"Protection of the environment and promotion of economic development are not separate challenges. Development cannot subsist on a deteriorating environmental resource base and the environment cannot be protected when growth plans consistently fail to consider the costs of environmental destruction." (World Commission on Environment and Development 1987).

"Natural resources are the engine for development; conversely, development is dependent on the continued productivity of the natural resource base. The paradox that emerges is that development is dependent on the very resources it threatens with extinction. Unless management strategies are developed that combine use with conservation, improvement in living standards and national wealth are jeopardised" (Dr. Wanjiku Mwagiru in the World Environment Day Supplement; 5th June 1990).

ENVIRONMENTAL THRESHOLD: ITS APPLICABILITY TO AGRICULTURAL LAND-USE PLANNING. A CASE STUDY OF NG'ARUA DIVISION, LAIKIPA DISTRICT, KENYA.

BY

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DECLARATION

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

Signed____________________________

(Candidate) MR. STEPHEN WAIGWA GITONGA

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

Signed____________________________

(Supervisor) MR. GEORGE NGUGI

DEDICATION

Dedicated to my father Gitonga Waigwa, my mother Gathoni Gitonga, who introduced me to the realities of the environment and to all those who care for the environment.

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A study of this magnitude could not be possible without much assistance of many persons and in many cases the institutions they represent.

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Stephen Waigwa GITONGA

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ABSTRACT

In the semi -arid and arid lands in Kenya, great structural changes have taken place and are still taking place in regard to agricultural development. This has been brought about by the progressive expansion of agricultural activities coupled with sedentarisation in these marginal environments. Marginal environments are fragile and less resilient to the effects of man and his concomitant labour activities. In this context, the study is based on the themeof conservation of marginal agricultural environments by use of the concept of environmental threshold approach in agricultural land-use planning. From the onset, the study is a scientific experimental effort to attempt prior application of the approach for the purposes of planning and policy development for sustainable agricutural development in marginal areas in Kenya.

From the above context, the study has used the concept of enviromental threshold for an attempt to comprehensively perceive the spatial variation of environmental thresholds in Ng'arua Division. This was aimed in establishing the environmental thresholds in the area and policies designed to mitigate overstepping of environmental threshold were drawn.

To achieve the above goals, the study aimed at identifying various agricultural land use types and assess the environmental thresholds spatially in the context of the identified agricultural land use types. For this purpose delienation of agricultural land use types and environmental threshold is done resulting to thematic maps of the above considerations.

Survey and study of the resource base of the Division was done to assess the area's resource potential and sensitivity of the ecosystems to man's labour activities. Soil and climate are the major parameters that were used. However, the systems of environmental exploitation and management are studied to help in assessment of environmental trends and situation. Negative environmental consequences are used as manifestations of overstepping of the environmental threshold.

The analyses reveals that environmental threshold studies is a useful tool in guiding the description of the environmental situation of the marginal agricultural land so long as it is not assigned permanent value because of the dynamic nature of the

agricultural process. It is evident from this study that the approach is important in the overall agricultural land-use planning process and decision making for the settled and unsettled marginal environments.

In a nutshell, the study has revealed that environmental threshold approach in agricultural land-use planning can be used as an instrument for policy development prior to the use of other instruments of policy implementation and evaluation. In this respect, sustainable agricultural development and conservation of the arid and semi-arid environments can be achieved by use of the environmental threshold approach in agricultural land-use planning.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

CHAPTER ONE:

This Chapter contains an introductory section outlining the background information and purpose of the study. This gives a full account of the issues that pre-empted the conception of this study. Included is a statement of the study purpose in the general land-use planning process.

The chapter also highlights the underlying assumption and objectives that the study aims to achieve. The scope of the study and location of the study area is given which includes factors that contributed to the choice of the study area. Justification of the study as a sub-topic underscores the relevance of environmental threshold studies in agricultural land use planning.

An outline of the methodological approach of the study gives the procedure and the methodological techniques used in carrying out the study. The chapter closes with a sub-topic study limitations which underlines the major limitations encountered in the process of carrying out the study and the attempts made to overcome the limitations.

CHAPTER ONE

BACKGROUND AND PURPOSE OF THE STUDY

Over the years man, his biology and his labour activities have consistently utilized and exploited land. The result of all this is that land has been altered and is being moulded to man's needs. However, in recent years, man has realised the detrimental aspects of his exploitation of land and the many environmental implications associated with it. Under the same situation it has dawned again to man to realise what Thomas Malthus in 1798 signalled as a disastrous trend or tendency of people increasing in numbers at a geometric rate while food production was increasing at an arithmetic rate.

Save for Malthus's (1798) fears, the technological advancement, economic and sociological changes are more to be acknowledged for reducing such a disaster. However, in recent years, increase in population and exploitation of the marginal ecosystems for agricultural use are threatening the firm holding by the technological advancement for increased food production. Exploitation of the marginal areas for agricultural activities beyond their capabilities has reduced the productivity of these ecosystems, disrupted their components and has reduced the stability of the same. This has serious environmental implication because the productivity of these marginal lands for sustainable agriculture is impaired. In this respect the study is based on the concept that land usually returns the highest profit when it is used most intensively but that use needs to be within its capabilities(1).

Agricultural practices have undergone various structural changes in Kenya. These changes can be traced far back from the pre-colonial, colonial, and the post-colonial periods. In all cases, there existed spatial variation of agricultural practices and more important, environmental thresholds in different parts of the country. Spatial variation of these agricultural practices and the environmental thresholds are manifested today by the diverse intensities of agricultural land uses and the relative densities in population of different parts of the country.

However, spatial variation of agricultural evolution in different parts of the countr_ has resulted into what can be referred today as "agricultural concentration areas". These areas are in the major high agro-ecological zones in the country. Consequently, population pressure in these zones has pushed more and more people to lower agro-ecological zones. These zones are characterised by fragile ecosystems and thus marginal to agricultural production. Crop production risks are great and fallow periods required for natural soil replenishment are long. With settling of sedentary farmers into more marginal lands, the fallow periods have been shortened.

The marginal areas were initially used by nomadic pastoralists who depending on the rainfall patterns rotated their grazing. In some marginal areas in Kenya (study area included), "white settlers" replaced the indigenous pastoralists by introducing ranching schemes(2). Under the migrants (subsistence farmers) introduced inherent agricultural land use practices.

The practices associated with the migrant settlers (new farmers) are mainly centred on sedentarization. This is accompanied by cultivation of annual crops such as maize, beans, potatoes, wheat etcetra and some times cultivation of perenial crops such as fruit trees, coffee, livestock keeping (cattle, goats, sheeps, donkeys) is also practiced. The heart of the matter is that these practices are done in small farms averaging about 5 acres under fragile ecosystems(3). Coupled with bush clearing, overcultivation, and overgrazing, the land in these marginal areas is undergoing extensive degradation. The major environmental degradation in the marginal areas is soil degradation as a result of the earlier mentioned reasons. It is usually manifested in form of soil erosion and lowered soil fertility. Lowered vegetation cover, disturbed soil stability and decreased moisture content as a result of man's agricultural activities. Sometimes result is total ecological imbalance after the environmental stress limit is reached (Kowzlowski 1985, World Bank 1978).

In Kenya, the problem can be summarised as follows;- increased trend towards sendentarisation in the marginal areas caused by rapid population growth and limited arable land coupled with shortage of employment opportunities has caused increased settlement and progressive exploitation of limited land. This has resulted to overgrazing, deterioration of the natural balance of the environment, overcultivation and finally lowered biological (biomass) productivity of the areas in question. Ironically, the population is still rising and there is continuous overexploitation of the natural resources for agricultural use; fallow periods in the marginal areas are constantly being reduced by agricultural intensification and there is threat of total depletion of the natural agricultural environment. The result of all this is lowered land prodcutivity and damage to the rural systems and therefore consequently erosion of the national economy which depends on primary production (Dangana L.B. 1983: 82).

In order to enhance continuous agricultural development and to nurture a sustainable environment, the study has used the concept of environmental threshold in agricultural land use planning. This is to try to tackle the above mentioned problems associated with the introduction of "sendentary" agricultural practices in the marginal areas. It is observed that agricultural development in the marginal areas in Kenya encounters physical limitations that are imposed by various features of the existing natural and man-made environment[4]. Limitation to development can be considered as development thresholds. It is contended by Kozlowski J. (1985: 148) that thresholds to any developmental activity would occur when further development of that activity in a given area and within given period would encounter - a decrease or absence of resources required by this activity or such an impact of negative side effects as would damage both the ecological balance of the environment and its ecological functions. It is on the basis of that concept that the term threshold to further development of a given activity as encountered if - "the activity cannot extend to a new area produce additional output, achieve higher quality, accelerate production without involving increase of investment, social or ecological cost" (Ibid 1985). Threshold deriving directly from the natural resources are defined by Kozlowski (1985:148) as "environmental thresholds".

Environmental thresholds are of special significance in this study. They have been used with environmental conservation consideration for agricultural land use planning. It is exemplified by Kozlowski (1985) that thresholds which cannot be overcome by existing technology or which can only be overcome by serious and irreversible damage to the natural environment can be described as "ultimate environmental threshold". These indicate final boundaries of possible location, level, quality, and rate of development of a particular activity[5]. Overstepping of environmental threshold in course of agricultural development in the marginal areas in Kenya, has resulted to earlier mentioned negative environmental consequences.

Environmental threshold varies spatially as reflected by different agro-ecological potential. In this study four general dimensions or principles for rational exploitation of environmental resources as outlined by Kozlowski (1985) are used. They have been modified in content and context to fit in the purpose of this study. These principles are:- (1) Agricultural land use activities should be developed where there are required resources and where negative side-effects of activities do not impinge on a sensitive facet of the environment. This is referred to as locational or territorial dimension of the environment. (2) Agricultural land use activities should be developed only up to the levels (volume) determined in quantitative terms by the resource potential - size, yield and by the degree of tolerance of the ecosystem to negative side effects (example, soil erosion, loss of vegetation cover etc). This is referred to as quantitative dimension of the environment. (3) Agricultural land use activities should be developed at the quality of output which either directly or through side effects will not lead to significant degradation of the environment e.g. (tractorisation of farms which lead to distabilised soil structures). This is referred to as qualitative dimension of the environment. (4) Agricultural activities are required to be developed at a rate and in time periods which will conform with the rythm of the natural processes (e.g. fallow or resting period between cropping season and the other one etc) (6).

These four dimensions of the environment namely territorial or locational, quantitative, qualitative and temporal form our framework to determine where and which agricultural activities should be developed and up to what quantitative levels with what quality of output and at what rate or over what time period so that sustainable agricultural development in the marginal areas can suffice.

Limitations to agricultural development aspecially in marginal areas are mainly generated by the natural resources. The limitations are manifested in form of negative environmental consequences either on the activity itself or the components of the ecosystem[7]. The raison d'etre of conceptualizing agricultural land use planning by environmental threshold consideration has been sparked off by the observation that there is marked structural variation that has undergone agriculture (and is still continuing) through evolution of agricultural land use practices in the marginal areas. (Sing E.G.Y. 1968:3, Karinge P. 1985).

In Kenya's marginal areas a wide range of variation exists in agricultural land use practices, e.g. from predominantly subsistence to predominantly commercial; from livestock rearing to crop production, from simple farming implements to tractors drawn plough, from natural dependence, on natural regeneration for maintaining fertility to the application of organic and inorganic fertilizers (Sing G.E.Y. 1968). In all these cases, agricultural development thresholds derived from the natural resources are viewed in terms of the four environmental threshold dimensions discussed before.

Territorial to indicate the areas over which a given agricultural activity can take place without outstripping the ultimate environmental threshold, quantitative to indicate the level or volume up to which a given agricultural activity can be developed without showing negative ecological consequences, qualitative to indicate the kind of output or input that can be achieved or applied before negative side effects can be felt and temporal to indicate the acceptable development rate or the permitted time periods in which agricultural development can take place to suit the natural rythm. In this study soil and climate has been taken as the determinant of the environmental or natural resource potential for environmental threshold consideration. However, existing negative environmental consequences or the predicted ones as the land is already under agricultural use, are used as manifestations of overstepping of the envrironmental thresholds.

In this context, application of environmental threshold to agricultural land use planning is based on the understanding of the evolution of agricultural land use type and the existing agricultural land use type. This is used to help in defining areas, levels, and time periods to which various agricultural land use types would provoke a negative side effect to the environmental quality in form of soil degradation vis-a-vis conservation.

It is the essence of planning to deliberately choose ends and do analytical determination of the most effective means to achieve these ends; these being means which make optimal use of scarce resources and which when implemented are not accompanied by undesirable consequences[8]. Based on that contention the purpose of the study is to help agricultural land use and resource - use planners to rationalize their overall planning process at the same time giving them a logical approach to agricultural land suitability studies for the marginal areas. It is also to act as an eye-opener to the formation and reviewing of a checklist of the important factors related to agricultural land use suitability and soil conservation which hitehrto are overlooked and ought to be considered when making policy decisions. It is also to assist in incorporation of environmental considerations in agricultural development planning in marginal areas and decision making process.

After identification of various negative environmental consequences in regard to soil that results from overstepping of environmental thresholds in course of agricultural development expansion process in marginal areas; the study is anticipated to assist in early warning by relevant Government authorities on the consequences that would befall the marginal lands if further agricultural developemnt expansion is not properly managed or conceived.

The study however, is not a problem solving one rather is problem identifying therefore, helps in giving answers as to where, what level, and at what rate, can agricultural development take place in the marginal areas without causing serious environmental degradation. In this respect therefore the study acts as a tool to other problem solving oriented methods. It in essence supplements other environmental conservation methods in the context of marginal areas agricultural land use planning and decision making.

1.01 Problem Statement

Spatial variation of agricultural land use types in marginal areas is of great relevance in environmental conservation endeavours. This is so because environmetnal threshold varies spatially in a given marginal land. Rapid sedentarisation of pastoralists and migration of sedentary farmers in the marginal areas ones used for nomadic grazing is causing concern because of its detrimental effects to the marginal ecosystem.

Kenya is no exception in this regard. High population pressure in the high agro-ecological zones has pushed people to more marginal lands. The marginal ecosystem is very sensitive to heavy intensities of agricultural uses. Shortening of fallow periods for natural soil replenishment without satisfactory artifial replenishment has resulted in lowered soil productivity and disruption of the marginal ecosystems and its components. All these in a nut-shell lead to what is referred to as environmental degradation.

Exploitation of the marginal areas is not the real verdict of environmental degradation. The problem lies in answering the following questions: To what quantitative levels (volume) and to what quality of labour activity (agriculture) can such a marginal area accommodate before any negative environmental consequence is provoked? The other questions are at which locations or territories should such an agricultural activity be carried out and at what rates or time periods (temporal perspective) should the activities be carried out to avoid reaching the environmental stress limit of the marginal areas? These questions tied together can be phrased as follows: How can overstepping of the environmental thresholds of various parts of marginal areas be avoided so as not to cause any significant negative environmental consequences to the areas in question?

This study is in this context concerned in conservation of the marginal agricultural environment by harmonizing agricultural development activities with the characteristics of the marginal areas through agricultural land use planning by integrating agricultural land use types and the environmental threshold so as to attain a sustainable agriculture.

It is in the conviction that population in the high agro-ecological zones will continue to increase leading to more marginal lands to be opened up for arable farming. With this sedentarisation, marginal areas will continue to be exploited with the unfortunate result of being degraded environmentally. It is on these bases that this study is conceived.

An environmental threshold map in the presence of an agricultural land use type map is a requiste in answering environmental threshold question to mitigate overstepping of the same.

1.02 Study Objectives

In line with the theme of the study, its appropriate to pay special attention to the purpose of the study and give a systematic criteria of putting more environmental considerations in agricultural land use planning in the marginal areas. This is anticipated to pave more avenues for decision making process in matters related to agricultural development expansion in Kenya's marginal areas. In this context, the general objectives of the study are to:-

1. Identify various agricultural land use types taking into consideration the evolutional development of the same.
2. Identify major negative environmental consequences as manifestations of overstepping of environmental threshold of the study area inthe context of the agricultural land use types.
3. Come up with an agricultural land use type map and an environmental threshold map.
4. Come up with suggestions on how the two maps can be used as a guide to agricultural land use experts, resource use planners and resource assessment groups in their environmental conservation endeavours.

To be able to accomplish the above objectives, the study is based on the following assumption/or premises.

1) Negative environmental consequences are manifestations of overstepping of environmental threshold.
2) The present agricultural land use types are homogeneous within a given representative areal unit in the study area.

1.03. <u>Scope of the Study and Location of Study Area</u>

The study was carried out in Ng'arua Division in Laikipia District. Ng'arua division is the most western division of the district. The district is in the Rift Valley Province of Kenya. Ng'arua Division covers an area of 109,800 hectares. It is boundered on the west by Baringo District, on the east by Rumuruti Division and on the Northern end by Samburu District. It is bisected by longitude $30^{o}30'$E and latitude $0^{o}30'$N. (See figure 8).

The Division can be divided into three main agro-ecological zones, namely agro-eco-zone 3 which covers most parts of the Ol Arebel Valley and its environs; agro-eco-zone 4 which covers the middle parts of Ng'arua and agro-eco-zone 5 which includes some parts of the northern and north-eastern parts of the division. In this respect, the upper Ng'arua zone which covers the Ol Arebel Valley is of higher agro-ecological potential relative to the others with distinct environmental characteristics. The middle parts of Ng'arua has medium to marginal agro-ecological potential and the lower parts of Ng'arua which covers the north and north-eastern parts lies in semi-arid areas with marginal agricultural land (see figure 12).

The advantage of carrying out the study in Ng'arua Division is in that over the last decades the Division has undergone various agricultural land use changes and the process is still continuing today. It has also received many migrants from other areas of the country and settled in all the three mentioned agro-ecological potential zones. Consequently, the Division has undergone different and varied environmental consequences because of the varied environmental thresholds in the Divsiion. In this respect it acted as a good base to study the applicability of environmental threshold to agricultural land use planning for environmental conservation.

The scope of the study is towards tracing of the evolutional development of agricultural land use types in the division and its spatial variation. It is also towards identification of major negative environmental consequences brought about by overstepping of environmental thresholds by different agricultural land use activities in the area. In this respect, soil and climate are paramount in the study as parameters for assessing the resource potential and therefore determining the environmental situation of the study areas. They are used to determine the ultimate environmental threshold of different agricultural land use types. The main issues in soil will rotate around the aspects of soil erosion, loss of soil fertility through continuous intensive cultivation without replenishment, loss of soil structure and stability, lowered soil moisture and other soil related issues that reflect overstepping of environmental thresholds. The scenario consists of major factors that directly or indirectly influence soil degradation. These include topography, soil types, climate, ecology (vegetation), geological factors and human factors.

For climate; temperature, rainfall, wind and relative humidity are the main factors of consideration. Combining climate and soil aspects, the sensitivity, resistance and resource potential of the study area vis-a-vis spatial variation of relative environmental threshold is determined.

1.04 Justification of the Study

Spatial variation in the stages of agricultural evolution and the environmental consequences associated with it is of importance if the complexity of Kenya's agricultural practices is to be understood. This is so because unless the agricultural land use types and the environmental threshold studies are done, degradation of the natural or environmental resources is inevitable.

Agricultural land use planning has a great role to play in the provision of policy guidelines for sustainable agricultural land use. However, it is even of much assistance when the general trends of agricultural evolution is understood, negative environmental consequences as a result of overstepping of environmental threshold are well studied and the present agricultural land use types in the fragile ecosystems mapped.

Agricultural land use potential vary considerably from one land use type to another(8). In this context, identification of agricultural land use types and environmental thresholds in the marginal lands is expected to equip the planner with a deeper knowledge and better understanding of existing conditions and predicted future trend than could the more conventional land use survey.

In Kenya, great structural variation has occurred in existing agricultural land (Sing G.E.Y. 1968) and more so in the marginal lands of Kenya over the years (Winston cone and J.F. Lipscomb 1972). This is because the population pressure which keep on pushing farmers from the high agro-ecological potential areas into more marginal lands (Frederick R.F. et al. 1980). In this respect, a land-use map devoid of th element of environmental threshold or ecological consequences is rendered inadequate as a planning tool if sustainable agricultural development is to suffice.

