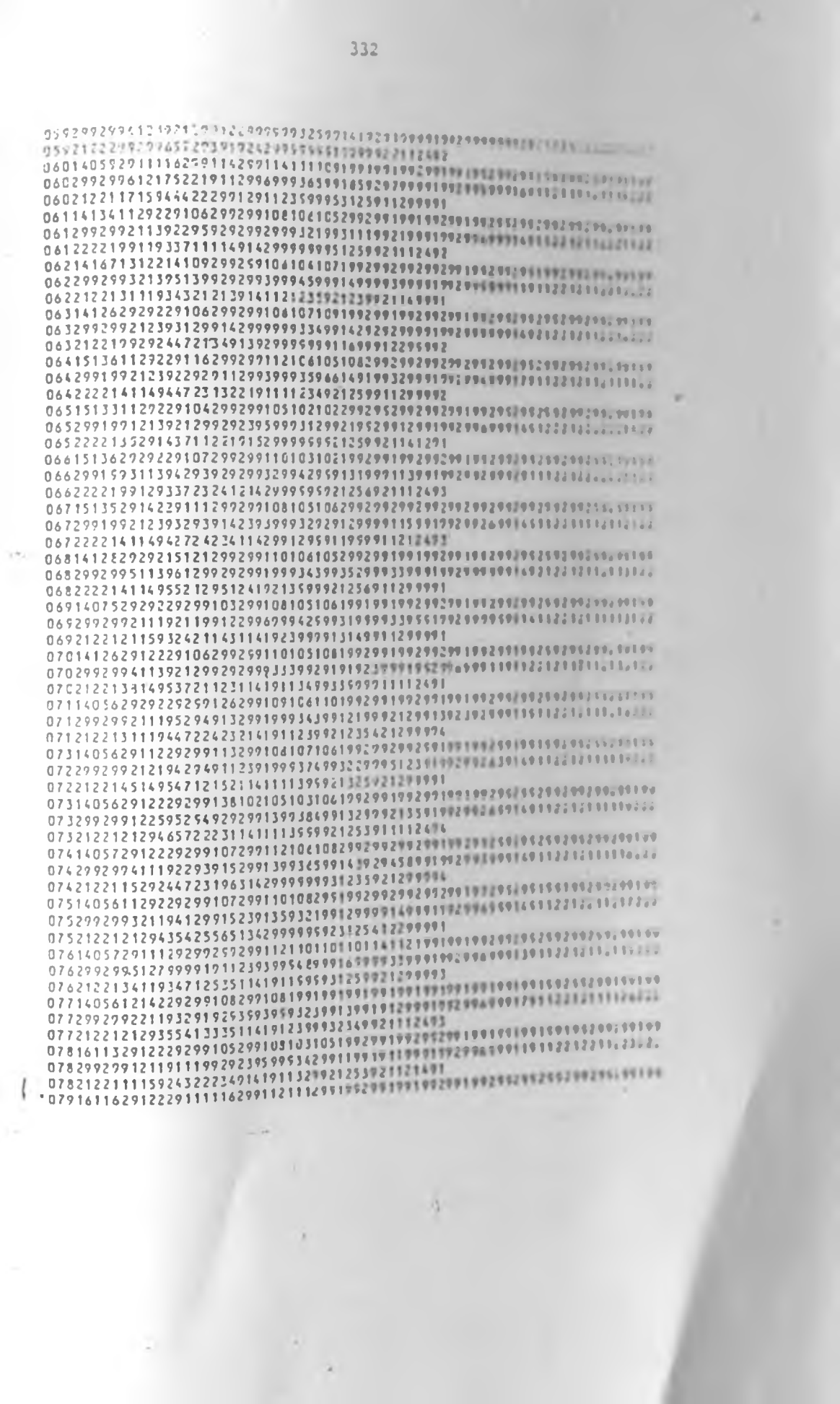

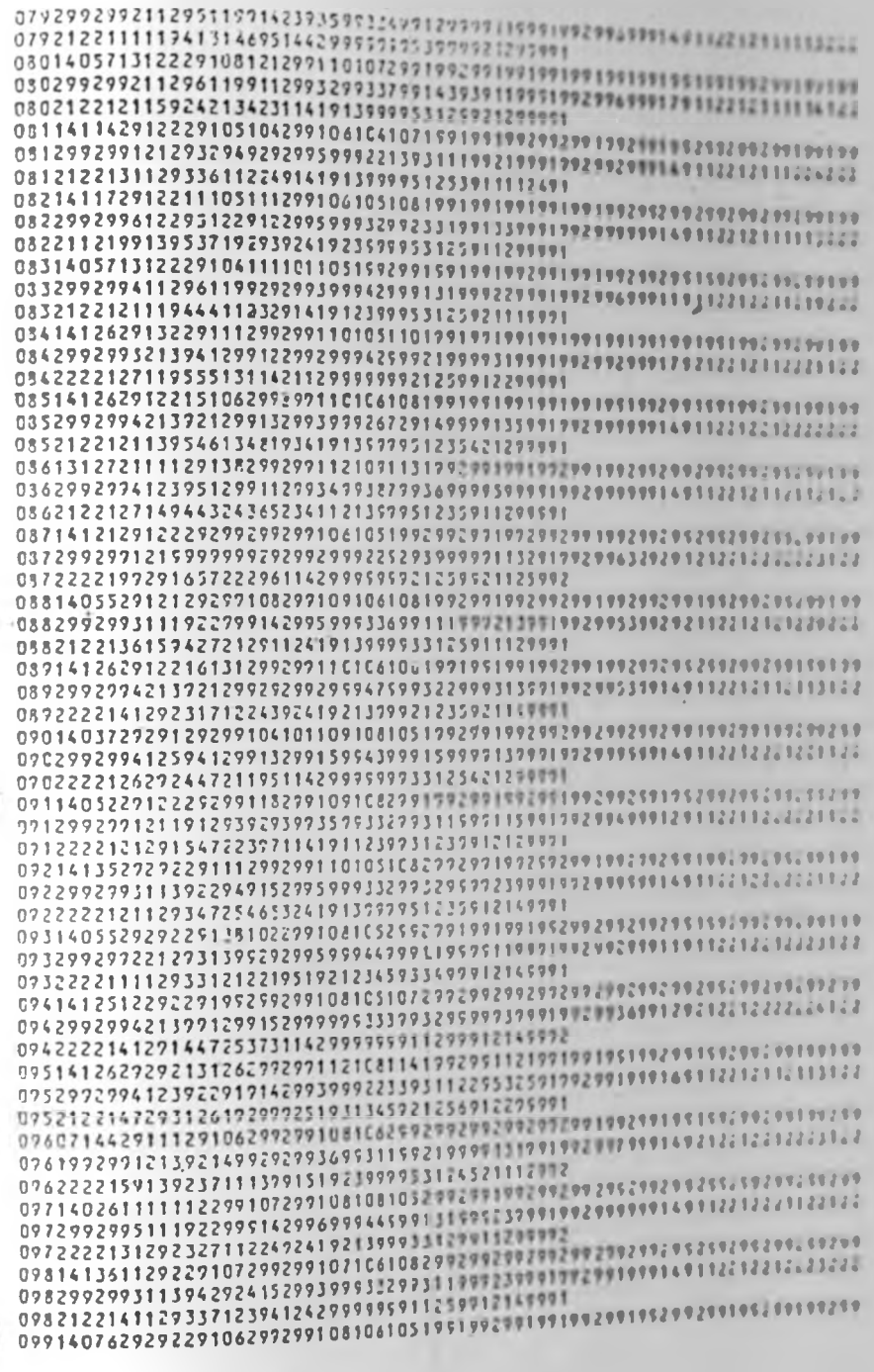

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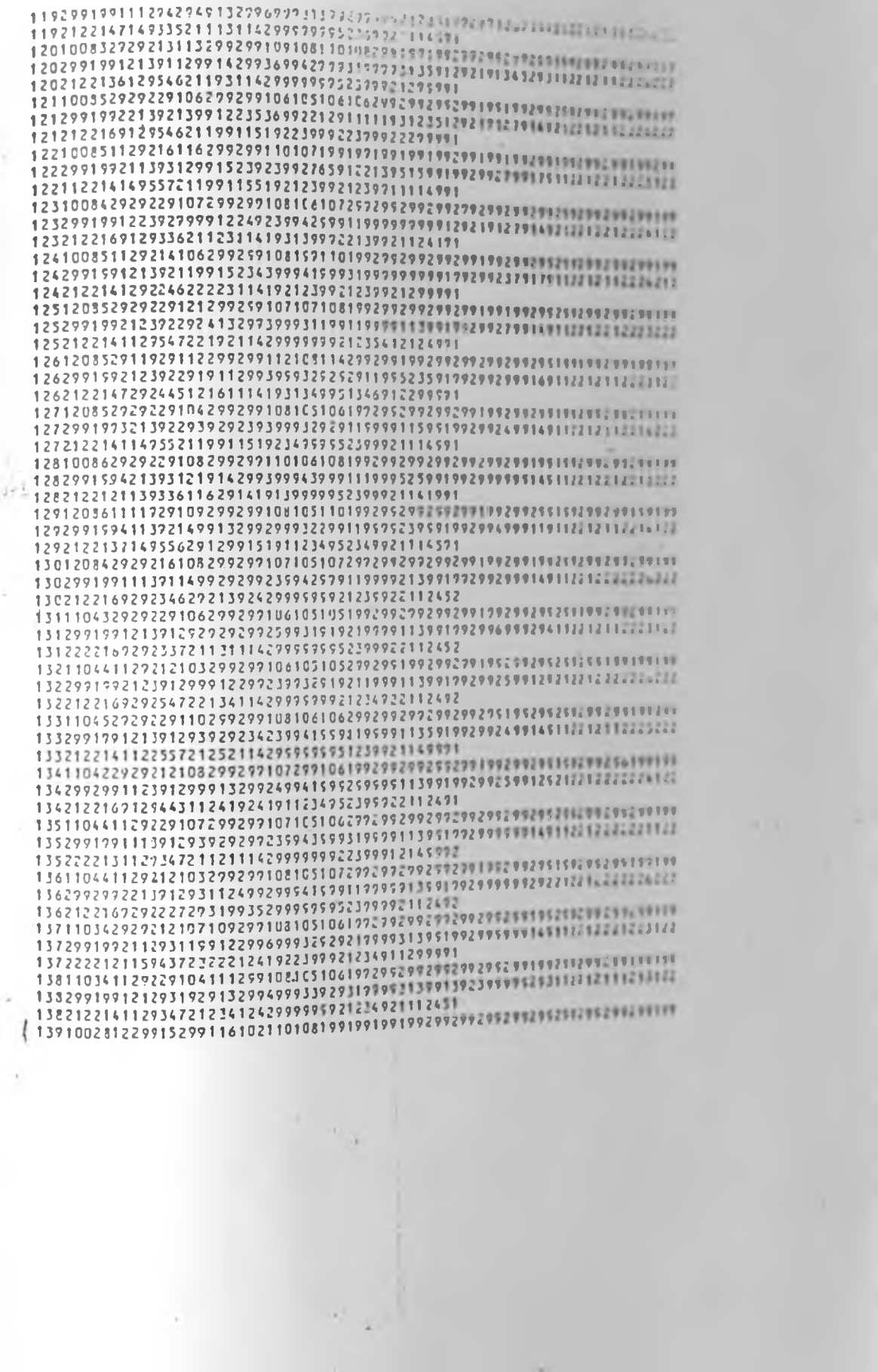

APPENDIX III

LAND SIZE VIS-A-VIS POPULATION

TABLE A.

LOCATION	LAND SIZE (ACRES)	ESTIMATED POPULATION	PER CAPITA LANDHOLDING
RUGURU	13,765.0	26,408	0.5 Acres
MAGUTU	11,293.75	20,[illegible]	0.54 acres
KONYU	13,272.0	[illegible]	0.41 acres
IRIAINI	12,541.5	21,022	0.6 acres
KIRIMUKUYU	12,955.5	26,[illegible]	0.48 acres

TABLE B

LOCATION	LAND SIZE (ACRES)	ESTIMATED POPULATION	PER CAPITA LANDHOLDING
MUHOYAS	17,750	14,2[illegible]	1.25 acres
TETU	14,500	19,946	0.73 acres
AGUTHI	17,500	35,536	0.49 acres
THEGENGE	23,250	35,235	0.66 acres
DIVISION	73,000	104,949	0.7 acres

TABLE C

LOCATION	LAND SIZE (ACRES)	ESTIMATED POPULATION	PER CAPITA LAND HOLDING
CHINGA	11,192.0	16,[illegible]	0.65 acres
OTHAYA	18,311.5	33,367	0.55 acres
MAHIGA	22030	18,4[illegible]	1.2 acres
DIVISION	51,537.5	68,[illegible]	0.[illegible] acres

TABLE D.

LOCATION	LAND SIZE IN ACRES	ESTIMATED POPULATION	PER CAPITA LAND HOLDING
MUHITO	12,121.4	2,[illegible]	0.45 acres
SITHI	14,625.14	2,1259	0.7 acres
SIKONDI	9,365.3	16,971	0.[illegible] acres
NUTUNE	7,005.95	6,204	1.13 acres
DIVISION	44,017.95	80,500	0.55 acres

DISTRIBUTION OF VARYING FARM SIZES PER LOCATION

TABLE A.