FAO (1976), Beek (1978) outlined a framework for land evaluation using land suitability as the fitness of a given type of land for a defined use. However, although this method tries to draw various suitability levels as related to land-use types and the limitation accompanied with each; negative environmental consequences as a result of overstepping of environmental threshold mars all efforts of conservation.

Development of land suitability classifications for land use planning for various activities and evaluation of the same has been the centre point of many land use planning considerations including agriculture. However, where environmental considerations are needed, development thresholds have proved to be a second tool in getting a sustainable development and avoiding reaching to a point of environmental fatigue.

It is on this note that a map that shows spatial variation of agricultural land use types and environmental thresholds based on the negative environmental consequences as perceived within a framework of environmental conservation for marginal agricultural lands is imperative. This enables planning for an environmentally sound agricultural land as an objective for sustainable productivity.

Ng'arua division in Laikipia District like many other parts in Kenya has undergone the mentioned structural agricultural land use changes through evolution process in the division. The Division has spatial differences in agro-ecological potential (Karinge P. 1985). Sendentary farmers have settled in the Division replacing the original agricultural land users who usually had large farms hence leading to subdivision of these farms into small farming units (Winstone Cone & J.F. Lipscomb 19772, Karinge P. 1980).

The environmental threshold of the division varies spatially as reflected by the variation in agro-ecological potential (Karinge P. 1980). Inherent agricultural land use practices as mentioned in the previous discussion have been and are being introduced in this area. Because of increased pressure on land use practices, the components of the ecosystem of the area are changed with consequent degradation of the environment in form of land degradation.

The Division has given a good case for environmental threshold and agricultural land use typology studies in a bid to incorporate environemntal conservation in agricultural land use planning and in decision making process for the marginal areas.

1.05 Methodolgical Approach for the Study

The study began with survey of literature related to the field of study. This included information concerning the study area. Historical background of the evolution of agricultural developemnt in the study area was sought. The main source of data on the above undertaking were:- Old records especially in the Kenya

National Archives. This included District Commissioner's annual report. Interview was done with three old people who used to live in the region during the colonial period. Other source of informtion was from old maps and photographs. However, published literature on this region was used to add to what was collected in other sources. Ministry of Agriculture and that of Livestock old records were a rich source of information.

Spatial variation of agricultural land-use type currently was obtained by studying the area in transects, interviewing farmers and officers working on related field. Critical observation by the author and studying maps added to the information obtained from interviews. Interviews were conducted in two forms:- namely, by use of questionnaires and rapid appraisal of the situation through face to face interviews with farmers. These interviews were aimed at establishing the crops grown, animals kept, tillage methods, size of the farms, fertiliser application and method of application, farm implements used for cultivation, percentage of farm under cultivation, types and number of animals kept per farm and their distribution, time of ploughing, planting and harvesting, problems faced in farming among others.

Spatial variation of environmental threshold in the study area and the consequences associated with it were sought by use of various methods, namely: study of the vegetaion of the area, use of soil maps, interviews with agricultural environmental officers and the farmers, use of ministries (various) annual reports on the environment, studying of fertiliser use trends, trends in productivity, temperature and rainfall records, soil survey records and other documents and any other information that was found relevant.

However, the political systems of environmental exploitation was determined by studying the mode of agricultural production, land ownership (tenure), land sizes, population size and stucture, agricultural land use among other considerations.

Questionnaires were administered in the Division on a stratified random sampling of 60 households. However, the Division was devided into three working units defined by use of agro-ecological potential zones. In this respect an agro-ecological potential zone map was used to select the three units. In each unit, 20 questionnaires were administered. For logistic reasons, the survey was confined in the small-scale farming areas of each unit. For the ranching farms, interviews and observations were done without use of the questionnare. In the administration of the questionnaires in each working unit, survey areas were chosen on the basis of variation in land sizes and/or the physical characteristics of land. In this respect, homogeniety in environmental characteristics was used.

After data collection and compilation was completed, analysis was done. This was done by use of descriptive methods and simple distributional statistics. Cartographical presentation of the analysis is also used.

Interpretation of the data involved the Integration of all the various aspects of the study. Mapping of thresholds is done by use of a rating criterion defining various threshold levels in the region. However, analysis of environmental thresholds was guided by the four environmental threshold principles cited for environmental considerations.

In course of carrying out the study, discussions were held with professionals in various fields related to the field of the study.

In many instances during the data analysis and interpretation and prior synthesis, photographs were used to depict important features in the study area.

1.06 Study Limitations

Various limitations were encountered in the process of carrying out this study. One of which includes poor communication network i.e. some areas in the Division are not accessible. This factor was even made worse by the fact that some areas were inhabited by wild animals. This limitation was usually serious in the large scale ranching farms. In this context, it limited our movement into some of the important areas which could have served to improve our understanding of the environmental status of the Division. To offset this limitation, soil maps, climatic aspects maps and study of vegetation was used.

The other major limitation was lack of specific baseline data as regards the Division. Such data could have served as a supportive information to help in enriching the data collected from the survey. This inhibited our critical assessment and consequent appraisal of the resources in the study area, especially as concerns the aspects of water resources in the study area and how this affect the water - soil regime in the region.

Notes

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CHAPTER TWO:

The chapter contains among others, the survey of literature in which the aspect of land degradation/or environmental destruction is explored. Historical development of environmental considerations is highlighted. This section also underscores the environmental realities in regard to agricultural development in the marginal areas in Kenya among other areas. At the end, it examines the development of criteria developed over the years for the purpose of marching development activities (Land-uses) and the environmental quality. Finally it summarises in underscoring the development of environmental threshold approach and its ultimate use in environmental planning/land use planning.

Structural characteristics of agricultural practices in marginal areas as a sub-topic examines the general characteristics of the marginal areas in general and Kenya in particular. It also outlines the effects of introducing agricultural practices in the marginal areas. Emphasis are laid on the evolutional structural changes of agriculture in the marginal areas in Kenya and the resultant effects that accompany it.

The above is followed by a sub-topic Government policy which explores the development of environmental considerations in land use policy in Kenya. It examines the chronology of events and policy development by the Kenya Government in its fight against environmental (land) degradation. The actors of the game are also highlighted.

CHAPTER 2 SURVEY OF LITERATURE:

2.00 Introduction: Survey of literature

FAO (1976) defined land as an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictable cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal population, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of land by man.

Man has solely depended on land for his agricultural needs. In the course of exploiting land for this purpose, many changes are inflicted on land. Some changes are detrimental in the long run but others tends to improve the productivity of land. However, at any rate and at any case slight disruption of the natural ecosystem is caused. Some disruption are reversible while others are irreversible.

Needless to say, changes in human population and man's labour activities are man's response to survival phenomenon triggered by the man's effort to produce enough food for his sustainance. This is a global phenomenon.

Changes in agricultural land use in Kenya can be traced way back in the 1920's when white settlers started replacing the traditional African agricultural land use practices and introduced European methods of agricultural land use (Winstone Cone & J.F. Lipscomb 1972). One major change that brought remarkable structural organisation in agricultural land use is the introduction of commercial/specialised farming systems from purely subsistence/underspecialised farming systems (Sing G.E.Y. 1968:1). These historic changes penetrated to the very structure of traditional agricultural systems of the peasant farmers in East Africa and Kenya in particular (Ibid 1968:1). These structural changes included; farm size and layout, land tenure, type of tools, techniques of maintaining and improving soil fertility, labour needs and the range of agricultural tasks, types of crops; role of animals, distribution of output and so on (Opcit:2).

However, one result of these changes was the reorganisation of agricultural land use systems. As contended by Frederick R.T. et al. (1980:25), people have cultivated crops only relatively recently; originally they were hunters and gatherers. As population increased shifting cultivation was started as a system of cultivation (Sing G.E.Y. 1968, Frederick R.T. et al. 1980). It involved clearing of land for cultivation followed by long fallow periods. These fallows in the tropics could go over ten years, in this case they were referred to as forest fallows. As population increased further, the fallow periods decreased to periods of 5-8 years referred to as bush fallows and later to 3-4 years becoming grass fallows (Bayliss, Smith 1982:17-18). Population increase was the main factor of agricultural land use changes. However, as fallow periods were becoming less and less; intensification of agricultural land use practices resulted to more production per unit of land therefore, supporting even a larger population. This resulted into even more population increase (Sing G.E.Y. 1968:2).

A major result of population pressure is the development of less agriculturally suitable land, much of it characterised by fragile ecological systems (World Bank 1978:47). As mentioned before, increased human population in the marginal areas is attended by increased livestock population in grazing lands, shortening of the soil rejuvenating fallow periods in cultivated lands and introduction of agricultural pratices which are not always suitable for the environmental conditions (FAO, UNEP, UNESCO, WMO, 1986). This leads to deterioration of the natural resources of the marginal areas (Ibid 1986). Leniham J. and Williams W.F. et al. (1975:21-31) contends that the two important tools of destruction of the environment or assertion of man's dominance of his ecology is fire and the axe. The extent of modification of physical environment by man is however, dependent on the nature of the pre-existing vegetation and soil cover and on pest and present climatic conditions together with the degree of modification and length of time since it was first affected (Lenihan J. & William W.F. 1975:21-31).

In Kenya particularly, effects of cultivation of marginal areas and negative environmental consequences were observed as early as in 1930's which were referred by Frederick R.T. et al. (1980:49) as advancement of the desert. This fact is highlighted by Winston Cone L. and Lipscomb J.F. (1972:73-74) who contends that, "there was little evidence of any appreciation by the white settlers of the need to nurse the soil and to adopt their farming methods to the soil and climate". It was until the end of 1937 under the charge of J.F. Lipscomb and R.O. Barnes, that the Ministry of Agriculture by then formed a section of soil conservation service (Ibid 1972:74). The advancement of the desert was as a result of the expanded cultivation in the semi-arid desert fringe (Opcit 1980: 49).

Perry M.L. (1978:95) contends that "there is a range of environmental constraints on agriculture which while operating within the context of a social, technological and political framework may under certain conditions; condition of extreme marginality be a critical factor behind the location of agricultural limits for marginal subsistence economics. These constraints may determine the limits of the habitable world. Desman R.F. (1976:119) has the notion that "throughout the world, marginal land farmers have attempted to squeeze a living from mainly the lands not suited to commercial crop production and have ruined the lands in the process". According to him, classification of lands according to land capabilities could help to avoid such misuse. The classification would take into account the soil types, slope and drainage of the land, the erodibility and rockiness of the soil and all factors which influence capability of the land.

A seminar organised by American Association for Advancement of Science (AAAS) in Nairobi on desertification (1978), introduced the concept of carrying capacity of land to renewable resource management to "indicate the level of sustained use at which the resource will not be permanently damaged or its productive capacity lowered". They emphasized its application to the "tillage of rainfed croplands vis-a-vis erosion" (Ibid 1978:41).

All these sentiments expressed above are sparked off by the observation that the natural resources (soil and vegetatin) of arid and semi-arid zones are deterorating to an increasing extent due to increased human pressure and to a change in the living conditions of the population making use of these resources in climatically-stressed areas (FAO, UNEP, UNESCO, WMO 1986). The whole situation can be put in the Interagency Group on Agricultural Biometeorogy's (IGAM) 1986 words that these agricultural "practices are not always suitable for the environmental conditions and the effect of this has been to hasten the various processes of erosion in a particularly vulnerable and fragile environment. these processes quickly lead to a deterioration in natural ecosystems, resulting, particularly in the destruction of the vegetation mantle and the deterioration of its potential for production, and in the decreased fertility of soils and their ability to store water".

In bid to reverse and check this tendency towards environmental degradation and to reduce man's detrimental effects on land, various methods have been developed. Such methods includes use of land capability methods. They were developed in different countries emanating into having (a) the American method, Canadian method etcetra (Donald A. Davidson (1980). However, the results of these endeavours were followed latter by the publication of FAO (1976) Soil Bulletin 32 on the "framework for land evaluation"; FOA (1978) "Land evaluation standards for rainfed agriculture", Beek, K.J. (1978) "land evaluation for agricultural development" among others. In all these publications, emphasis are laid on arrangement of land in classes. This entails classfication of land on the bases of their suitability for certain uses or activities, which resulted in what Beek K.J. (1978), FAO (1978) is referring as land utilization types. Land use planning embraces all the various ways of presenting the knowledge of the land in such a manner that they can easily be integrated (Vink A.P.A. 1983: 200). In this respect all the above mentioned authors used the interpretation and execution of surveys and studies on soils, climate, vegetation, land forms, and other aspects of the natural environment to determine the suitability, limitation and performance of specific land units. the primary aim of use of land capability methods is to assess the degree of limitations to land use or potential imposed by land characteristics on the bases of permanent properties (Donald a. Davidson (1980). The kind of limitations to any land use or potential are such as soil erosion hazard, rooting restriction and problems of climate, stonniness, low fertility, salinity or wetness (Ibid 1980: 16-18). A new aspect of sustainability was incorporated in the Canadian method for planning rather than for management purposes (Opcit 1980: 19-21). Same emphasis on land use planning is expressed by FAO (1976); Beek K.J. (1978). However, effect of the performance of a land use activity in a specific piece of land or a region are more emphasized rather than the effects of land-use activity to land and its resources. The end-result of this factor is that land is put into suitable uses but slowly, continuously and progressively undergoes degradation. This is not an oversight on the side of the various methods developed for sustainable development but rather a new development in the process of evolution of man and his labour activities in the exploitation of land resources.

However, Kozlowski J. (1977) developed another method of looking at the same development factors as discussed above but with a new angle of approach. It was first published by the United Nations (1977) under the title "Threshold Analysis Handbook". It outlined the method of identification of development constraints or threshold and methods of calculating the costs of overcoming these constraints. However, the 1977 threshold analysis by Kozlowski was biased mainly on urban development. In the following years, Kozlowski developed the ideas of the threshold analysis further for environmental planning. At ths juncture he applied it on the effects of tourist activities on the natural environment at Tatry National Park in Polland (Kozlowski J. (1985). His contention of environmental threshold as those development threshold generated directly by the natural environment opened a new chapter in environmental planning and complimented other efforts by FAO (1976), FAO (1978), Beek K.J. (1978) among others in the development of a land use planning method that incorporates the aspect of sustainability of the environment. Kozlowski (1985) contends that its after overstepping of these environmental thresholds that negative environmental consequences are inflicted on the natural resources and results in lowered productivity of the environment.

His notion concurs with the concept of carrying capacity as contended by AAAS (1978). According to the two authors, development beyond the stress limit of the environment often is attended by adverse environmental effcts. Sometimes it is coupled with irreversible effects that usually leads to environmental fatique. Application of environmental threshold in agricultural land use planning give an added effort in environmental conservation for sustainable agricultural developemnt especially in the marginal areas. Usually the basic biolological carrying capacity or threshold of a particular soil and vegetation type is often determined by the biological activities such as animal units, number of people, type of crops that a particular geographic area can support (AAAS 1978; Kozlowski J. 1985).

In the same note, even if the agricultural activities may be within the "save range" of environmental threshold, another serious aspect in environmental deterioration is the consequences of excessive demographic pressure on land resources (Denmen R.F. et al. 1968). In this context "Carrying capacity is related to the number of people whose food needs can be satisfied by production from lands under traditional food crops at land use intensities which do not destroy the resource base" (Ibid 1968: 171).

Marginal environments which are highly vulnerable to environmental deterioration are those which are settled recently and/or whose formerly sparse population have exceeded the subsistence carrying capacity. Kozlowski J. (1985) contends that when ultimate environmental threshold is reached the effects caused to the environment are irreversible. Very high ecological costs are incurred in such cases. However, overintensive or destructive uses of the marginal land is related to the carrying capacity as conceptualized by the AAAs (1978). Victims of the above considerations are the subumid and semi-arid tropical environments which naturally are less resilient to agricultural developent than the humid tropical ecosystems.

2.01 Structural characteristics of agricultural practices in marginal areas in Kenya

Marginal areas can be defined in terms of the fragility and sensitivity of these environments to man's labour activities. Fragility of the marginal ecosystems is brought about by the variable nature of rainfall, droughts, soils and vegetation. In agricultural point of view, the marginal areas include those in sub-humid and semi-arid tropical environments. In Kenya, marginal areas are characterised by varying natural phenomenon but still support less denser populations than other wetter areas. In Kenyan point of view they can be taken to range from the transition end of agro-eco-zone 3 and 4 to agro-eco-zone 5. Agro-eco-zone 6 and beyond is in this respect considered extemely marginal for any economical agricultural development.

For any agricultural development, high economic and ecological cost are met in the marginal areas in Kenya. For the purpose of this study ecological cost is of much importance.

In Africa and East Africa in general, the marginal areas were mainly used for livestock production. In pre-colonial years, these areas in Africa were used by nomadic pastoralists for grazing their livestock. Livestock numbers in that time were more controlled by diseases and pest rather than lack of pastures.

The economy of the marginal lands depends heavily on the conditon of the catchment areas which in recent years because of advancement of technology in control of livestock diseases, is threatened by overstocking.

International Union for Conservation of nature and Natural resources (IUCN 1968) reported that "there are a few sectors of the environment that have been more badly damaged by man's activities than the grazing lands of the world. The productivity of the marginal areas began to be impaired when man first domesticated hoofed mammals and began to control the movement of their lands (Ibid 1968:78).

At this juncture, its important to mention some of the pertinent natural characteristics of the marginal areas based on the Kenyan context. The climate of the marginal areas is generally characterised by unreliable rainfall. It is usually sporadic and/or seasonal usually falling in heavy downpours. Rainfall is usually erractic and less predictable. These sporadic episodes of rainfall are interrupted by an interlude of varying number of drought years. This can be illustrated in wet and dry cycles behaviour leaving little room for reliable estimation of the next wet season for any planned agricultural activity. By their very nature of location (geographical), dry winds accelerate evaporation and transpiration and their combined effect depletes the soil of its moisture immediately.

World Meteorological Organisation (WMO) noted in 1972 that the major concern of man with his environment is the need to udnerstand the natural environmental processes and to utilize his acquired knowledge for useful and positive purposes. This would enable for efficient use of the natural resources. In this context man will be ensuring that his activities do not interfere with the natural environmental processes and hopefully will be able to rectify some of the damages already done in the process (Davies A.D. 1972). In this respect knowledge of the characteristics of the marginal areas is paramount in its management.

The natural vegetation of the marginal areas varies from dominant woody plants in some areas to dominance of grasses and herbs in other areas. In an ecological point of view, vegetation of any particular area is a reflection of the balance between climate, soil, water and the fauna. However, where man has already exploited, pressure exerted overtime by man is also manifested in that area's vegetation. In many cases flowering herbs including many kinds of composite and legumes, are much less important than grasses (Kormondy E.J. 1984:169). The scattered woodlands and shrubs in the marginal areas are usually drought resistant (Ibid 1984; 176). Something that needs unduly mention is periodic fires in many Kenyan marginal areas to which the grasses and relatively few trees are well adapted (Opcit 1984:176).

The soils found in the marginal areas varies from place to place. However, there is some relationship between the soils and the vegetation and the evapotranspiration rates of the marginal areas. Many plant nutrients are locked up in chemical combinations which render them unavailable to plants (Kormondy 1984). This results in mineral imbalances resulting in excesses and in other cases deficiences. Where the evaporation regime is high there are high concentrations of salts at the soil surface. A problem of salinity or alkalinity in such cases is inevitable in some marginal areas. As a consequence in many parts of marginal areas, the top soil has low humus content and this renders it shallow in agricultural point of view.

Taking the above discussed points into consideration, it is now important to look at the implications of these factors and to answer the question of fragility and sensitivity of the marginal lands to man's labour activities like agriculture. Areas with more sparcely scattered woody vegetation and less grass are very sensitive to heavy downpours of rain because the soil has little shelter against heavy rain drops. In such cases the soil is exposed to erosion hazards. Introduction of an agricultural activity in such an environment depletes the sparse grass cover because of grazing and trampling and will accelerate the process of soil erosion. Vink A.P.A. (1983: 126) contends that extensive grazing may lead to overgrazing due to uncontrolled increase in cattle density in particular in semi-arid and arid regions. This leads to serious kinds of soil erosion partly due to the general ecological conditions and partly because the land use itself has few possibilities to control erosion once this has started. What Vink A.P.A. (1983) is trying to highlight is the sensitivity of the marginal lands to any form of agricultural activity which manifests the fragility of the marginal ecosystems.