OTHAYA

LOCATION	2 Ha	2-5Ha	5-10Ha	10Ha	TOTAL
CHIINGA	1085	687	85	35	1892
OTHAYA	4,000	401	105	50	4,556
MAHIGA	1,986	94	65	31	2,176
TOTALS	7,071	1,182	255	116	8,624

TABLE B

TETU

NUMBER OF HOLDINGS - 1983

LOCATION	2Ha	2-5Ha	5-10Ha	10Ha	TOTAL
HUHOYAS	781	560	50	2	1,393
TETU	1,376	852	535	7	2,770
AGUTHI	2,819	1,505	122	32	4,478
THEGENGE	4,657	1,314	67	-	6,038
TOTALS	9,633	4,231	774	41	14,679

TABLE C

MATHIRA

NUMBER AND SIZE OF HOLDINGS - 1983

LOCATION	2Ha.	2-5Ha.	5-10Ha	10Ha.	TOTALS
RUGURU	1468	1,350	448	13	3279
MAGURU	3056	1034	142	2	4234
KONYU	2864	1,535	33	3	4435
IRIAINI	1506	1048	88	15	[illegible]
KIRIMUKUYU	2991	731	36	[illegible]	[illegible]
TOTALS	11,885	5,698	747	39	16,369

TABLE D

MUKURWEINI

NUMBER HOLDINGS - 1983

LOCATION	2 Ha	2-5Ha	5-10Ha	10Ha	TOTAL
MUHITO	2,963	594	53	4	3614
GITHI	2,179	1405	249	109	3,942
GIKONDI	2,363	744	22	2	3,131
RUTUNE	735	444	521	1	1,701
TOTAL	7,505	3,137	841	114	12,308

DISTRIBUTION OF AGRICULTURAL EXTENSION SERVICES PER LOCATION

LOCATION	NUMBER OF AGRICULTURAL EXTENSION STAFF	NUMBER OF FARMERS PER AGRICULTURAL EXTENSION OFFICER
Magutu	6	342
Nonyu	4	1,064
Irialini	3	930
Ruguru	8	303
Mirimukuyu	4	927
Muinoya's	5	278
Ietu	4	692
Agutiri	5	836
Thegenge	3	2,013
Thiriito	11	329
Githi	8	493
Lower Thiriito	5	911

AGRO-CLIMATIC (AGRO-ECOLOGICAL) ZONES

TABLE I

ZONES	MEAN ANNUAL TEMP. (°C)	ALTITUDE (METRES)	MEAN ANNUAL RAINFALL (mm)	CLASSIFICATION	ZONAL DESCRIPTION
I - 9	10°	3050	1100-2700		
I - 8	10-12	2750-3050	"		
I - 7	12-14	2450-2750	"		
I - 6	14-16	2150-2450	"	HUMID	
I - 5	16-18	1850-2150	"		
I - 4	16-20	1500-1850	"		
II-7	12-14	2450-2750	1000-1600		
II-6	14-16	2150-2450	1000-1600		
II-5	16-18	1850-2150	"	SEMI-HUMID	
II-4	18-20	1500-1850	"		
II-3	20-22	1200-1500	"		
III-6	14-16	2150-2450	900-1400	SEMI-HUMID	
III-5	16-18	1850-2150	"		
III-4	18-20	1500-1850	"		
III-3	20-22	1200-1500	"		
IV - 5	16-18	1850-2150	600-1100	SEMI-HUMID III	
IV - 4	18-20	1500-1850	"	SEMI-HUMID	
V - 5	16-18	1850-2150	500 - 750	SEMI-ARID	

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TABLE 2

LOCATION	RAINFALL RANGES (mm)	TEMPERATURE RANGES (^{o}C)	CROP SUITABILITY
MIGORI	[illegible]	[illegible]	[illegible]
MAGUTU	1100-2700 (MH)	16-18°C	[illegible]
IRIAINI	1100-2700 (MH)	14-22°C	LOWER MIDLAND TO MIDLAND CROPS
KONYU	1000-1600 (HM)	16-22°C	LOWER MIDLAND TO MIDLAND CROPS
KIRIMUKUYU	1000-1600 (HM) 800-1400 (TM)	18-20°C	[illegible]
GIKONDI	1100-2700 (TS) 1000-1600 (HM)	18-22°C	[illegible]
GITHI	800-1400 (TM)	20-22°C	[illegible]
MUHITO	800-1400 (TM)	20-22°C	[illegible]
L. MUHITO	800-1400 (TM)	20-22°C	[illegible]
OTHAYA	1100-2700 (TM) 1000-1600 (TM)	14-20°C	LOWER MIDLAND TO [illegible]
KIINGA	1100-2700 (TM)	14-20°C	LOWER MIDLAND TO MIDLAND CROPS
KAHIGA	1100-2700 (TM) 1000-1600 (TM)	14-20°C	LOWER MIDLAND TO [illegible]
KIGENGE	1100-2700 (TM) 1000-1600 (TM) 800-1400 (TM)	14-20°C	[illegible] TO [illegible]
KEIU	1000-1600 (TM)	12-18°C	UPPER MIDLAND TO LOWER MIDLAND CROPS
KARITHI	1000-1600 (TM) 800-1400 (TM)	18-20°C	[illegible]
KIRUYA'S	1000-1600 (TM) 800-1400 (TM)	12-18°C	[illegible] TO UPPER MIDLAND CROPS