It is important to point out the distinction between natural soil erosion and accelerated soil erosion. Natural soil erosion usually keeps pace with the natural processes of weathering and soil formation (Ibid 1983:171). It is usually common in semi-arid and arid areas with a scarce vegetation under natural conditions (in situ). However, what has been mentioned in the previous discussion is the soil erosion induced by man. Coming back to overgrazing, the fragility and sensitivity of the marginal areas can be observed when the overgrazed lands are unable to regenerate the original vegetation and the area is hence invaded by less palatable shrubs. Desman R.F. et al. (1968). Springs also ceases to flow and streams become intermittent and undependable (Ibid:82). This one example of an agricultural activity outlines the kind of vicious cycle that can befall such a fragile marginal ecosystem if heavy and intensive agricultural activities are introduced.

In case of structural characteristics of agricultural practices in marginal areas in Kenya. Discussions can be based on three subheadings. These are the characteristics in (a) pre-colonial periods, (b) colonial and that in (c) post-colonial period.

In the pre-colonial period, the marginal areas were characterised by low human and livestock populations. Nomadic pastorism and periodic fires during the dry periods were a characteristic phenomena (Lipscomb et al. 1972). There was low competition of the natural food resources between livestock wildlife and man. Livestock population, wildlife and that of man were naturally controlled by diseases and pests. The traditional agro-pastoral systems of agriculture was balanced between use of the natural resources and the environmental natural processes. The interplay was more like the darwinian phenomenon.

However, in the colonial days, this steady state phenomenon was changed and European settlers introduced western style agricultural practices in many Kenyan marginal areas (Winston Cone L. and Lipscomb J.F. 1972). The major practices were ranching, and large scale wheat and maize growing. In ranching, the animals were reared in demarcated areas. The immediate difference between nomadic cattle rearing and ranching as done by the white settlers was that nomadic pastoralists followed closely the rainfall patterns as they grazed their animals from one part of the country to another. However, in ranching, the degree of free movement from one part of the country to another was reduced. This brought the aspect of overstocking in many areas in Kenya. Overstocking lead to overgrazing and the ultimate acceleration of soil erosion. In Kenya problems of overstocking first received formal attention in 1927-29 with the first formal programme of destocking beginning in the middle of that period to the 1930's (Programme for International Development, Clark University 1977). Wheat and maize were grown in large scale farms in the sub-humid areas of the marginal environment. This was particularly in the Rift Valley region (Winstone Cone and Limpscomb 1972). Introduction of monocropping in this case left the soil uncovered when the land is not under cultivation. This was the most direct effect on the vegetation and soils of the marginal areas in Kenya.

The fragility of the marginal environment manifested itself on the occurrence of severe droughts in these areas. This meant leaving the farms with no vegetation cover until the rainy season. When the rain fall, all the exposed soil is washed away by erosion and this is the craddle of environmental deteroration in Kenya. Monocultures introduce artificial ecosystems (Kovda V.A. 1971). Monoculture with the concomittant shortening of trophic food chains, adversely affect the soils of a given ecosystem by the provocation of what is known as soil fatigue (Ibid 1971:365). This lead to necessity of application of fertilisers to compensate for the elements that have been removed and to expand their biological cycle.

The above practice brought a very radical change in the replenishment of Kenya's marginal soils because, it marked the start of artificial soil fertilization as opposed to the natural soil fertilization that was native to the marginal lands (Winston Cone and Limpscomb 1972). This structural change in the characteristic of traditional agricultural land use resulted in the disruption of the environmental balance that existed before between the vegetation, climate and soils of the marginal areas of Kenya. Needless to say, mechanical treatment and ploughing provoked considerable changes in the soil structure. In a nutshell, the new agricultural land use type that dominated during the colonial period in the marginal areas had the following direct effects to the soil system alone - the soil temperature regime as a function of the heat balance of the soils was changed; soil moisture regime as a function of the water balance of soil was affected; soil aeration regime as a function of soil air balance was changed and the soil fertility regime as related to the soils capacity to store, retain and release plant nutrients was affected. These effects are the outcome of direct and indirect influence of the agricultural development on the effective soil depth, texture and stoniness within the capacity of the resource potential of the marginal areas.

However, because of the fragility of the marginal environment to heavy intensities of agricultural developemnt, land degradation was inevitable. In some marginal environemnts of Machakos and Baringo Districts, the repercussions reached an irreversible point because the detrimental effects to the life support capacity of land reached the environmental stress limit (Wahome E.K. 1984).

In the post-colonical period the environmental situation is siezed in a shaky arm. This is because of the fact that after independence, the white settlers farms in the marginal areas were taken over by the Government for subdivision to settle the landless. Usually the Government settled people in higher agro-ecological potential areas in these marginal lands. However, land buying companies, co-operative societies and individuals also bought the former white settlers' farms. For the latter three categories, they subdivided the land into small farms and sold out the shares. There was no consideration of the economic land size for a family in regard to the agro-ecologic potential. This meant exploitation of the marginal land under high densities of population and cultivation.

In this context most higher potential lands of agro-eco-zones 3 and 4 has been withdrawn from livestock production to crop production (Pratt, D.J. et al. 1966). This has led to intensification of both livestock production activities and crop production activities in the marginal areas (Shaabani, S.B. et al. 1988). The crux of the matter is that because most of the settled farmers are overspills of the high agro-ecological potential zones of the country (the Kenyan highlands), inherent agricultural production practices are carried to the marginal areas. These inherent practices like cultivation of maize, beans, potaties etcetra are not well suited to the marginal environment. The major components of the marginal ecosystem are disrupted. Such components includes the protective vegetation/organic cover with its diverse species. Greater stresses that in many time inhibit re-establishment of the vegetation were caused and the process is still continuing. These effects are the aftermath of environmental degradation in the marginal areas in Kenya.

Where land is brought into production through expansion of agriculture into unused areas most oftenly dryer and less fertile, the new farmers have comparatively low levels of experience with the new marginal environments. The marked structural changes that are caused to the agricultural land use practices in marginal envronments in this context are, changes in land sizes, crops/animals kept, methods of replenishing the land of its nutrients, methods of tillage and intensities of cultivation.

In the Kenyan marginal lands these structural changes have tended to include reduction in land sizes of farms, introduction of new crops and methods of cultivation, change from natural soil fertilisation to artificial soil fertilisation, increased use of machines for land preparation and farm operations.

The immediate result to the environment is decreased productivity of land and loss of soil by erosion, and devegetation. UNESCO(1983) reported that the majority of rural population in Africa derive their livelihood from the exploitation of environmental resources such as land, water and vegetation. Man's impact on the environment has resulted in drastic environmental consequences such as reduced soil productivity, deforestation, pollution, desertification etcetra (Ibid:21).

In the marginal areas in Kenya, the structural agricultural changes that has occurred over the years as cited in the previous discussion has resulted in changes in land tenure systems, overstocking and overgrazing. Impairment of the environment thus impoverishing the land quality, denudation of vegetation, soil erosion, loss of soil fertility which ultimately lead to poor crop yields, lowered incomes from the farms and in some cases famine (Opcit:21).

The changes in land ownership structure as pre-empted by the independent period of Kenya since 1963 with consequent subdivision of former European farms and selling them out to small-holder farmers; has resulted in shift from dependance on local natural resources for sustainance of productivity to more artificial form of dependence. However, with the natural limiting factors such as rainfall, evapo-transpiration and run off, the price humans have to pay for the successive exploitation of organic resources (agriculture) is that of maintaining the stability and increasing the resilence of the man-made agro-ecosystems by constant management (Tivy, J. *et al*. 1981).

However, for the marginal area small-holder farmers, the price is too high to pay under the socio-economic environment emanated from the whole phenomena. This has led to the cost being shared by both the farmer and his immediate natural environment that he exploits with his labour activities. Ironically, it is the same environment that is being deteriorated that his livelihood and therefore survival depends. This scenario displays a dilemma that the farmer in the Kenyan marginal area is facing and the seriousness of the matter. One thing is clear the farmer himself is undergoing a process of "marginalization" and his environment is undergoing a process of "desertification".

Desertification is the impoverishment of arid, semi-arid and some sub-humid ecosystems by the impact of man's activities (UN 1977). In the United Nations Conference on desertification in Nairobi, Kenya in 1977, it was contended that it is a "process of change in these ecosystems that leads to reduced productivity of desirable plants, alteration in the biomass and in the diversity of life forms, accelerated soil degradation and increased hazards for human occupancy "(Ibid 177:1).

The phenomenon of desertification as defined by the United Nations (1977) expounds the consequences the marginal areas in Kenya are exposed to with the current agricultural structural changes. Desertification as implied in this context is a man-made phenomenon brought about by overstepping of the environmental threshold of the marginal areas. Land degradation is an inevitable consequence of extending cultivation into the marginal areas (Opcit 1977: 2).

The United Nations (1977) outlined that the sequence of events for the above phenomenon begins with relatively moist periods in these marginal areas, consequently land is planted with a crop and frequently a good yield is obtained. However, prosperity of the land may last for just a few years when the next inevitable drought hits the area; land is usually abandoned in most instances or left under the mercy of all agents of land degradation. It is ironic that the humanitarian extension of agricultural development for food production inadvertently accelerates land degradation.

Essentially, the above consideration can be summarised in Mutua Kihu's (1983) sentiments that "the nature and character of the land type including the nature of the soil, the slope and locality, weather conditions etcetra will sometimes preclude certain activities or at least renders them sub-optional vis-a-vis other possible alternative uses. Thus except with the application of expensive technologies, arid and semin-arid areas will not be suitable for some forms of agriculture while they may not be entirely unsuitable for range developemnt or infact certain forms of human settlement (Mutua, K. 1983:88).

2.02 Government Policy:

The development of environmental policy in Kenya became a reality in the late 1920's and early 1930's. Institutionally, the concern for environmental conservation was put into practice at the height of severe soil erosion in many parts of Kenya especially Machakos's District in the 1930's (Programme for International Development (PID, 1976). Since that time soil erosion has been systematically recorded. There was severe environmental extremes in Kenya in 1933 in aspects of droughts, soil erosion and overstocking (Ibid 1976:10).

The Kenya's environmental reality is highlighted in the Kenya's environmental profile which indicates that the most severe environmental problems in Kenya is soil degradation. However, some facts have to be contended with:- First, the arable land in Kenya accounts for only a third of the country's total land; secondly half of Kenya's livestock population are found in the marginal agricultural lands. In the arable lands (high agro-ecological potential areas): The human population is great and land sizes are small relative to the marginal agricultural lands.

The above realities reveal that, the government is facing a big challenge on how to reconcile the environmental issues with demographical pressures with its concomittant labour activities.

Recent surveys have revealed that the question of environmental considerations needs more pragmatic endeavours today than ever before. It has been reported that the average annual depletion rate of Kenyan forest is 1% acting on a 3.4% forest covered area of the country in overall (Government of Kenya, 1989). The Government's concern towads this trend is very positive. However, the Government's efforts are marred by the migration of people to the marginal lands and the realities of weather. Over 25% of Kenya's human population live in these marginal areas. In essence, the 75% of the population that live in the high potential areas are being pushed by demographic pressures and in near future, the human population in the marginal lands will be even more than it is to-day.

In light of the above, the Government has emphasized the evaluation of the marginal lands to assess their contribution towards the national economy. These areas had been neglected by the colonial Government and received little attention in the first two decades of post-independence period. Development of a region is a requisite to environmental considerations. This is because, it is the human behaviour to consider economic or social returns before other considerations are taken. In this respect, development of the arid and semi-arid lands (ASAL) is seen as a step forward towards environmental conservation. However, there are paradoxical relationships between development and conservation.

Sessional paper No.1 of 1986, the strategy for renewed growth emphasized the reclamation of the dry marginal environments and the protection of these fragile natural environments (GOK:1986). It emphasized environmental assessment and resource surveys for all the districts. This was to identify the production potentials and negative environemntal consequences of the "economic activity given the existing technologies" (Gok 1989).

These endeavours are aimed in bringing a balance between the current and future generation needs and the exploitation of the natural resources. Conservation for sustainable development is the key factor in the Governments view. Directing development of whatever type to the marginal areas requires a commitment in paying the price of sustaining the same environment in the long-run. It has been noted by the Government (1989) that even though the "process of development leads to high Gross Domestic Product (GDP) and improvement in the welfare of the Kenyans, it has deleterious effects on the environment mostly in terms of deforestation, overstocking and soil erosion; air and water pollution as well as urban blight" (Dev. Plan 1989-93). Development comes with the populace and where development is spreading, population tend to increase at the same time. This tendency has resulted into outmigration of the newly developing marginal lands and the consequent subdivision of farms. Opening up of these areas to sedentary agriculture is attended by functions such as devegetation exposing the soil to wind and water erosion. The subsequent result is that land where livestock rearing was the main activity has been put into crop production. Overstocking is the immediate reaction in the marginal lands that are left for livestock production. Reduction of the grazing land have resulted to severe environmental degradation.

It is the Government policy to increase food production through intensifying production methods. It is also the Government's policy to conserve natural environment. Intensification of agricultural activities in the marginal areas can result to serious negative environmental consequences. In this respect, a balance of the two is the only remedy to the paradoxical situation. However, it is inevitable that the natural environment cannot be reconciled for socio-economic development because these developments depend on it. In this respect solutions to harmoniously incorporate environmental conservation consideration for sustainable developments is the Government's main objective.

Towards this objective the Government has various institutions for environmental aspects, they include the National Environment Secretariat, more recently the establishment of the National Resource Surveys and Remote Sensing Department is a boost to the struggle towards environmental conservation. The National Environmental Secretariat liaise with other Non-Governmental Organizations and UNEP in all matters related with the environment. Nationally the Permanent Presidential Commission on Soil Conservation and Afforestation, the District Environment Assessment programme etcetra are many of the institutions involved in environmental conservation not to mention the National Research bodies and institutions.

However, it has been contended by PID (1976;:17) that "direct incorporation of environmental dimensions in development planning has not matured as quickly as have the instituions concerned with Kenya's environment". This contention is supported by Danganas B.L. (1983) implicity but he emphasized that the events have overtaken the environmental concervation endeavours. These events include trends towards sendentarisation of pastoralists, rapid population growth, limited arable land, shortage of employment opportunities etcetra. In a nutshell all these events lead to one or another environmental problem such as increased settlement and progressive exploitation of the fragile natural environments leading to denudation of vegetation, overgrazing and overstocking, depletion of wildlife etcetra.

It is on the basis of the above aspects that the Government through the national environment secretariat is involved in "mapping", developing and establishing the intricasies of the land use policy and environmental management so as to address in the most strict sense of the matter the environmental question (Mutua Kihu 1983).

In the chronology of events; in 1977 the marginal lands pre-investment study project was implemented. Its results pre-empted the development of a framework for implementation, planning and evaluation of programmes initiated in the arid and semi-arid regions. This development was a positive move towards Government;s efforts to implement its environmental policies. In 1981, the Permanent Presidential

Commission on Soil Conservation and Afforestation was formed. This is seen as an interpretation of the past experiences and publication of the pre-investment report for ASAL in 1976 on the magnitude of the Kenya's environmental problems.

In 1982, the National Environmental Secretariat completed a national state of the environment report. This project was under the auspices of the Government of Kenya, UNEP and UNDP. In the following circumstances, the initiation of a District Environment Assessment programme was done. This was anticipated to have direct link with the District Focus for Rural Development strategy. The effort towards environmental conservation currently are undertaken by use of an inter-ministerial committee to draw up conservation strategies. Kenya Range Ecology Management Unit (KREMU (1979) was the forerunner of the Resource Survey and Remote Sensing (RSRS) which is anticipated by the Government to monitor droughts, crop forecasting, and reporting on negative impacts of development activities on the environment (Dev. Plan 1989-93:99).

The 1986 Sessional Papaer No. 1 further emphasized the fore discussed efforts by incorporating the reclamation and protection of the natural environment especially in fragile natural environments into the National planning strategies. It emphasized drawing of a strategy that would achieve sound exploitation of the environment consistent with its natural limitations for a sustainable development. This chronology of events got overwhelming emphasis in the National Development Plan of 1989-1993. In a nutshell, the Government policy for the Conservation of the environment is towards the integration of all ministries, institutions, persons and agencies for the fight of one common enemy - the degradation of the environment.

The above considerations are inevitable in a country where 4/5 of the land (473,000 sq Km) is arid or semi-arid and therefore marginal to agricultural development. Only a mere 18% constitutes the medium and high potential areas supporting 2/3 of the country's population (Dev. Plan 1989-93).

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CHAPTER THREE

The chapter contains an outline of the environmental threshold concept as used in the study. However, before environmental threshold concept consideration are made, a comprehensive examination of the aspect of resource utilization and the relationship between man and nature is outlined. This forms the background to the understanding of the threshold concept. A hypothetical graphical representation of the environmental threshold concept is given to underscore the underlying theoritical aspects of the concept as used in this study.

Environmental threshold in agricultural land-use planning components are emphasized and intricacies entailed in each component outlined in flow charts. The above endeavours are followed by a subtopic detailing how environmental threshold approach in agricultural land-use planning is used in the study area. It includes the method and criterion developed to map the environmental thresholds of the area and the agricultural land-use types.

It is imperative to mention that, the chapter outlines the theoritical bases of environmental threshold concept as used in this study. In a nut-shell, the chapter outlines the theoritical framework under which the study is conceived.

CHAPTER THREE

ENVIRONMENTAL THRESHOLD: THE CONCEPT

3.00 Introduction

Development activities usually are associated with change in quantity or quality of the resources used. In real terms, development is associated with economic activities. The resources used in any development activity include either natural resources or man-made resources or both. One major resource that is undispensable of development is the natural resource.

In order to understand the intricacies of development activities, it is important to highlight some pertinent aspects of the environment in which development activities are carried out. Environment was defined by Goldsmith E. et al 1972 as a system which includes all living things and the air, water and soil which is their habitat. In other references, the environment as a system is referred to as the ecosphere. Monkhouse F.J. and Small J. 1965, defined the environment as the whole sum of the surrounding external conditions within which an organism, a community or an object exists.

Environmental threshold as a concept is nurtured in the studies of the interaction between man and the earth's natural systems (environmental geoscience). The raison d'etre of conceptualization of environmental threshold is eminently significant in the prerogative that development activities use resources. A resource is defined by Tivy J. and O'Hare G. (1981) as any stock of some material of use to humans. However, distinction is important between natural resources available from the lithosphere, atmosphere, hydrosphere and biosphere and man-made resources (labour, capital, etc.), that are used in the exploitation and utilisation of natural resources.

In the discussion of environmental threshold, the role of resources in the functioning of the ecosystems and in maintaining the appropriate environmental balance; and the role of resources in production or in service activities as determinant of development possibilities is crucial. In this respect, the phenomenon of exploitation and utilization of natural environment is centred on the ecological utility and the economic utility. (Kozlowski J., 1985).

The interaction between man and nature is clearly seen in the light of how man exploits and utilizes the environmental resources and how he manages it. Exploitation of environmental resources and the consequence that befall the same is mainly determined by the political systems of environmental exploitation (Hardin G. 1971). In essence both ecological utility and economic utility as governed by the political systems of environmental exploitation creates conditions - conditions related to the resource potential and the sensitivity of resources to overuse/misuse.

It is imperative for development planners to realise the interdependence between man and nature. Man increasingly and progressively depend on nature for sustainance. In return, nature has become increasingly and progressively dependent on man for sustainance. Therefore, to attain socio-economic goals in development, the state of the environment has to be maintained. Consequently, as noted by Kozlowski J. (1985:47), "any consequence which is ecologically negative and undesirable is also economically negative and undesirable".

The concept of environmental threshold is in this respect significant in an attempt to attain sustainable development in a "healthy" environment.

3.01 Theoritical Base of Threshold Concept

Monkhouse F. J. and Small J. (1965) defines threshold as, "a factor complicating the simple self-regulation of systems by negative feedback and thus, the maintenance of equilibrium states. When a threshold is crossed, irreversible changes may be set in motion, e.g. the permanent destruction of vegetation cover by a major flood may initiate a wholly new run-off regime and a different texture of landscape dissection, even though geological and climatic 'control' remains unchanged".

In every development activity, specified resource requirements are defined. This is done by examining the physical environment with particular emphasis on utility and sensitivity of its resources. In agricultural point of view, land plays the most crucial role. Existing and future relationships between economic activities and resources present in their surrounding in a given time and area are important to examine. Understanding of the relationships will help in identifying development constraints that occur when existing resources cannot satisfy requirements or when they are sensitive to particular side effects. In the same context, development possibilities that could occur if the requirements are satisfied and when the resources are not over-sensitive to side effects can be identified. (Kozlowski, 1985)

Rational exploitation of environmental resources therefore, would require set principles that require critical examination in the location of human activities and corresponding land-uses on all levels of planning. Kozlowski J. (1985) developed four principles for rational exploitation of environmental resources. These principles are; that any development activity should be "developed where there are required resources and where negative side effects of activities do not impinge on a sensitive facet of the environment". The second principle requires that activities should be "developed only upto level (or volume) determined in quantitative terms by resource potential and by degree of tolerance of the ecosystem to negative side effects". The third principle requires that activities should be "developed at that quality of output which either directly or through side effects will not lead to significant degradation of the environment". The fourth principle requires that activities should be "developed at a rate and/or in time periods which will conform with the rythm of the natural processes". These four principles can be categorised in the following four dimensions of environmental threshold; territorial, quantitative, qualitative and temporal dimensions respectively. (Ibid 1985:143)

Depending on the political systems of environmental exploitation, all development activities brings about changes in the distribution or allocation, the quality and quantity of output of various activities. In the same respect, changes in the rates at which these activities grow are also effected.

Following this discussion therefore, it is clear that development of any particular activity must cause corresponding changes in the physical environment. Consequently, in most cases, development of such a particular activity encounters physical limitations. Robert Adams et al (1978) contends that these limitations cause discontinuity in development process. The discontinuity is expressed by slowing down or even stopping of the process unless limitations are overcome. (Kozlowski J. 1985)

It is in attempting to overcome the limitations that social and ecological costs are involved. Ecological costs include degradation of the environment. The limitations are called <u>Development Thresholds</u>. (Ibid 1985:148). Development thresholds are encountered, "when there is a decrease (degradation) or absence of resources required by the development activity or when there is such an impact of negative side effects as would damage both ecological balance of the environment and its ecological functions". (Opcit 1985). Kozlowski (1985) expounds this further that thresholds which cannot be overcome by accessible technical means or which can be overcome only at the expense of serious irreversible damage to natural environment can be described as "ultimate thresholds". These indicate the final boundaries of possible location, level, quality and rate of development of a particular activity. (Ibid 1985).

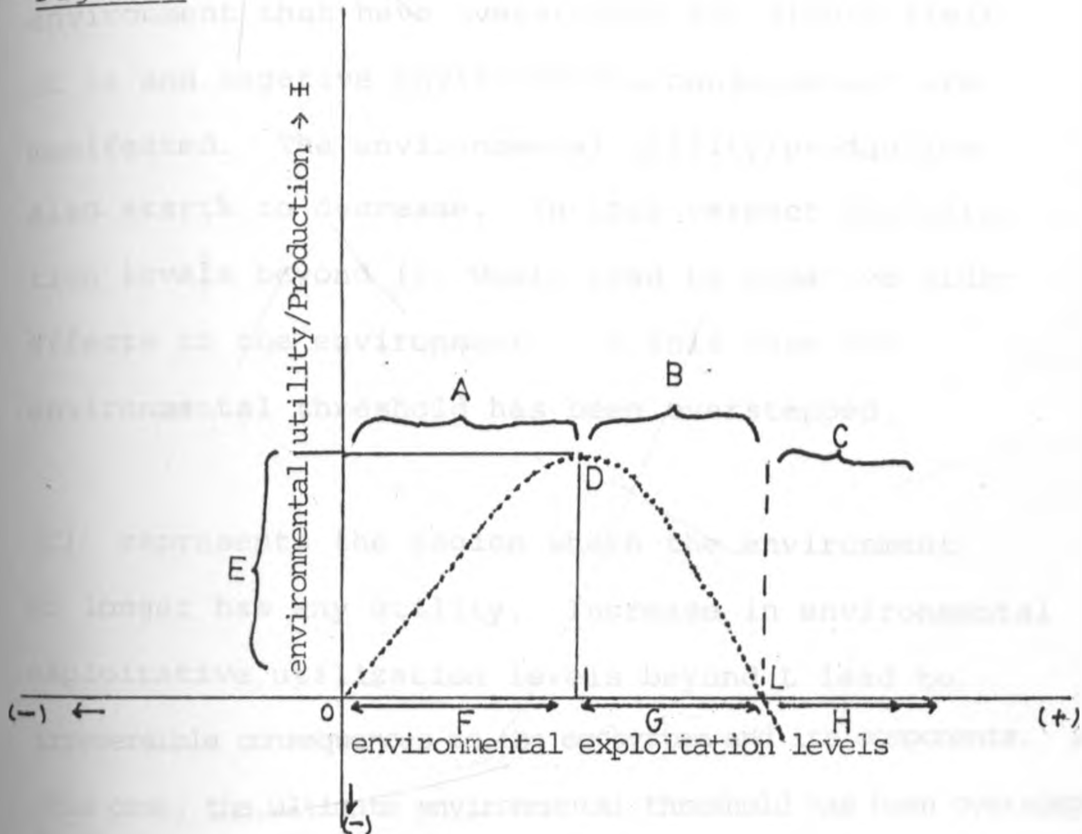
From the foregoing discussion, it is clear that development thresholds can be imposed directly by the potential of resources needed for a given activity or indirectly by resources which may be seriously affected by side effects of the development activity.

Conceptually, thresholds deriving directly from natural resources are in this study referred to as "environmental thresholds". Environmental thresholds define the limit to which development activities can be carried out in an environment beyond which negative side-effects would result to the resources. As was mentioned eariler in the discussion, environmental thresholds are dictated by the natural resource potential and the sensitivity of the environment to such impacts of development activities that could cause negative side-effects. Overstepping of environmental threshold often lead to negative environmental consequences caused by overuse/misuse of the environmental resources through over-exploitation. The other aspect of development threshold discussed earlier is the "concept of 'ultimate thresholds'". Ultimate environmental thresholds indicates the final stress limit beyond which a given ecosystem becomes incapable of returning to its original condition and balance. Overstepping the ultimate environmental thresholds often lead to irreversible changes or such changes that would require excessive social, economic and ecological costs to reverse. (Kozlowski J. 1985).

To understand the general aspects of the concept, the following hypothetical representation is illustrative. (Fig. 1) However, it is important to mention that the consequences that befall the environment are determined by the political system of environmental exploitation and the management considerations that entails the same.

Hypothetical graphical representation of the environmental threshold concept:

Figure 1



Source: Author

Explanations:

(A) represents the region where the environment in consideration can be utilized without causing any significant environmental disruption. Exploiting and utilizing the environment at levels between (0-I) will lead to sustained productivity and "healthy" environment.

(B) represents the exploitation levels of that environment that have overstepped the stress limit of it and negative environmental consequences are manifested. The environmental utility/production also starts to decrease. In this respect exploitation levels beyond (I) would lead to negative side-effects to the environment. In this case the environmental threshold has been overstepped.

(C) represents the region where the environment no longer has any utility. Increase in environmental exploitative utilization levels beyond L lead to irreversible consequences to the ecosystem and its components. In this case, the ultimate environmental threshold has been overstepped.

(E) represents the capacity of environmental utility of a particular environment. It is usually dictated by the resource potential and the sensitivity of the environment to development activities. It is also dictated by the technology used in the exploitation and the management aspects of the users.

(D) represents the maximum utility level that can be accrued in a particular environment before further exploitation level of the environment lead to decreasing utility. It however, mark the final limit of production - if further utility can be achieved, increase in area or change in technology would be called upon.

(I) represent the limit level of environmental exploitation beyond which negative side-effects result to the environment. Further exploitation of the environment would be accompanied with decreasing utility and adverse effects to the environment.

(L) represents the final level of environmental exploitation beyond which irreversible side-effects results. It is the "ultimate environmental thresholds" level.

(F) represents the <u>acceptable levels of development</u>. It represents the environmental "carrying capacity". It indicates the acceptable levels of exploitation in that particular environment if sustainable development/environment is to be achieved.

(G) represents the region where signs of <u>environmental exhaustion</u> are manifested. In this region, the negative consequences are reversible with additional costs.

(H) represents the situation where <u>environmental fatigue</u> is manifested. At this terminal stage, the environment has no utility unless heavy costs of investments/technology is involved. In some cases, there is total degradation of the environment. Examples are desertification, deep gullies among others.

Using the above simplified conceptual analysis, the applicability of the environmental threshold concept in agricultural land-use planning can be attempted.

NB: The locus/graph represent the various environmental utility levels that can be accrued by exploiting the environment at various levels at a given technology.

3.02 Environmental Threshold in Agricultural Land-Use Planning

The process of land-use planning embraces all the various ways of presenting knowledge of the land in such a manner that they can be easily integrated. It uses the help of maps and tables. (Vink A.P.A. 1983). In the process, it is more effective to produce maps based largely on/and derived from the basic scientific maps in order to present the interpretative data and classification in a more easily readable manner (Ibid 1983). In agricultural land-use planning, pertinent maps such as soil maps, aerial photo-interpretation maps, maps showing climatic aspects, etcetra, are used. Production of maps is done by extraporating and predicting aspects on the basis of certain assumptions. However, relevant information on the socio-economic and institutional circumstances are imperatively useful. In this respect, sound agricultural land-use planning has to use modern scientific knowledge together with the various empirical undertakings that have proved effective for land-use planning.

In the use of environmental threshold concept in agricultural land-use planning, various important factors are considered in this study. These are:-

(a) identification of environmental thresholds in the study area;

(b) relationship of political systems of environmental exploitation in the area; and,

(c) identification of agricultural land-use types.

Agricultural land-use planning studies can be approached in various angles. Use of land suitability studies which is heavily based on land constraints to different agricultural development is most widely used. This is mainly based on the potential of land, the risks and possibilities of agricultural activities in relation to limitations caused by the land (Vink A.P.A. 1983, FAO 1976).

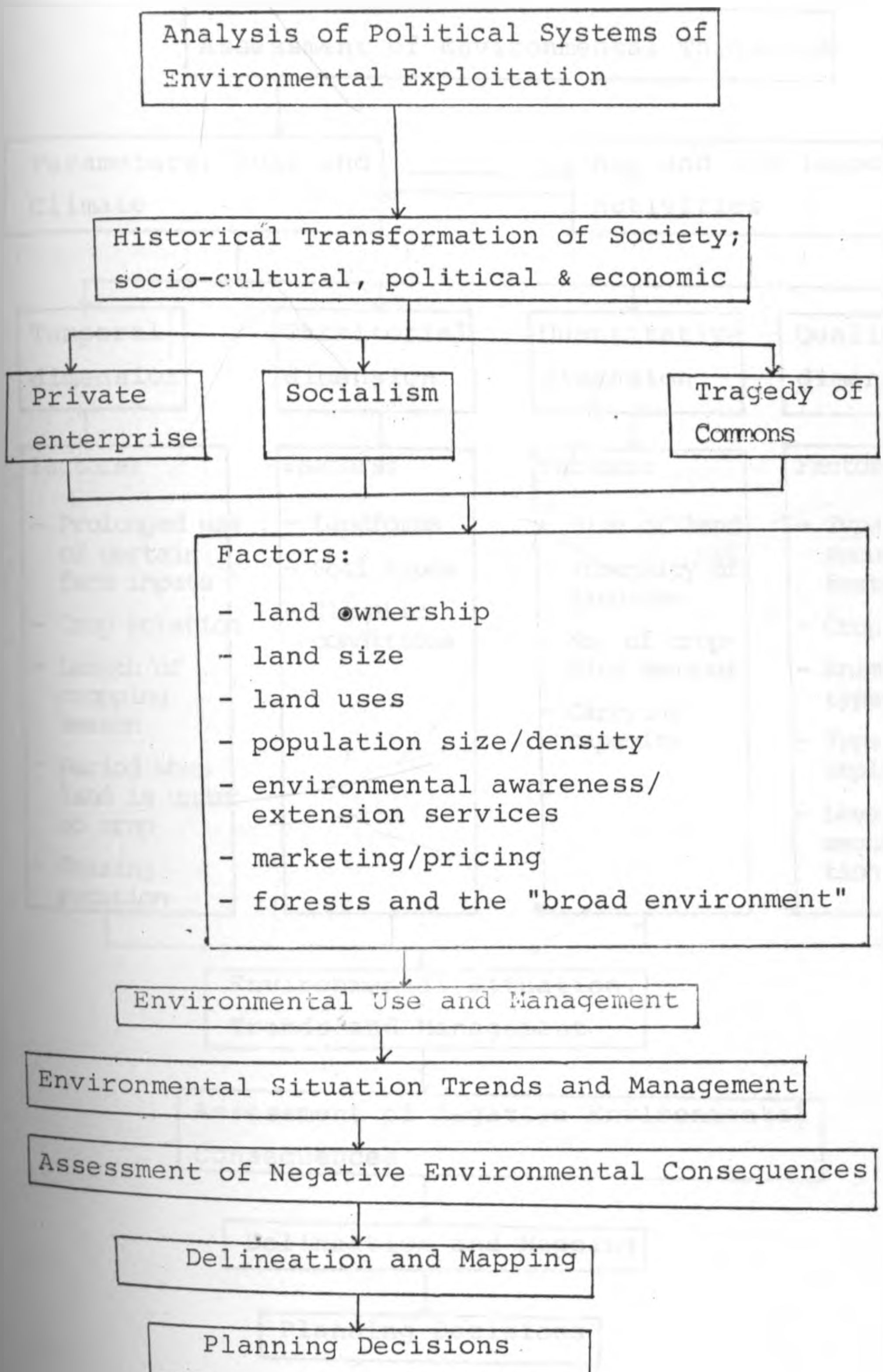
However, in use of environmental threshold approach, negative consequences as manifested in the area and extrapolition of experiences from one area to another through analysis of the environmental status are used. In this respect, existing negative side-effects and future or expected consequences can be interpreted from the analysis of soil status and climatic aspects. This approach is attempted in this study and forms the "backbone" of environmental threshold studies in this paper. However, in assessment of environmental thresholds, resource potential and sensitivity of the environment to the impact of the activity help to intermarry implicitly the two agricultural land-use planning angles of approach. Examination of the role of the political systems of environmental exploitation adds a new dimension in the process and help in determining the rate of destruction/management practices as employed in the exploitation process.

Basically, it is indispensable for land-use planning to establish the exact nature and location of the different current land-uses in an area. In this respect, identification of the spatial evolution of agricultural land-use types is crucial in the use of the concept.

The whole concept of environmental threshold in this study is considered under the notion expressed in the hypothetical representation of environmental utilization in Figure 1. The procedural aspects in the application of environmental threshold concept is based on the following flow charts (2,3 and 4) which will be explained in detail later in the paper.

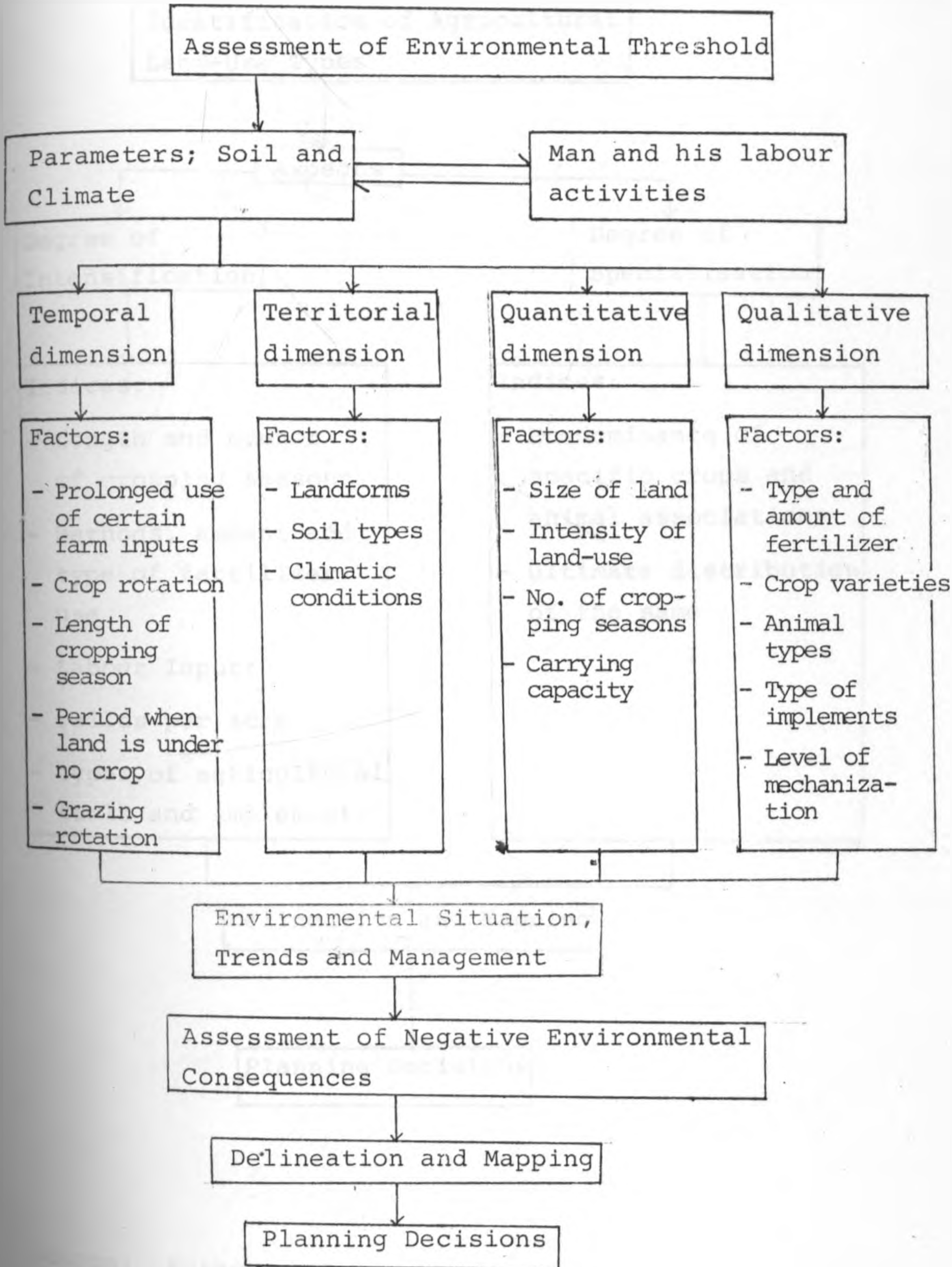
The three considerations as outlined in Figures 2, 3 and 4 are integrative and their totality help in applying the environmental threshold concept purposively in agricultural land use planning. In a nutshell, the whole study process in the application of environmental threshold in agricultural land-use planning is shown in the flow chart. (Figure 5).

Figure 2:



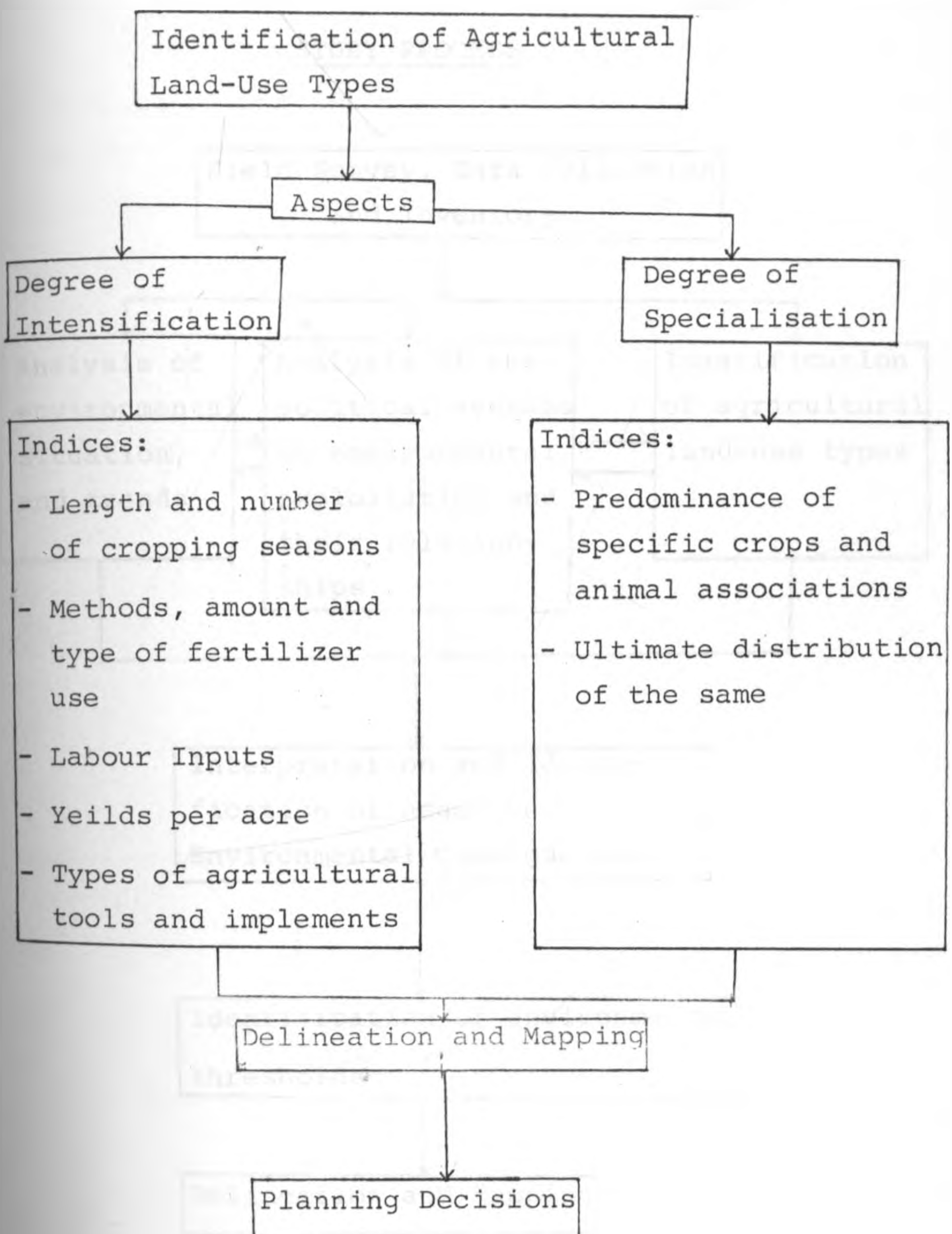
Source: Author

Figure 3:



Source: Author

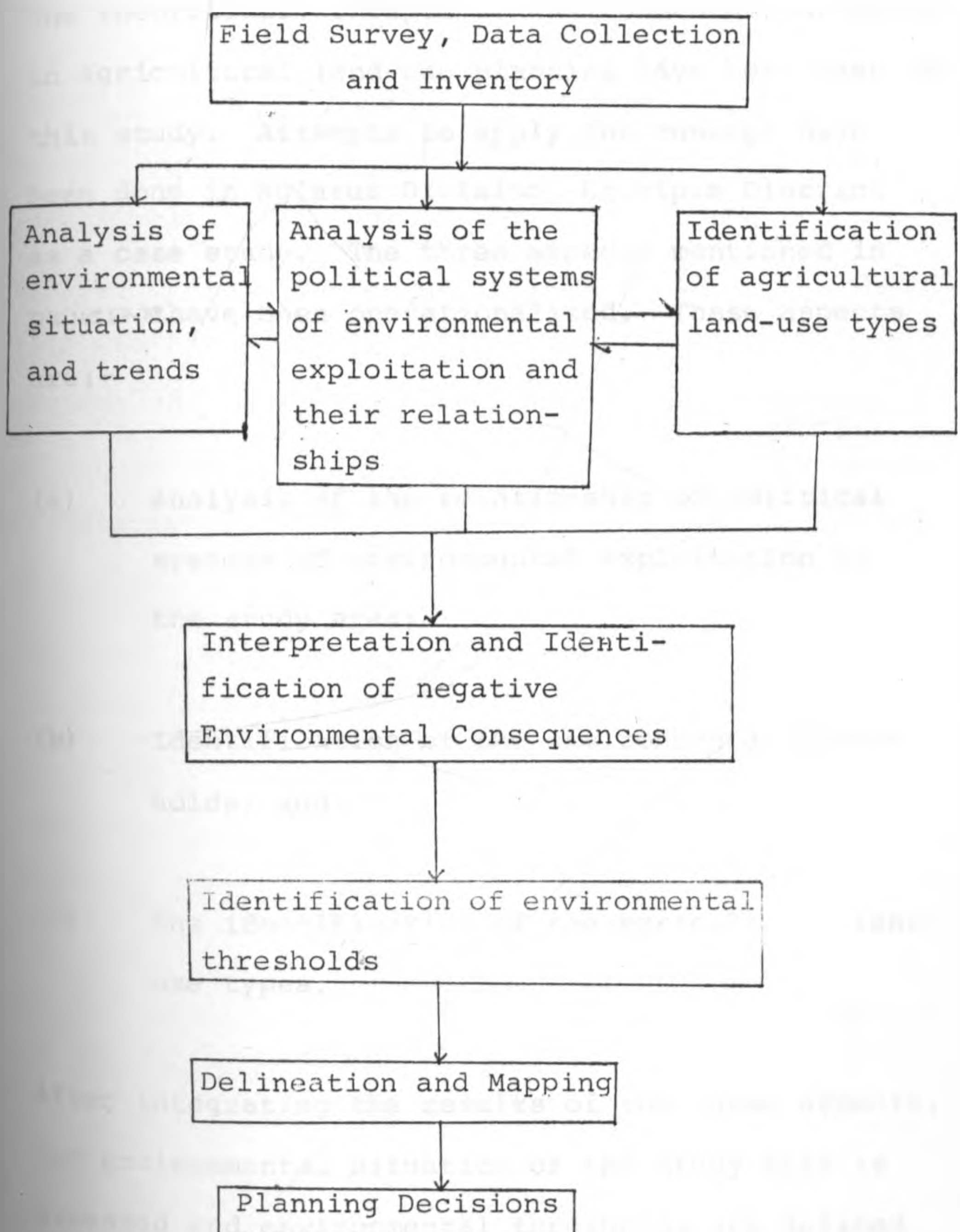
Figure 4:



Source: Author

Figure 5:

STUDY PROCESS



Source: Author

3.03 Practical Application of the Environmental Threshold Concept in Agricultural Land-Use Planning

The theoritical concepts of environmental threshold in agricultural land-use planning have been used in this study. Attempts to apply the concept have been done in Ng'arua Division, Laikipia District as a case study. The three aspects mentioned in pages 87-89 have been operationalized. These aspects are:-

(a) analysis of the relationship of political systems of environmental exploitation in the study area;

(b) identification of the environmental thresholds; and,

(c) the identification of the agricultural land-use types.

After integrating the results of the three aspects, the environmental situation of the study area is assessed and environmental thresholds are defined accordingly.

The following paragraph discusses each aspect in detail.

3.03.1 Analysis of Political Systems of Environmental Exploitation:

Figure 2 summarises the process in a flow chart. However, prior understanding of the main issues used in the study area is important. Political systems addressed are the private enterprise, sociolism and the tragedy of commons. Before the three systems are considered, historical transformation of the society utilizing the resources in the area in relation to socio-cultural, political and economic attributes is considered.

In order to give light to the intricacies of the analysis, a review of the political systems of environmental exploitation as expressed by Hardin G. (1971:62), is given below.

3.03.2 Review of Hardin G. (1971) Political System of Environmental Exploitation

Hardins G. (1971:61) classified the political systems of environmental exploitation into four classes. These are; private enterprise, sociolism, tragedy of commons and the fourth which he gave no name for the matter of logical completeness of the system

In the classification he uses "raising of cattle" to explain the systems. The number of animals in the pasture initially are assumed to be at the "carrying capacity" of the environment. Addition of one more animal would damage the pasture and produce less profits. The number of animals in the pasture must be adjusted to a maximum sustainable yield yearly as dictated by the inherent carrying capacity of the environment.

Case 1 (Private Enterprise):

The environment (pasture) may be managed under the private enterprise. In this case, the owner is the decision maker and he fences his pastureland for his cattle only. Overall gain only accrues to him. When he make wrong decisions, he will take responsibility to rectify to regain his profits. In essence he will respond positively to correct and improve the quality of the environment. His ability and capability sometimes limit his efforts.

Case 2 (Sociolism):

Hardin G. (1971) contends that this is believed to be more just but faces some significant operational disadvantages. One person has to make the decision for the utilization of the pastureland. If a wrong decision is made; the negative gain resulting from it is shared by all members of the society. Moreover, the decision-maker is not motivated to respond to the consequences of the environment because of the shared gains. To motivate him, rewards for good work and penalties for wrong decisions can be given. In this respect, the decision-maker will hold information that are penalizable in secret and the environmental consequences will be less addressed to.

However, in almost all environments in the world, no single system is followed alone. Modification in each of the discussed systems are made and the two systems are combined to form a dualistic system of environmental exploitation.

Understanding the environmental consequences that results from the use of either is important if conservation and sustainability of development activities is to be achieved.

Case 3 (Concept of Tragedy of Commons):

In this case, each herdsman brands his cattle and then all are run together on a common pasture without necessarily fencing. Under this system addition of one animal by one man benefits him alone but, the consequences resulting from overloading the environment are faced by all. The environment is disadvantaged because no single herdsman would accept responsibility of any predicament. The inevitable ruin of the environment (pasture) is referred to as tragedy of commons.

The three scenarios are elaborated on Table 1. Understanding the theoritical bases of these environmental exploitation systems will help us understand the environmental threshold concepts more deeply and negative environmental consequences that results from the agricultural development activities. Management of the environment should be understood in relation to these systems. However, for the purpose of the study, crucial modification are made.

3.03.3 Analysis of the Political Systems as Used in the Study

The management of the environment is determined by the political system operating in that area. The utilization of environmental resources is limited by the resource potential and the sensitivity of

TABLE 1 : Political Systems of Environmental Exploitation

	Rules of the Game				Results of the Game				
	Exploitation of environment by:		Profits go to:		Gains from stressing the system		Intrinsic responsibility	Temptation to sabotage information	Name of the Game
CASE	Individual	Group	Individual	Group	Overall gain	Gain to the decision-maker			
1	Individual utili-		Individual profits		negative overall gain	negative gain	positive responsibility (+) response	no attempt to sabotage	private enterprise
2		Group utilization		Group profits	negative gain	no gain to the decision maker	no responsibility (o) response	high chance of sabotage	socialism
3		Group utilization	each individual gains		negative overall gain	positive gain	no intrinsic responsibility	low chance to sabotage	tragedy of commons
4	Individual utilization			Group profits	negative overall gain	no gain	no intrinsic responsibility	high chance of sabotage	?

Intrinsic responsibility is the adaptive responsiveness of the decision-maker brought about by his acting in his own self-interest.

Source: Hardin G (1971) - Population, Environment and People, page 62.

the environment to man's impact. However, the conflicts between development activities and ecology are attributable to the method and system the development activity is carried out. In essence, compromise between the ecological principles of "stability" for the sustainability of the ecosystem and economic principles of "growth" and expansion of development activities lies on the political systems in which the environment is exploited. In this respect, analysis of the relationship of the political systems of environmental exploitation is imperative if practical policies can be drawn.

Historical transformation of the utilization of the agricultural environment based on changes in:-

a) culture of resources utilization;
b) politics of resource utilization; and,
c) economics of resources utilization;

are addressed. In the evolutional development of agriculture in any place in the world, the social-cultural aspects of the communities involved in the exploitation of the environment determines the levels, the rates, the quantities and the quality of resource utilization. For instance, in the study area, pastoral herdsmen who were the initial users of that environment used to have communal ownership of land. The political system of environmental exploitation in this case reflect the components of the tragedy of commons. However, land size, land tenure and mode of resource utilization used to be different. Land/resource privatisation followed; and more radical changes are in operation today. Analysis of the interaction of social-cultural, political and economic attributes in different stages of the evolution of agriculture, will give light to the environmental situation, trends and management issues at present.

The factors that are very crucial in this analysis include patterns of land ownership (tenure), land sizes and land-use. Population size and its density will open more avenues of consideration. Environmental awareness is assessed and access to extension services, marketing and pricing of the produce/ inputs are studied. Mode of resource utilization in the forest areas, and the responsiveness of the community to the consequences of the environment form pertinent aspects that are considered.

In light of the above, the environmental situation, trends and management issues are assessed and integrated with the knowledge from the analysis of the other two aspects namely, environmental threshold assessment and identification of agricultural land-use types.

This form the basis of identifying the negative environmental consequences of the study area. The negative consequences are used as manifestations of overstepping of the environmental threshold of the areas in question. Delineation and mapping follows. In this respect, land-use planning decisions are made accordingly.

3.04 Assessment of Environmental Threshold

The application of environmental threshold in agricultural land-use planning in this study is borrowed heavily from work by Kozlowski Jerzy, author of the "Threshold Analysis Handbook", forthe United Nations. (1977) He further applied these concepts among others in the planning of Tatry National Park in Poland in 1984; Kozlowski outlined four principles for rational exploitation of environmental resources. In this study, the four principles outlined by Kozlowski (1985) are used as the basis for use of environmental threshold studies in agricultural land-use planning. The author has modified the principles to fit in the purpose of the study and help to make out a strong case for their application in agricultural land-use planning.

The basic ideas in the principles are geared towards rational exploitation of resources thus, incorporating the notions of conservation of the natural environment. It is in this respect that this approach is seen as a requisite for planning for a sustainable agricultural land-use.

Agricultural activities are in the forefront in the determination of the "environmental destiny" of the areas they are practised. Consequences to the natural environment as a result of any agricultural activity is a product of the intensity of that activity under the natural resources in its disposal and the time span when that activity has been in practice in that environment. It is in this respect that deliberation on the concepts of environmental threshold to agricultural land-use planning are centred on the conservation context.

Environmental threshold for agricultural land-use planning can be viewed in the following four dimensions based on the four principles mentioned before. These are; terrritorial dimension, quantitative dimension, qualitative dimension and temporal dimension. The scenario entailed in each environmental dimension is the main discussion here below.

3.04.1 Quantitative Dimension:

This view of discussing environmental threshold consideration requires that agricultural land-use activities be developed upto certain levels determined by; (a) the resource potential; and, (b) the degree of tolerance of the ecosystem to negative side-effects. This means that outstepping these two aspects in the development of these activities would lead to adverse effects to the natural environment. To be able to understand the complexity of the whole situation, the parameter that would determine the resource potential for agricultural use is the land (the resources on the land or that endowed to it through the natural phenomena).

In light of this, type of soil and its characteristics; and climate (rainfall, temperature, evaporation, wind, etcetra) will give an indication of the resource potential on the disposal of any agricultural activity. The resource potential will determine the extent to which any agricultural activity can be carried out without causing any significant environmental stress.

However, to be able to assess the negative environmental consequences and to define them (that has already occured, that could probably occur if the current trends continue, perceived or on the verge of occuring); the following factors in control of an agricultural land-use type would be used:-

(i) size of land;

(ii) intensity of agricultural land-use;

(iii) number of cropping season per year and its length; and,

(iv) carrying capacity of land and/or livestock units per unit of land.

Consequently, degree of tolerance of the ecosystem to the agricultural activities would be determined by:-

(i) type of soil and its characteristics;

(ii) the slope of the area;

(iii) vegetation cover; and,

(iv) the general climatic conditions of the area.

After analysing these factors as discussed above, expected negative environmental consequences that could occur if this dimension of environmental threshold is overstepped are:-

1) Soil exhaustion leading to lowered soil fertility (unless nutrient recycling is done). This could be brought about by continous use of land under "high" intensities under "small" land sizes and/or outstepping its carrying capacity without recycling the soil nutrients. Recycling of soil nutrients can be done naturally or artificially in cultivation, manuring, crop rotation, or leaving the land fallow for enough period to allow natural soil replenishment. Artificially by applying the recommended fertilizers.

2) Overgrazing - this is brought about by overuse of land mainly through overstocking. It can also be brought about by continous grazing of one piece of land without rotating the grazing. Overgrazing phenomena and trampling on the natural vegetation in sensitive ecosystems leave the soil bare at the mercy of wind and water. This phenomena is very common in ranching areas.

3) Loss of vegetation cover - this is the end result of overgrazing (overstocking) and increased intensity of agricultural land-use. The two factors are considered here because

overstocking for instance, leads to destruction of the natural vegetation while increased agricultural land-use intensity is attended by human settlements and continued use of the natural vegetation for fuelwood and for building shelter. However, in some cases, forests have been cleared to give way to cultivation.

4) Loss of soil water (moisture) - this is a two-fold problem caused by increased use of ground water for domestic use and, exposure of soil to direct sunshine (heat) by removal of ground cover. This has serious effects on the components of the ecosystem especially plants.

5) Soil erosion - it is the most serious form of soil degradation caused by multiple factors namely; overgrazing, over-cultivation, or cultivation on slopy areas without taking conservation measures into account especially in areas with soils with high erosivity, removal of vegetation cover, etcetra.

However, it is important to mention here that there are two forms of soil erosion; natural soil erosion and "accelerated" soil erosion. Natural soil erosion occurs without man's interference. It usually keeps pace with the natural processes of weathering and soil formation. However, "accelerated" soil erosion which will be referred to here as accelerated soil erosion is due to human action. In this study, accelerated soil erosion will be used interchangably with soil erosion.

Definition of this quantitative dimension of environmental threshold is carried out with the following assumption:-

(i) that the technological knowledge of the farmers (who are the subject in this case), remain unchanged for the planning period; and,

(ii) that agricultural land-use intensity will continue to increase so long as population pressure continues to increase.

The perceived or expected negative environmental consequences can be mapped or delineated on a map of the study area as manifestation of overstepped environmental threshold.

3.04.2 Qualitative Dimension:

For agricultural land-use consideration, this dimension requires that agricultural activities should be developed at the quality of input which either directly or indirectly will not cause any significant environmental degradation. In case of this study, the following quality of agricultural activities conceived in a framwork of agricultural inputs will form our angle of approach:-

(i) type and amount of fertilizer use;

(ii) crop varieties - different crop varieties have different environmental consequences on the areas they have been planted. For this case most negative consequences are indirectly influenced by the behavioral adaptation or responses of the crop variety to the natural phenomena such as climate or soils. For instance, in Kenya, the Kitale hybrid maize varieties takes a longer period to mature compared with such varieties as the Embu hybrid series or the Katumani composite. If Kitale hybrid maize variety is planted in such areas where rainfall or in general climatic conditions are not favourable, it is liable to fail leaving the soil cover bare leading to soil water loss and other adverse effects such as soil erosion. This is an indirect effect to the environment. Prolonged periods without plant cover on such peice of land is attended by loss of soil moisture, wind erosion and soil compaction through the trampling effects by animals (livestock);

(iii) tractor use - this is used widely during land preparation periods, planting, weeding and harvesting. Sizes of tractors and the implements they use determine the kind of damage that could be caused to the soil. The negative side effects could be pulverisation of the soil reducing its stability and resistance to erosion and thus, increasing its erodability or compaction of the soil depending on whether tractor use was on a rainy season or dry season and the type of soil. Other effects of tractor use is when the depth of tillage is not well adjusted; if exceeded to the subsoil there is danger of lowering the soil fertility as a result of reduced humus context of the top soil. Other negative side effects is general loss of soil structure. This is determined by the type of soil and its moisture regime;

(iv) type of livestock - indigeous (local) or exotic breeds. This qualitative aspect of this agricultural activity has a bearing on overstocking and overgrazing magnitude. Negative environmental consequences on this aspect could be as a result of putting this quality of livestock under areas where they directly or indirectly through side-effects cause environmental degradation. Consequences could be denudation of the vegetation cover with its consequent attendant problems;

(v) mechanization - it is in this case considered in holistic situation in agricultural industry. In this study mechanization include use of mechanized farming inputs such as, combine harvesters in wheat growing and with its associated tractor use either for hauling the produce, hallowing, spraying, planting or plowing. The general negative environmental consequence is compaction of soil because of continous operations on the same piece of land per year.

The qualitative dimension of environmental threshold in this study is considered under the following assumption:-

(i) that farmers objective is to increase the productivity of their farms and its stock and will use to their capability the available or existing technology to do so; and,

(ii) that although the technological knowhow is imparted, environmental implications caused by these inputs are not well versed to/and therefore, by the farmer.

The negative environmental consequences could be mapped to reflect the environmental threshold of the area in question per this dimension.

3.04.3 Territorial Dimension:

In this dimension, agricultural activities are required to be developed; (i) where there are the required resources; and (ii) where negative side-effects of the activities do not impinge on a sensitive facet of the environment. In this respect, the perceived or expected consequences are; lowered soil fertility unless recycling of nutrients is done. This is much prevalent where the soils are shallow. The fertility levels are highly sensitive in such a case because of the low humus content of the top soil. Continous use of such soils under any form of agricultural activity lead to lowered fertility and consequent loss of vegetation cover. This later lead to soil erosion. The aspect of negative side-effects such as, one demonstrated above (impinging on sensitive facet of the environment) can be observed where such an activity is done on shallow soils in marginal environments. The subsequent result is serious soil erosion when rain falls and irreversible changes are sometimes inevitable.

Another consideration is where such areas are over-grazed or overcultivated. Taking all the factors mentioned above in consideration, the probable negative environmental consequences are delineated as manifestations of environmental threshold as per this dimension.

Assumption considered in this case is that choice of any farming area is determined by availability of land and farmers engage in any farming activity regardless of land conditions/climatic conditions.

3.04.4 Temporal Dimension:

This dimension of environmental threshold consideration requires that agricultural activities should be developed at rates or time periods that conform with the rythm of natural processes. In this respect, factors to be considered include:-

(i) the prolonged use of certain farm implements (ploughs, hallows, harvesters, etcetra);

(ii) lack of crop rotation;

(iii) length of cropping season;

(iv) the period the land is left bare during the dry period when nothing is growing in the farm;

(v) for livestock production, continued use of the same unit of land for grazing without rotation under marginal conditions.

The above considerations are put into analysis to determine the probable negative environmental consequences. These are:-

(i) loss of soil fertility - unless nutrient recycling is done;

(ii) loss of vegetation cover;

(iii) soil compaction/pulversation both leading to loss of soil structure which has other negative side-effects to the environment;

(iv) soil erosion hazard on the onset of rains. Identification of these environmental hazards and delineation on a map will form the framework for reflecting environmental threshold for agricultural land-use under the temporal dimension.

Assumptions are that farmers exploit all areas under their disposal for agricultural development and continue to do so in many numbers regardless of the negative impacts on the environment provided some little benefits are accrued from such an activity.

3.04.5 Mapping of Environmental Thresholds

Mapping of environmental thresholds is done by use of the negative environmental consequences as manifestation of overstepped thresholds. However, because the degree of manifestation varies, a criterion for rating of the negative environmental consequences is developed based on the relative environmental situation of each study unit in the division. In light of the above, the following levels of rating (threshold ratings) are devised.

Level 1 : Not Significant

Level 2 : Significant

Level 3 : Serious

Level 4 : Very serious

These levels are mapped and delineated accordingly.

Explanations of Threshold Rating Levels (TRL):

Level 1 : Not Significant - This implies that there is no significant manifestation of negative environmental consequences as per the time the study was carried out. However, the area is vulnerable to the consequences in future if the current agricultural land-use practices continue.

Level 2 : Significant - This implies that the area has significant manifestation of negative environmental consequences. More serious environmental situation might appear in future if the trend is not checked.

Level 3 : Serious - Serious negative environmental consequences are manifested and urgent measures need to be taken to reverse the situation.

Level 4 : Very serious - In this case, the area shows serious negative environmental consequences which under the present technology locally, it has reached an irreversible situation. However, heavy investment is required before the situation can be corrected.

These ratings are based on reasoned estimates based on both primary and secondary data of the area. The data have varying degrees of firmness and accuracy but for the purpose of this study, adequate information has been achieved. Observations by the author and interpretation of the environmental situation in the study area and extrapolation of experiences of one area to the other, have contributed much to the rating.

3.05 Boundary Thresholds

Before all the discussed environmental threshold dimensions are considered and later delineated and mapped; delineation of what in this study is referred to as boundary threshold - (this term was used by J. Kozlowski in his "Threshold Analysis Handbook", 1977 for the United Nations)- is done. Boundary threshold in this study refers to the limitations for any agricultural development as set by the:-

(a) specific features of the existing natural environment for instance, steep slopes with rocky soils, gullies, gorges, etcetra. These features renders an area unsuitable for any agricultural development.

(b) policies, rules and regulations set by the government of the country in order to protect the existing natural environment. In this case, any agricultural development is prevented by law to protect the existing natural environment. These areas protected by law include; (i) gazetted forest reserves; (ii) river catchment areas; (iii) national parks or animal reserves; etcetra.

The areas mentioned under (a) and (b) above create a boundary of the "agricultural areas". It is by removing the acreage covered by these areas that the total agricultural land that can be developed is got. It is on the areas suitable for agricultural activities that the four environmental threshold dimensions are applied.

In the definition of the boundary threshold, it is assumed that the existing government policies for environmental protection will remain during the planning period. It is also assumed that change in the current technology for the exploitation of land for agricultural purposes during the planning period is minimal especially on use of steep slopes or escarpments, gullies, etcetra.

For the application of the four environmental threshold dimensions, namely, territorial, temporal qualitative and quantitative; the negative environmental consequences can be established by various methods. For instance, direct measurement, extrapolation and classification (i.e. transfering of experience from one area to another on the basis of soil maps, climatic aspects, etcetra); single resource interpretation (based on either vegetation or soil or climatic information and synthesis of existing data). (Vink A.P.A. 1983)

However, for the purpose of this study, interpretation of aerial photographs, existing soil and climatic aspects maps and documents; and analysis of raw data collected in the field is used to establish the named negative environmental consequences.

The whole process of assessing the environmental thresholds can be presented in a flow chart as shown in Figure 6.

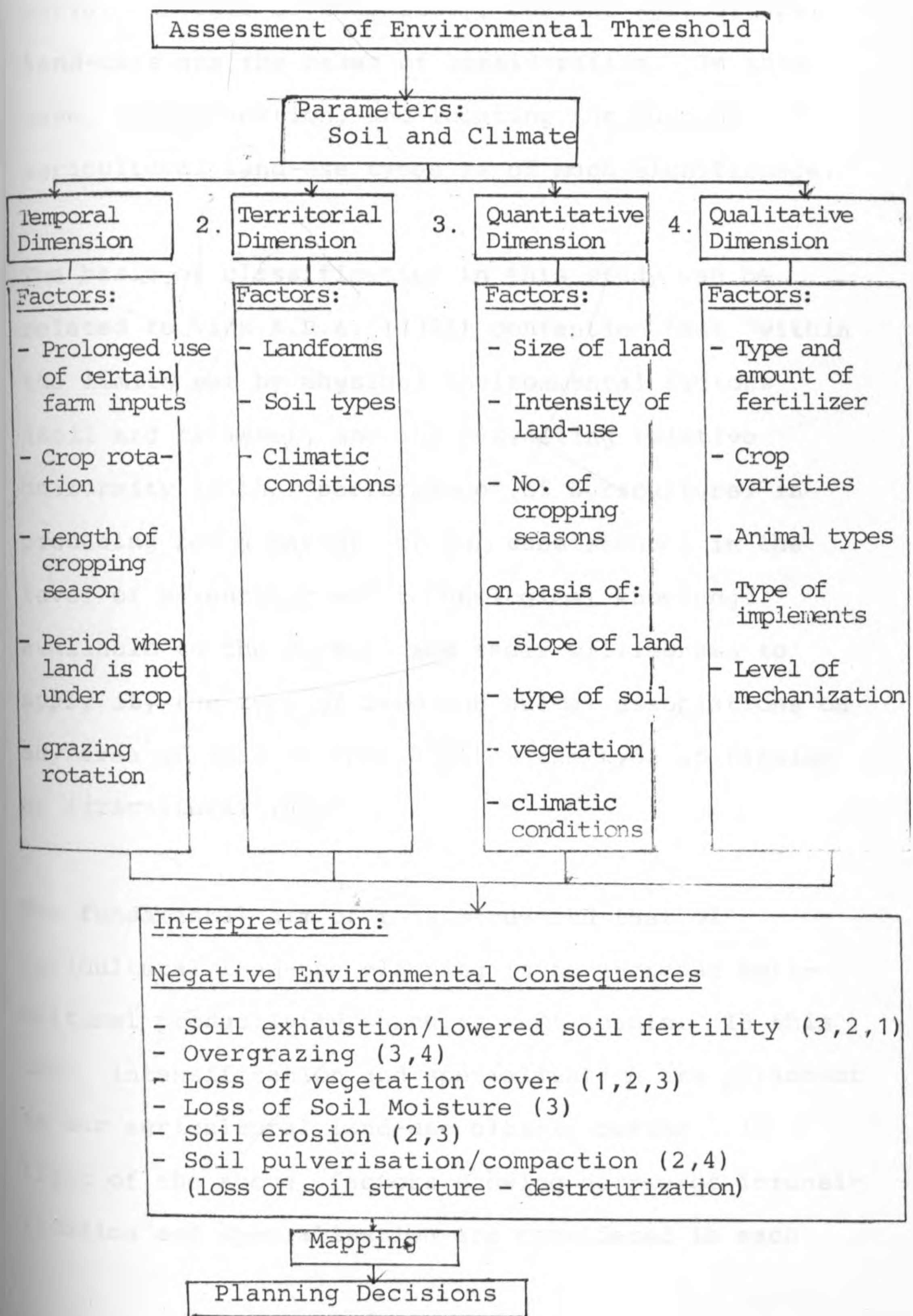
3.06 Development of Mapping Criteria of Agricultural Land-Use Types

In the development of mapping criteria of agricultural land-use types, various considerations are made. However, for mapping or delineation of the agricultural land-use types, various categories of agricultural land-use type classification can be used. (Vink A.P.A. 1983) These include:-

(a) current agricultural land-uses;
(b) potential agricultural land-uses;
(c) recommended agricultural land-uses; etcetra.

Figure 6

Summary of Assessment of Environmental Threshold: (Flow Chart)



Source: Author

use of any category depend on the objectives of the study and the purpose the study is supposed to serve. In case of this study, current agricultural land-uses are the bases of consideration. In this case, identification, and locating the current agricultural land-use types is of much significance.

The basis of classification in this study can be related to Vink A.P.A. (1983) contention that "within the limits set by physical environmental factors (soil and climate), and the prevailing relative uniformity in the "performance" of agriculture; in producing for a market (or for subsistence) in the level of scientific and technological knowledge available to the farmers and their willingness to apply it, the type of crop and animal associations on any area of land roughly equates the type of farming or agricultural type".

The fundamental aim of this study and that of agricultural land-use planning is to increase agricultural productivity which is sustainable. In this case, intensification and specialisation are paramount in our agricultural land-use classification. In light of the above, factors showing degree of intensification and specialisation are considered in each agricultural land-use type. Some indices of intensification are:-

(a) length and number of cropping seasons;

(b) methods, amount and types of soil fertilisation;

(c) labour inputs in terms of man-hours per year per hectare;

(d) yields per acre;

(e) type of agricultural implements used; etcetra.

In case of specialisation, predominance of specific crops and animals and their ultimate distribution give a reasonable indication of the degree of specialisation.

It should be mentioned at this juncture that accuracy of the measurements of degrees of intensification and specialisation depends largely on farmers response. However, data collected and compiled from aerial photographs coupled with information got from interviewing of the farmers and own observation have given reliable estimates for this study. Consequently, taking into consideration the purpose and objectives of the study, relevant information for compilation of a useful classification has sufficed.

Density of cutlivation as calculated and located to produce an agricultural land-use density map, proved to be a reliable guide to the location and spatial distribution of agricultural land-use types of varying degrees of intensification. A percentage of the cultivated land is calculated by dividing totalland by the total land cultivated. The whole process of indentification of agricultural land-use types is as shown in the flow chart. (Figure 4)

Combining and integrating the results of the following aspects considered, namely; the political systems of environmental exploitation, assessment of environmental threshold and identification of agricultural land-use types, the environmental situation, trends and management issues are determined. Delineation and mapping of the pertinent aspects as mentioned help in making planning decisions.

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CHAPTER FOUR

The chapter is divided into two sections. Section one gives an overview of the background information of the study area. In this respect, it start by outlining the general information of Laikipia district before giving an overview account of main features of Ng'arua Division.

Section two which is the analysis and data interpretation section starts with analysis of the historical evolution of agriculture in the study area. It is followed by an account of the identified agricultural land-use types and their spatial distribution. In this section analysis of major aspects that constitute the agricultural land-use practices is done with implicit interpretation of some pertinent aspects. Socio-economic attributes, environment situation and the political systems of environmental exploitation as reflected from the data obtained is outlined.

In summary, the chapter outlines an account of the existing situation of the study area as seen in the framework of this study.

CHAPTER FOUR

SECTION 1

STUDY AREA: BACKGROUND INFORMATION

4.00 General Introduction

Ng'arua Division is one of the four Divisions of Laikipia District. Laikipia District is divided into four Divisions administratively; namely:-

Rumuruti Division, Ng'arua Division, Mukogondo Division and Central Division. (see figure 8). In its National Context, Laikipia district extends from the western foot of mount Kenya to the north-eastern foot of the aberdares. (see figure 7). Topographically, Laikipia District lies in a plateau situated at an altitude of 1800m-2000m above sea-level. It lies east of the great Rift Valley to the west and Aberdares and Mt. Kenya massifs to the south. The plateau is characterised by varying altitude ranging from 1800 metres in

STUDY AREA: NATIONAL CONTEXT

LAIKIPIA DISTRICT

ENVIRONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE PLANNING

FIGURE 7

STEPHEN WAIGWA GITONGA
D.U.R.P 1990
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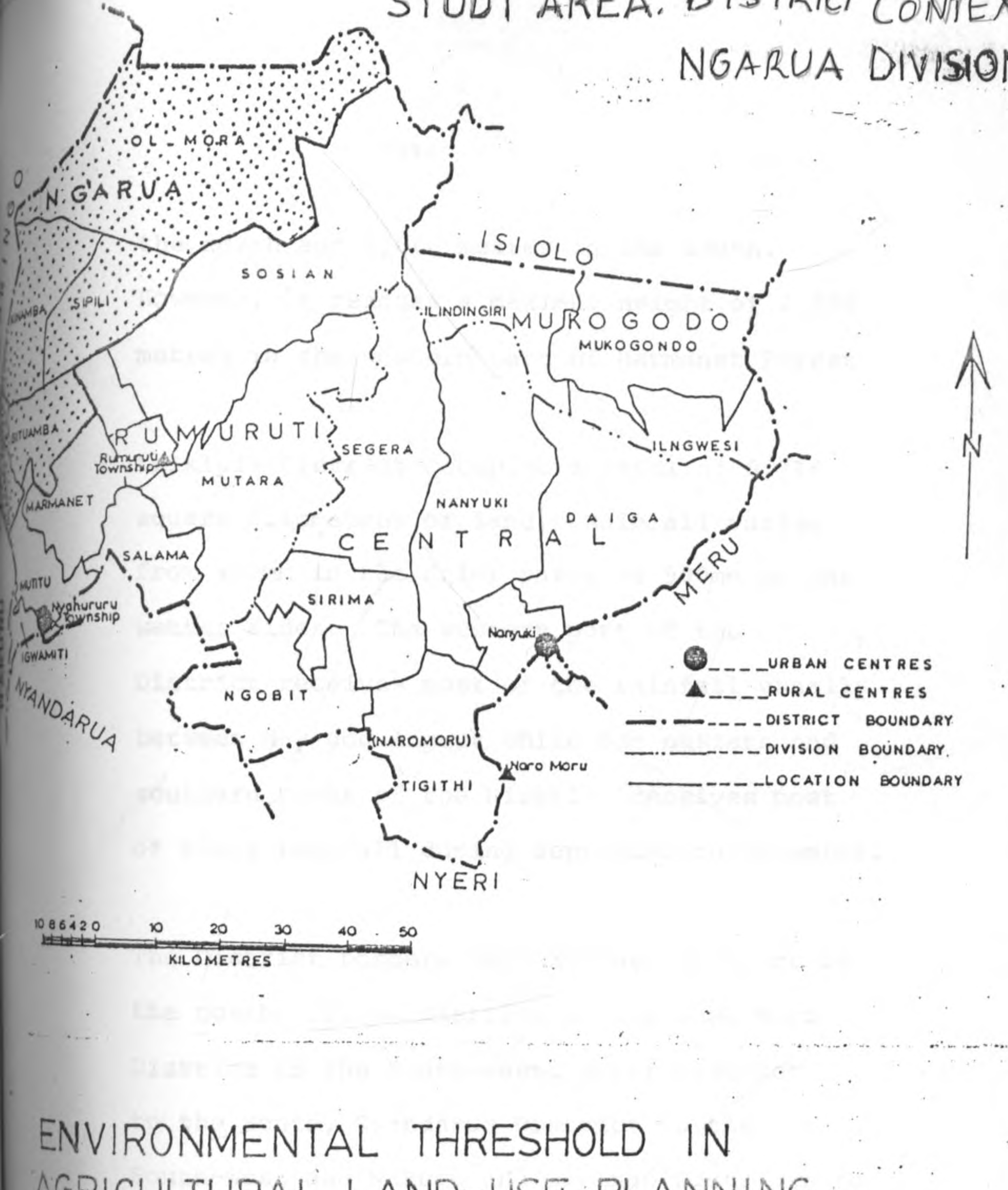
STUDY AREA: DISTRICT CONTEXT
NGARUA DIVISION



ENVIRONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE PLANNING

FIGURE 8	STEPHEN WAIGWA GITONGA D.U.R.P 1990 UNIVERSITY OF NAIROBI

the north and 2,000 metres in the south. However, it reaches a maximum height of 2,600 metres in the western part of Marmanet Forest.

Laikipia District occupies a total of 9,718 square kilometres of land. Rainfall varies from 400mm in the drier parts to 900mm on the wetter sides. The western part of the District receives most of the rainfall usually between May and August while the eastern and southern parts of the District receives most of their rainfall during September to December.

The District borders with Samburu District to the north, Isiolo District to the east Meru District to the South-east, Nyeri District to the South, Nyandarua District to the South-West and Nakuru and Baringo Districts to the West.

Average temperatures varies between 20^{o}C and 28^{o}C with average hours of sunshine between six and eight hours daily. The Western and southern areas of the District have cooler temperatures.

Out of 971,800 hectares (9718Km^2) of the total land area 1.7% of this area lies in the high agro-economic potential area of the district. This is mainly on the western parts of the District. 9.8% of the total land area lies in the medium agro-economic potential zones and the rest lies in the low agro-economic potential zone. This occupies 72% of the total land area. In this respect, Laikipia District mainly exhibits semi-arid conditions with sub-humid characteristics to the western parts. The semi-arid region of the District is charcterised by unreliable rainfall which in many instances is quite unfavourable.

Main crops grown by the small mixed farmers in the District include maize, beans, potatoes, wheat, cotton, sorghum, coffee, pyrethrum, vegetables, garden and fruit trees. Livestock production is practiced in both Small Scale farms and in Ranches. This is a major enterprise in the District. Animals kept include sheep, goats and cattle. Others include poultry, bee keeping among others.

About 75% of the District consists of rich basic ignenous parent rock. This displays soils with good fertility. However, fertility varies in different locations.

The estimated population for Laikipia District was 229, 136 people by 1988. In 1979, it was estimated that Laikipia District had 134,524 people (1979 population census).

<u>Laikipia District Population Projection on Divisional Level</u>:-

Division	1979	1983	1985	1988
Central	39,792	51,300	57,356	67,775
Rumuruti	48,279	62,241	69,589	82,231
Ng'arua	34,868	44,952	50,258	59,388
Mukogondo	11,585	14,935	16,698	19,732
Total	134,524	173,428	193,901	229,136

Source: Central Bureau of <u>Statistics; Kenya population census</u>, Vol. 1 - June 1981 and Central Bureau of statistics; <u>population projection for Kenya</u>. 1980 - 2000; March 1983, page 133-135

The population growth of Laikipia has been growing at an annual rate of 7.3% because of immigration and natural increase (Kohler 1985).

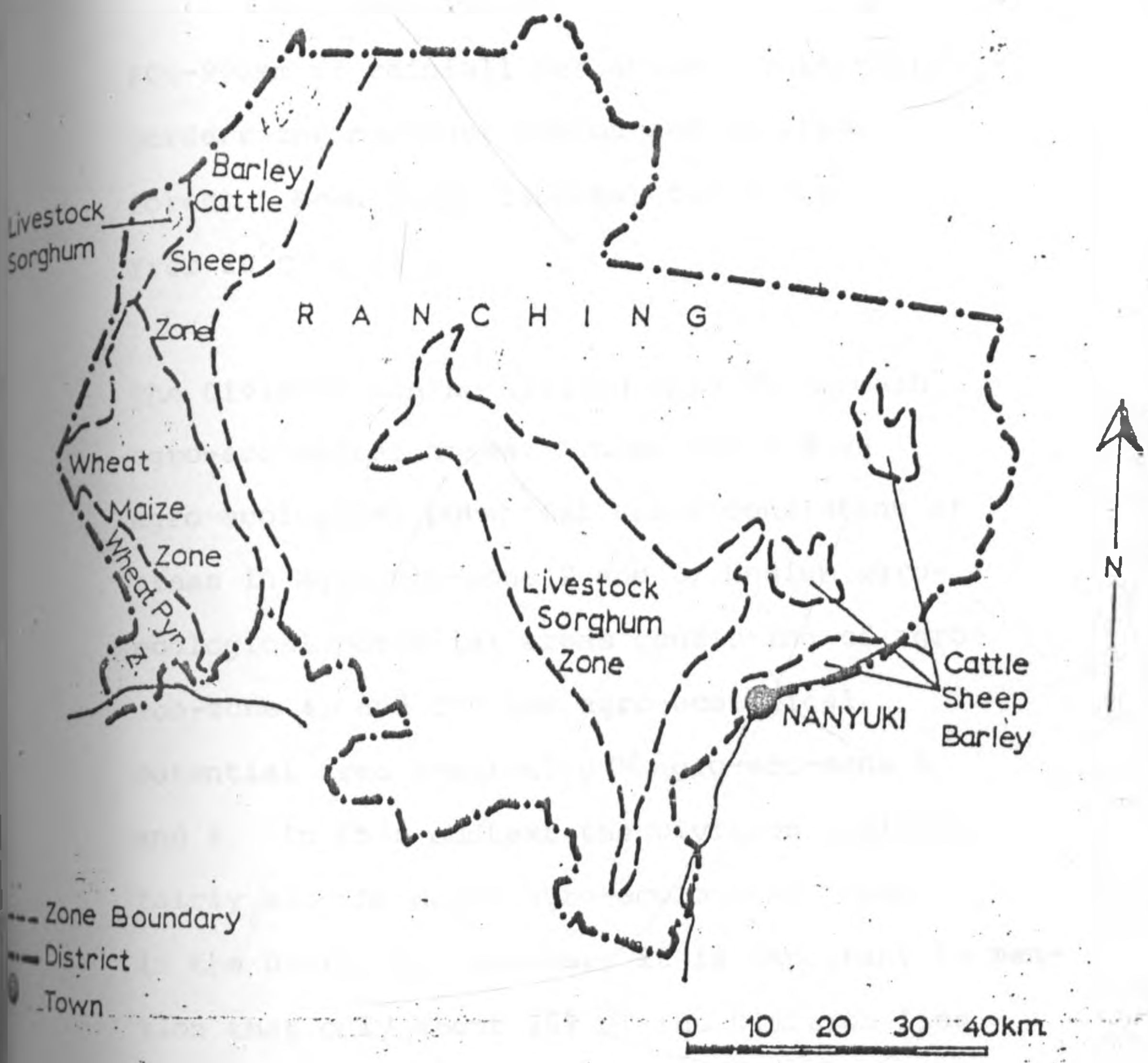
4.01 Ng'arua Division: (Overview Information)

Ng'arua Division is the Western-most Division in the District, it borders with Baringo District to the West, Samburu District to the North and North-eastern parts, and Rumuruti Division to the South and South-east end. The Division occupies parts of the wettest, regions of the District, which makes about 25% of the Division area. The rest fall in the medium and low agro-ecological potential areas of the Division.

The total land area in the Division is 1098 Km^2 which is 11% of the total District.

The Division receives most of its rainfall between May and August. Rainfall ranges from 500mm to 900mm per annum. The highest rainfall in the Division is in the Ol arabel valley and its environs which receives an average of

LAIKIPIA DISTRICT
AGRO-ECOLOGICAL ZONES



From Farm Manangement Handbook Of Kenya 1982

ENVIRONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE PLANNING

FIGURE 9	STEPHEN WAIGWA GITONGA D.U.R.P 1990 UNIVERSITY OF NAIROBI

800-900mm of rainfall per annum. This region borders the marmanet region and ol arabel forest. Mean daily temperatures varies from 20^{o}C to 28^{o}C.

The Division can be divided into three main agro-ecological zones. These are:- High agro-ecological potential areas consisting of areas in agro-eco-zone 2 and 3; Medium agro-ecological potential areas consisting of agro-eco-zone 4, and the Low agro-ecological potential area consisting of agro-eco-zone 5 and 6. In this context the Division exhibits fairly all the major agro-ecological zones in the District. However, it is important to mention that only about 25% of the Division lies in the high agro-ecological potential zone. This renders the Division exhibit semi-arid conditions in most of its region. Rainfall in the medium and low potential zones is unfavourable ranging from 500mm to 800mm per annum.

The northern region of the Division which borders with Samburu District is rather dry and rainfall is low and intermittent. (500mm - 600mm per annum)

In a nutshell, rainfall in the semi-arid areas of the Division is inadequate and unreliable.

The major agricultural enterprises in the Division are crop and livestock production. Crop production is usually done on small scale farm basis with most farms ranging from 3 to 18 acres. However, on the southern-western part of the Division where the rainfall is high (800mm-900mm per annum) farms ranges from 18 to 30 acres or more. This forms a major distinction between this sub-humid region of the Division and the semi-arid region of the Division. It is imperative to note that the state of agricultural marginalisation is centred on this spatial disparity and the climatic characteristics exibited by the region.

Livestock production is mainly based on large scale Ranching farms who specialise in beef production. However, dairy cows and/or small stock (goats and sheep) are reared in the small scale farms. Ranching farms are mainly on the north and the north-western parts of the Division.

Lariak forest (3988 ha) and Ol arabel forest (7724 ha) are the two gazetted forests in the Division. The Division has the following wild animals; namely, dik-dik, gazelles, antelopes, wildbeasts, elephants, lions, leopards, buffaloes, warthogs among others. These are mainly found in the two gazetted forests and in the Ranching farms.

The main crops that are grown in the Division include maize, beans, potatoes, vegetables and fruit trees, coffee and wheat. Others which are planted in small quantities include sweet potatoes, sorghum, millet and pineaples. Animals kept include cattle(both dairy and beef), sheep(both for meat and wool), goats(both dairy and meat) poultry and donkeys. However, the most important crops are maize and wheat among the small scale farmers.

The Division has good fertile soils. However, some areas especially the northern, central and the north-western parts has comparatively and relatively shallow soils.

Ng'arua Division is bordered on the western part by Baringo District. This region of the Division is characterised by steep escarpments, rugged and deep valleys which in places broken by gorges. This characteristic is phenomenal in land-use practices in the Division. On the South-western part, it is occupied by the Ol arabel valley which is bounded by a ring of mountain ridges on the Marmanet side and the Gatirima steep slopes on the eastern side. The other parts of the Division is a plateau forming the larger Laikipia plains which starts from the foots of mount Kenya.

The Division is lacking in rivers and has only two remarkable streams namely the Ol arabel stream(rivulet) and the muktan stream. The two streams join in Lake Baringo. In this Context the Division suffers from water problems especially for domestic needs.

4.02 Social - Economic Aspects

The main economic activities as discussed before include crop production and livestock production. These activities are carried out under small-scale mixed farming and large scale Ranching farms.

The projected population by 1989 was 62,727 people with a density of population of 55.2 people per square kilometre (1988). This population is mainly concentrated on the small scale farms especially in the medium and low agro-ecological potential areas. This tendency of population concentration is as a result of immigration of people from other parts of the country in the period between 1963 and 1980.

Since independence period in 1963, the large-scale farms owned by white settlers in the Division have undergone tremedous and progressive subdivision by the Government, Co-operatives/ land buying Companies and private individuals. This process of land acquisition and prior subdivision changed the mode of production in the Division from large scale mixed farming/ Ranching farms to small scale mixed farming. However, few large scale Ranching farms still exist as mentioned before.

In the above Context, the human population is concentrated in the settlement schemes. The process of subdivision and immigration was started in the period between 1969 and 1972 and continued during the periods 1975 and 1979. The process of immigration is however continuing to date, where many absentee farmers are settling in their farms. This pattern of events brought many structural changes in the Division and dictated the social-economic phenomenon as it is today.

Agricultural production for maize is medium to high per farm. However, variation exists with the high agro-ecological potential zone producing 20 to 40 bags per acre(1 bag = 90 Kg), while the medium and lower agro-ecological potential zones of the Division producing about 10 to 15 bags per acre. However, malnutrition cases are common in the Division. Ng'arua Health Centre recorded 129 cases of malnutrition in 1982. Nanyuki District Hospital malnutrition cases reported in Ng'arua Division are shown in the table below:-

Malnutrition cases reported in Ng'arua Division

	1985	1986	1987
Kwarshiorkor	45	16	15
Marasmus	60	55	10
Underweight	100	57	119
Overweight	none	none	27
Subtotal	205	128	171

Table 2: Source; Nanyuki District Hospital.

The Division is served by the following rural centres; namely, Kinamba(the Divisional headquaters), Sipili, Karandi, Muhotetu and Ol moran. Others include Thigio, Seria, Tandere, Muthiga, Kiamburi among others. These centres serve as trade links between the farmers and suppliers of consumer products. They are also used as marketing areas for farm outputs and in recent years, manufacturing and repairing is taking root in most centres in the Division.

According to the inventory of infrastructure (1987), the Division has 55 primary schools with a total enrolment of 8,628 males and 7,971 females. It has 6 secondary schools with 522 males and 465 female students. Consequently, it has 63 Day Care Centres with a total enrolment of 2,908 children.

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SECTION 2

DATA ANALYSIS AND INTERPRETATION

4.03 Introduction

In the previous chapters it was made clear that there are three important Components in the study. These Components were addressed under the following headings:-

(a) Identification of the agricultural land-use types.

(b) Assessment of the environmental threshold of the study area; and,

(c) analysis of the political systems of environmental exploitation in the study area.

In this respect, all aspects entailed in the above components are analysed and attempts made to interprete the data. Consequently in the following chapter, prior application of the findings is attempted.

The relationship between man and nature and the factors that entails understanding of the relationship are examined. In view of this, the evolution of agricultural land-use types in the study area is in the forefront of our endeavours to address to the above three Components. Subsequently, the forces of privatisation of production, historical changes in the means of agricultural practices including land ownership/tenure and the issues of resource management resulting from the changes are paramount in the Data analysis. However, the biophysical factors which includes, altitude rainfall, soils and vegetation; forms an important aspect in the analysis. Other factors underscored in the chapter are the Socio-economic factors. These include population density, farming practices, tenure and other factors.

Presentation of the findings is in form of tables, plates, and maps. In a nutshell, the analysis and interpretation of data is arranged in the following order:-

(a) Evolution of Agricultural Land-use types from 1985 to 1989;

(b) Spatial variation of agricultural land-use types;

(c) Socio-economic situation and;

(d) the environmental situation which includes climate, soils, agricultural land-use, and vegetation.

4.04 Evolution of Agricultural Land-use type

Analysis of the evolutional agricultural land-use types cannot be understood clearly without revisiting briefly, the historical development of agriculture in the study area. In this respect, agricultural land-use practices over the last century have been reviewed.

Laikipia had been the home of Laikipiak Maasai clan till 1885. The maasai used to move accross the plateau grazing their livestock in the rich ranges of the district. In 1885, the Laikipiak Maasai clan were wiped out by the purko clan. This action is important because the area was left virtually unoccupied until the European occupation. However, few Dorobo and some remnants of the Laikipiak Clan were left.

In general, the neighbours of Laikipia used to be Samburu to the North, Suk & Kamasia and Njemps to the west, the eastern side was occupied by the Gikuyu and the Southern side used to be an extension of the maasai grazing area.(1)

In 1902, the purko maasai clan occupied the plateau (Decurtins etal 1988). It is during this period that the white government carried out a survey of the whole, area to protect the forest from burning activities of the maasai and to prepare the area for the white settlers. (Ibid 1988)

In 1906 a census was carried out to help the polltax and huttax collector to establish the property owners, their wives, their dependents and their number of livestock. It is important to point out that at this period, Laikipia plateau was used as a grazing area for the pastoralists (mainly the maasai). It was estimated that the area had approximately 64,000 head of cattle and 1,750,000 sheep.(2)

In the same year, the white administration met with the maasai representatives in Rumuruti station to discuss about their boundaries. This marked the determination of European settlers to push out the maasai from the plateau for their own use.

In February 1907, a new Coinage was introduced in the plateau (pice was more popular in the region than the cents). It is noted that during this year, the few Europeans who had settled in the area took cattle to Samburu to trade. However, trading in sheep was more lucrative than any form of trade. Consequently there was severe drought in the Gikuyu County (Nyeri District) where most of the Laikipia people got their food. This resulted to severe food shortage in Rumuruti and Laikipia in general. The "White Government" by then started transporting food from Nyeri. Food transportation continued until 1908 when some irrigation was done in Rumuruti to grow enough food for the staff.(3)

In December 1908, the District Commissioner of Laikipia met with Lenana (Maasai Leader) and the Governor in Ngong to discuss the issue of evacuating the maasai from Laikipia. Lenana conceded to the idea. In the same year there was shortage of grazing pasture and the maasai were allowed to cross River Euoso Nyiro to the west. The total stock in Laikipia was estimated at 80,000 head of cattle and 2,000,000 sheep.(4)

In 1909 the maasai were again allowed to cross River Eoso Nyiro as the dry period of January to April was very severe. At this period the maasai were for the first time reported to be willing to sell their stock for cash. Laikipia plateau was noted to have been overstocked and there was clear shortage of grass.

In 1910, the maasai chiefs in Laikipia indicated some favour to leave Laikipia. In late 1910 and early 1911, there was scarce grazing (grass) in Laikipia and the maasai had crossed to the east of River Euoso Nyiro and Euso Namokye. This scarcity of grass and the grazing of maasai stock in areas restricted for European stock caused more impatience to the white settlers for the maasai to move out of Laikipia.

There was severe draught at the beginning of 1911. In June 9th 1911, the maasai started moving out of Laikipia to the southern maasai reserve. By the end of July 1911, all healthy stock had crossed Laikipia district borders. About 50,000 sick head of cattle and proportionate number of sheep were left behind.(5)

However, the exodus of the Maasai to the southern reserves hit a drawback after reaching the Mau ridges because of difficulties in passing through the Mau ridges. The maasai started pouring back on the edges of Mau and Gilgil and by the end of 1912, the maasai had returned back to Laikipia plateau on temporary basis. Subsequently, they started going back, out of Laikipia on the 7th June 1912 and by 26th March 1913 all the maasai had left with their stock.(6)

This was the beginning of European domination of agricultural land-use in Laikipia plateau. By 1921, the increase of Europeans in the District was reported. By end of 1920, there was 18 European farms and by end of March 1921, the number had increased to 58. European agriculture (crop growing) was on experimental basis. The total population in 1922 in the district was 1,224 including 1058 Africans and 166 Europeans with the European population breakdown thus, 98 men, 46 women and 22 children. Farms surveyed ranged from 1000 acres to 5000 acres. It was generally considered that 15,000 to 20,000 acres was the necessary size for a successful steak farm.(7)

In 1922, the Samburu tresspassed into the North-west the then unsurveyed and unoccupied area. By the year 1923, Laikipia was being considered entirely a European settlers area. The Somalis remained between Rivers Euso Narok and Euso Nyiro to the North east of the District. In this period the district boundaries were as follows, on the north was Samburu reserve, on the east was Euso Nyiro

River, on the south was Nanyuki and Nyeri, on the south-west was the Aberdare ranges and on the North-west it was marked by the Laikipia escarpment. The higher lying lands in the neighbourhood of Thomsonfalls were suitable for both crop growing and livestock keeping. However, the rest of the district was essentially a stock raising area.

The reasons hindering extensive large scale crop farming was the long distance to the nearest railway station. Gilgil station was the nearest. During this period Laikipia was conceived as suitable for cattle but the lower lying county of the district suitable for sheep. However, cattle industry was offering less profits and this rendered to keeping of sheep as the most profitable enterprise in the region. The director of agriculture by then agreed upon the average size of the farms to be 15,000 acres to 20,000 acres with obsolute minimum size of 10,000 acres.(8)

In 1924 Laikipia District comprised of an area of 3125 square miles. Out of this, 1500 square miles had been surveyed for farms but only 788 square miles had been taken up. Land on higher altitudes and heavier rainfall along the North eastern side of Laikipia escarpment (Laikipia west) and aberdares had possibilities of agricultural development (crop farming/mixed farming). Farms suitable for this purpose were estimated to comprise of 190,594 acres but because of forest, bushes and rocks, only 63,301 acres were actually available. There were 176,363 acres of gazetted forest.[9]

In August 1924, the question of extending the ailway from Gilgil to Nyahururu was debated. In 1st September 1929, the railway station was opened in Nyahururu. Freights originally contained of timber and cattle. Dairying was mainly carried out in small scale basis in Leshau, Ol arabel, and the aberdares. Ol arabel was reported as having very bad failure of wheat crop in 1927. Ol arabel valley and lands in the aberdare slopes were suitable for mixed farming. Crops grown included maize and wheat.

Ol ari nyiro (Muktan area) used to be occupied by the Wondorobo during this period. They were moved to Churo in october 1929 by the resident Commissioner.(10)

In 1930, the railway reached Nanyuki (Decurtins etal 1988) from Karatina. By 1931, farmers who had hitherto taken into maize and wheat growing in the suitable areas started going into dairying only. It is during this period that coffee was being grown successfully in sheltered areas of Ol arabel valley. The size of the District was 3195 square miles.

During the period 1931 to 1946 the white settlers embarked on developing their ranches and farms as their population increased in the district. Soil conservation endeavours were started during this period. Staff houses for the soil conservation officers were built in Thomsonsfalls (Nyahururu) in 1946. The population in the district by this period was as follows:-

Europeans	495
Asians	272
Africans	35,767

The African population was to provide labour in the ranches and crop production farms. They were however, allowed to cultivate few crops, and animals for subsistence especially in ranches where crop farming was unimportant activity to the white settlers.(11)

By 1949, soil conservation service offices were fully operational. It was reported that at this period many cultivation areas were closed down for soil conservation purposes. The chief forest formed a belt running from the Ol arabel to the aberdares. In 1956, maize was reported to have been doing quite well in Ol arabel areas. Acreage on maize was expanding more than that of wheat. The reasons being that wheat was very susceptible to stem rust in that lower altitude. However, elephants used to be a menace in Ol arabel region.

After Kenya attained independence in 1963, the process of Africanisation and re-allocation of farms in Laikipia started. The white settlers farms were opened for the Africans and this brought much influx of people to Laikipia mainly Laikipia west.[12]

The period between 1967 and 1969 marked the introduction of small scale farming and sub-division of large scale farms. The process of subdivision continued in the 1970's and 1980's. The main activities carried out after subdivision is subsistence crop production characterised by sale of surplus produce for cash and livestock production. It is essentially small scale mixed farming.[13]

The subdivision was carried out by two agents. These are:- (a) the Government under the custodianship of the Settlement Fund Trustee (SFT); (b) Private or Co-operatives. The Government subdivided and allocated land in areas and plots which can be economically exploited. This included mostly the sub-humid areas of the district. Ol arabel and Ndindika Settlements Schemes are examples in the study area. For the private and co-operatives, subdivision of farms is usually in marginal environments (semi-arid areas and rangelands) and in smaller plot sizes compared to the Government subdivision.

4.04.1 SUMMARY OF THE EVOLUTION OF AGRICULTURAL LAND-USE TYPES IN NG'ARUA DIVISION:

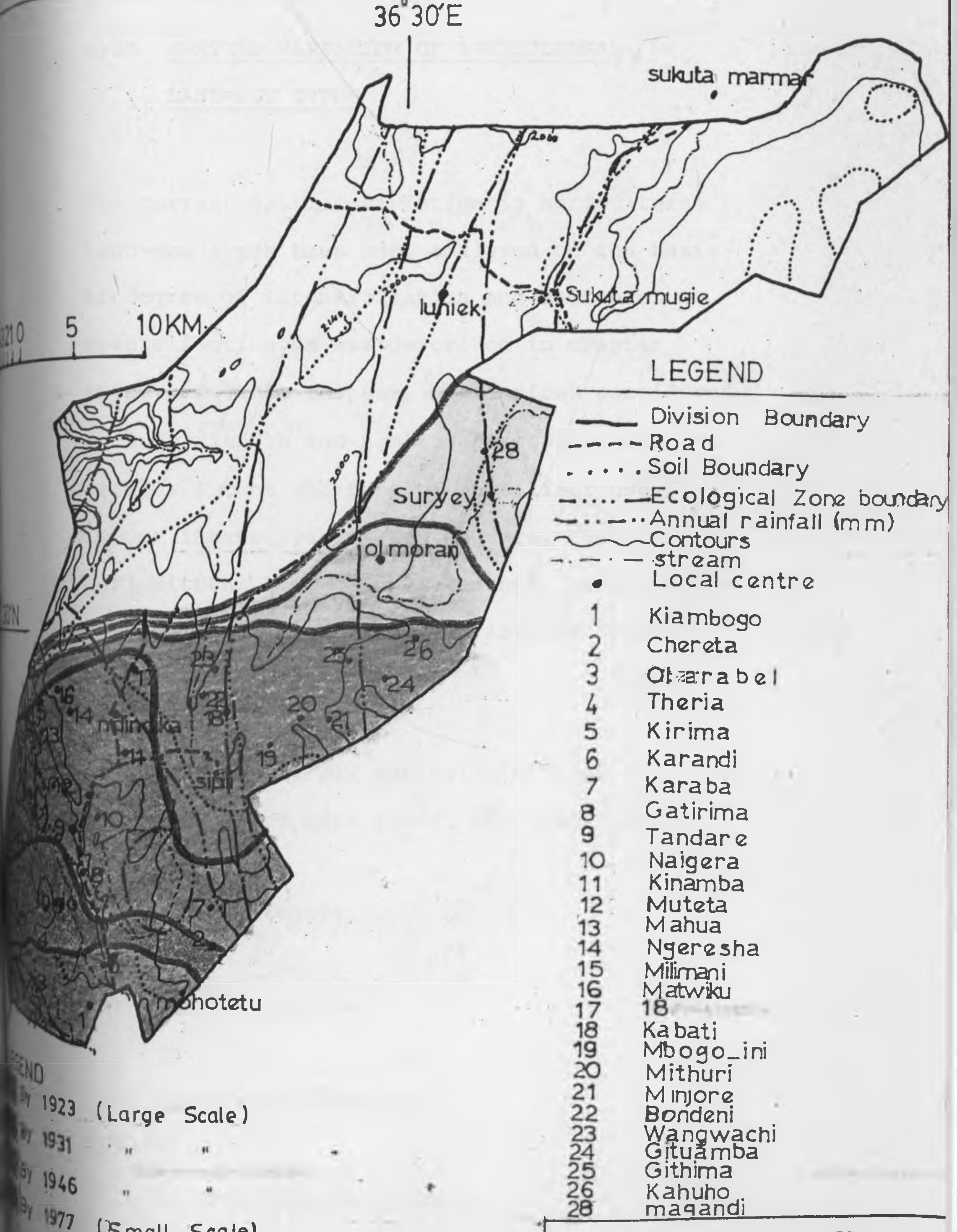
Period	Agricultural Land-use Type
1885 - 1906	Areas on the western half of the division were forested with scattered grassland islands which were used for grazing by Pastoralists. On the Northern and north eastern side of the division, grazing was the main agricultural land use type/ activity;
1906 - 1911	Grazing by both pastoralists and the white settlers was predominant However, the two agricultural land-users were in antagonism. The white settlers were involved in ranching while the maasai in nomadic grazing. This was true in all parts of the division.

1911 - 1923	The population of settlers involved in Ranching increased and of pastoralists decreased. Crop production was done on experimental basis in the Ol arabel valley and its environs. The rest of the area of the division was on livestock production.
1927 - 1931	Coffee was planted in the sheltered areas of Ol arabel valley. Large scale mixed farming (crop production and dairying) was intensified on the western part of the division. Ranching continued to dominate agricultural activities on the North and north eastern part of the division.
1931 - 1963	Large scale mixed farming dominated the western part of the division namely Ol arabel valley, marmanet/lariak parts

	and Ndindika areas. Ranching dominated on the northern sides, namely Ol ari nyiro, Sipili, Sukuta mugie and their environs.
1963 - 1989	Small scale mixed farming as an activity dominate the western side and the middle parts of the division namely, Ol arabel region, Mohotetu region, Ndindika and Sipili regions. Ranching in large scale farms still dominate the North and Northern eastern side of the division namely, the Ol ari nyiro, Sukuta Mugie and their environs. (See figure 10)

VIRONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE
PLANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT

EVOLUTION OF MIXED FARMING
FIGURE 10



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4.05 SPATIAL VARIATION OF AGRICULTURAL LAND-USE TYPES

The current spatial variation in agricultural land-use types have been analysed on the basis of degree of intensification and degree of specialisation as was described in chapter three. In this respect, the indices considered include, length and number of cropping seasons, methods, amount and type of fertiliser use, labour inputs, yields per hectare, type of agricultural tools and implements, predominance of specific crops and animal associations and ultimate distribution.

In this respect, six agricultural land-use type categories were identified, these are:-

(a) wheat category;

(b) Maize category;

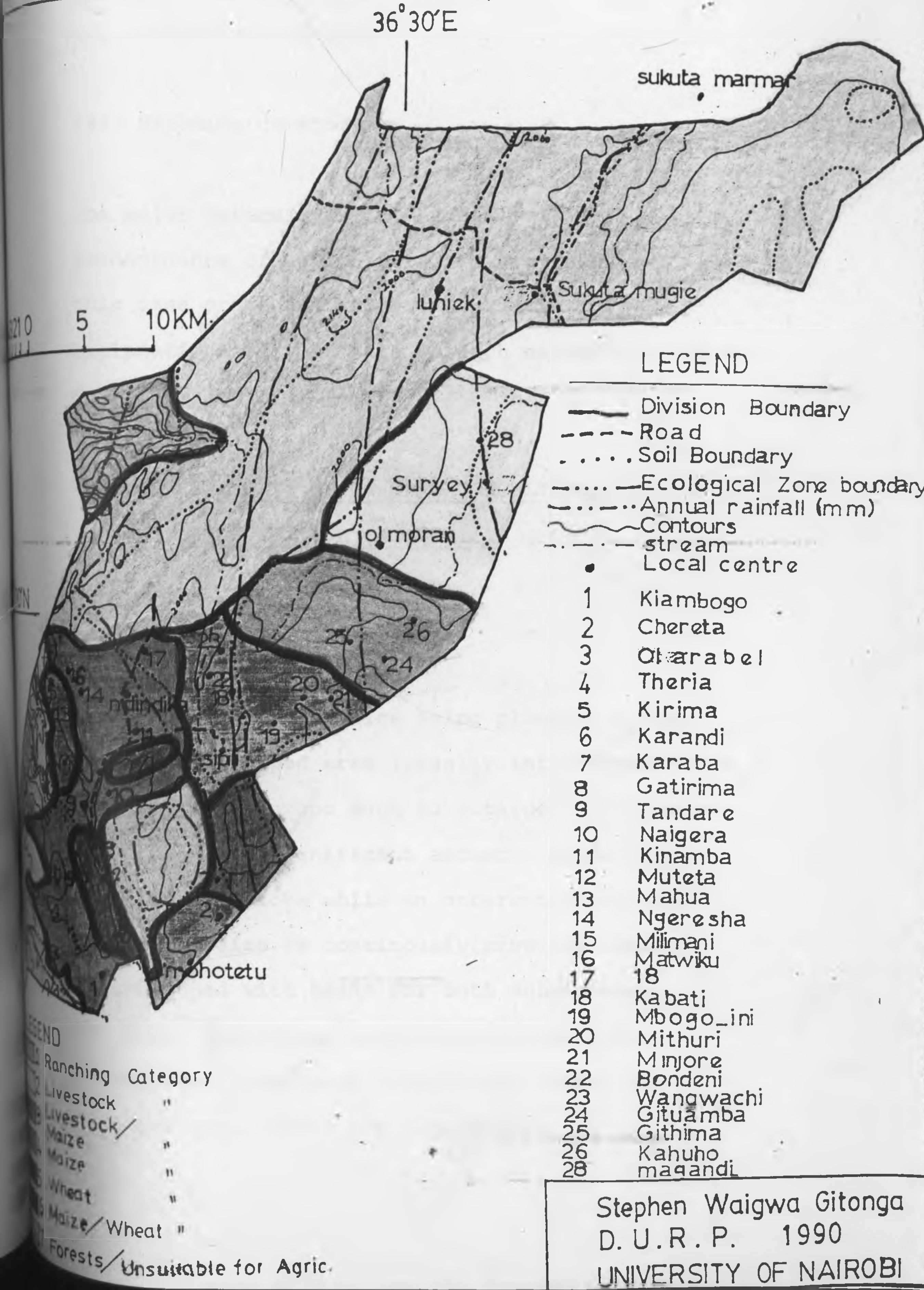
(c) maize/wheat category

(d) maize/livestock category

ENVIRONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE PLANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT

AGRIC LAND-USE TYPES

FIGURE 11



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(e) livestock category

(f) Ranching category

The major determinant in the analysis is predominance of agricultural enterprises, in this case crops and animal associations. Explanations of what entails each category is given hereafter.

4.05.1 EXPLANATIONS TO THE AGRICULTURAL LAND-USE TYPE CATEGORIES

(a) Maize Category:-

Predominant crop is maize being planted in over 50% of the cropped area (usually intercropped with beans). Other crops such as potatoes, vegetables are grown in insignificant amount. Animals are kept in some plots while in others there are no animals. Maize is continously produced usually intercropped with beans for both subsistence and cash. Livestock production is usually intergrated with these enterprises mainly for milk and small stock for subsistence.

(b) Wheat Category:-

Wheat crop is a continous pure stand predominate agricultural activities in the farms. It is usually grown for cash. Maize intercropped with beans is grown for subsistence but comparatively in insignificant proportions. Livestock is usually kept for milk production and for milk production and for subsistence.

(c) Maize/Wheat Category:-

This includes continous planting of maize and wheat in separate plots in the same farm. In essence, maize and wheat growing dominates the farms agricultural activity. Both crops are grown for cash. Livestock keeping is done for subsistence.

(d) Maize/Livestock Category:-

Both maize production and livestock rearing dominates the farms activities. Usually land sizes are small averaging 5 - 10 acres. In this respect its only when there is surplus production that maize is sold. In critical periods when money is needed, some maize may be sold. Livestock are reared mainly for cash.

(e) Livestock Category:-

Livestock rearing dominates the farmers agricultural activities. However, small stock (sheep and goats) dominates livestock rearing in these regions. Land sizes are small averaging 3 acres. Usually the stocks are raised in farms which are not yet settled.

(f) Ranching Category:-

Large scale ranching farms dominated by beef cattle rearing characterise this categor_.
In essence, there is no crop growing and where there is, its very little.

Complete summary of the indices and characteristics used in determining these categories is given in table 3. The map overleaf shows the spatial distribution of the agricultural land-use types. The photographs accompanied depicts some of the areas explained where agricultural land-use types characteristics are shown.

TABLE 3

Agricultural land-use type categories / indices	maize category	maize/wheat category	wheat category	maize/livestock category	livestock category	ranching category
1. Average Land size (acres)	•16.7 – 24 and more • 5–10	16.7 – 24 and more	>24	5 – 10	3 – 5	1000–5000
2. Average area under cultivation (acres)	• 10 – 15 • 5.8–2.26	10 – 15	>15	≈5.8	≈2.26	——
3. Approximate percentage of cultivated land on dominant crops/ livestock	>80%	60%–80%	>80%	>60%	90–100%	100%
4. Percentage of cultivated land	a) 61–62% (b) 55.9–62%	55.9–62%	≈60%	≈60%	——	——
5.*Average area used for livestock rearing	38%–44.1%	38%–44.1%	40%	40%	90–100%	100%
6. Length of cropping season	6 months	3–6 months	3–4 months	6 months	——	——
7. No. of cropping seasons	1	1	1	1	——	——
8. Average Yields per acre (1bag=90kg)	a) 20–25 bags b) 15–20 bags	Maize 5–20 bags Wheat 8–10 bags	8–20 bags	5–10 bags	-	-
9. Type of fertiliser used	Chemical manure	Chemical manure	Chemical	Manure	Manure	Manure
10. Amount of fertiliser used	DAP 50 kg/acre	DAP 50 kg/acre	DAP 50 kg/ acre	-	-	-
11. Type of agricultural tools and implements	Tractor with its accessories which include – plough, hallows, planters, trailers. In some cases maize shellers. Pangas & Jembes	- do - and combine harvestors and sprayers Pangas Jembes	- do -	Tractor for opening up of land. Jembes Pangas	Pangas Jembes	Highly [illegible]
12. Crops grown (in order of dominance)	maize, beans, potatoes, vegetables, others	maize/wheat, beans, potatoes, vegetables, others	wheat, maize, beans, potatoes, vegetables, others	maize/livestock, beans, others.	Livestock (small stock)	Livestock (beef cattle)
13. Livestock kept/farm (in order of dominance). 1 livestock unit = 2.5 cows, 20 goats/sheep and 1.25 camels	Cattle ave. 6 Sheep " 15 Goats " 15	Cattle 3–16 Sheep 12–15 Goats 9–15	Cattle 6 Sheep 15 Goats 15	Sheep 15–23 Goats 14–24 Cattle 3	Sheep 24 Goats 23 Cattle 20	*Data not available

* Include homestead area

DAP = Diammonium Phosphate

Source: Field Survey

Plate 1 (a) Wheat category of agricultural land-use type.. Note the continous pure stand of wheat.

Plate 2 (b) Maize/wheat Category.
Wheat is depicted on the extreme left (white patch) note the general continous maize/ wheat growing.

Plate 3: (c) Ranching Category;
concentration point of cattle.
Note the general loss of soil cover.

Plate 4: (d) Maize/livestock Category;
maize is on the uppermost background.
NB Note the overgrazed pastureland.

Plate 5: (e) Livestock Category;
Note the devastated pastureland and overgrazing.

Plat 6: (f) maize category;
Note the condition of the crop.

4.05.2 Functional Importance of the agricultural land-use types:

It is the contention of the author that the spatial variation in agricultural land-use types in the division depicts functional relationship of land and the the farmers who stand to benefit from it. Where maize is cultivated as the predominant crop, its mainly for subsistence and the surplus is sold for cash benefits. Wheat is usually grown primarily for commercial purposes. However, in areas where the land sizes are relatively big (averaging 40 hectares), maize is also produced for commercial purposes.

In drier parts of the division where land sizes are relatively small, (averaging 5 - 10 hectares) maize and livestock are the major enterprises. This is done primarily for both subsistence and cash. In this respect, the importance of the agricultural land-use type determines its existence. Consequently, the pattern displayed closely match the <u>agro-ecological potential</u> of the areas and the <u>land sizes</u>.

4.05.3 Local Areas represented by each agricultural land -use type category:

(a) Maize Category:

Represents the areas:- Sipili, Mbogoini, Mithuri,Minjore, Kabati, Bondeni, Wanguachi, Githima, Mlimatatu, Mahua, Muhotetu and environs.

(b) Maize/wheat Category:

Represents:- Thigio, Theria, Ol arabel, Kiambogo, Karandi, Tandare, Muteta, Kiamburi, Naigera, Ngeresha, Ndindika, Kinamba, Karaba, 18 and environs.

(c) Wheat Category:

Represents:- Gatirima, and some parts of Kinamba region, and their environs.

(d) Maize/Livestock Category:

Represents:- Githima, Kahuho, Donyoloip and Ol moran environs.

(e) Livestock Category:

Represents:- Ol moran, Survey, Magandi and environs.

(f) Ranching Category:

Represents:- ranching farms, Ol ari nyiro, Sukuta mugie, Luniek ADC Ranch P and Day development Ranch and other ranches to the north east.

These local names are illustrated later in the environmental threshold map and tables. It should be noted that in many instances there are super-imposition of agricultural land-use types and the six categories identified simply depicts dominant agricultural land-use types. Transitional changes between each categor exists.

For clarity of the varying land sizes and the agricultural land-use type, the functional importance of each land-use can be explained by a brief look at the existing land size and agro-ecological potential of each area.

Below is a tentative table of the average number of families and average farm sizes in each local area.

Table 4

Location	Local Area	Number of Families	Average farm size (in acres)
Kinamba Location	Mithiga	329	7
	Mwenje/Ndi-ndika	410	5
	Njorua	434	6
	Lobere	583	5
	Ndindika	434	5
	Matwiku	410	5
	Mlimatatu	420	6
Gituamba Location	Naigera	230	18
	Kiambogo/ Ol arabel	300	18
	Kiambogo	300	18
	Lariak	165	25
	Seria	200	40
	Thigio	130	40
Sipili Location	Naibrom	320	4
	Wangwachi	330	3
	Donyoloip	400	3
	Dincom	586	4

Table 4 (Contd)

Location	Local Area	No,of Families	(in acres) Average farm size
Mohotetu Location	Mohotetu	380	10
Ol moran Location	Ol moran	—	—

* Ranches not inluded.

Source: Divisional Agricultural office Kinamba. (1989)

Agro-ecological potential zone and local areas represented.

Table 3:

Potential	Location	Local areas
High Potential zone (AEZ 3,)	Gituamba Kinamba (western part) Mohotetu	Kiambogo, Ol arabel, Lariak, Theria. Mwenje, Thigio, Ndindika, Mithiga, Mlimatatu, Kinamba. Mohotetu, Chereta, Karaba.
Medium potential zone AEZone 4)	Kinamba (eastern part) Sipili (western part)	Matuiku, Lobere, Njorua, Ndindika (18) Wangwachi, Naibrom, Ol ari nyiro Ranch.
Lower potential zone (AEZ - 5)	Sipili (eastern part) Ol moran	Donyoloip, Minjore, Mithuri, Kahuho, Githima. Ol moran, Luniek,Sukuta Mugie, Survey, Magandi.

Source: 1. Own Survey

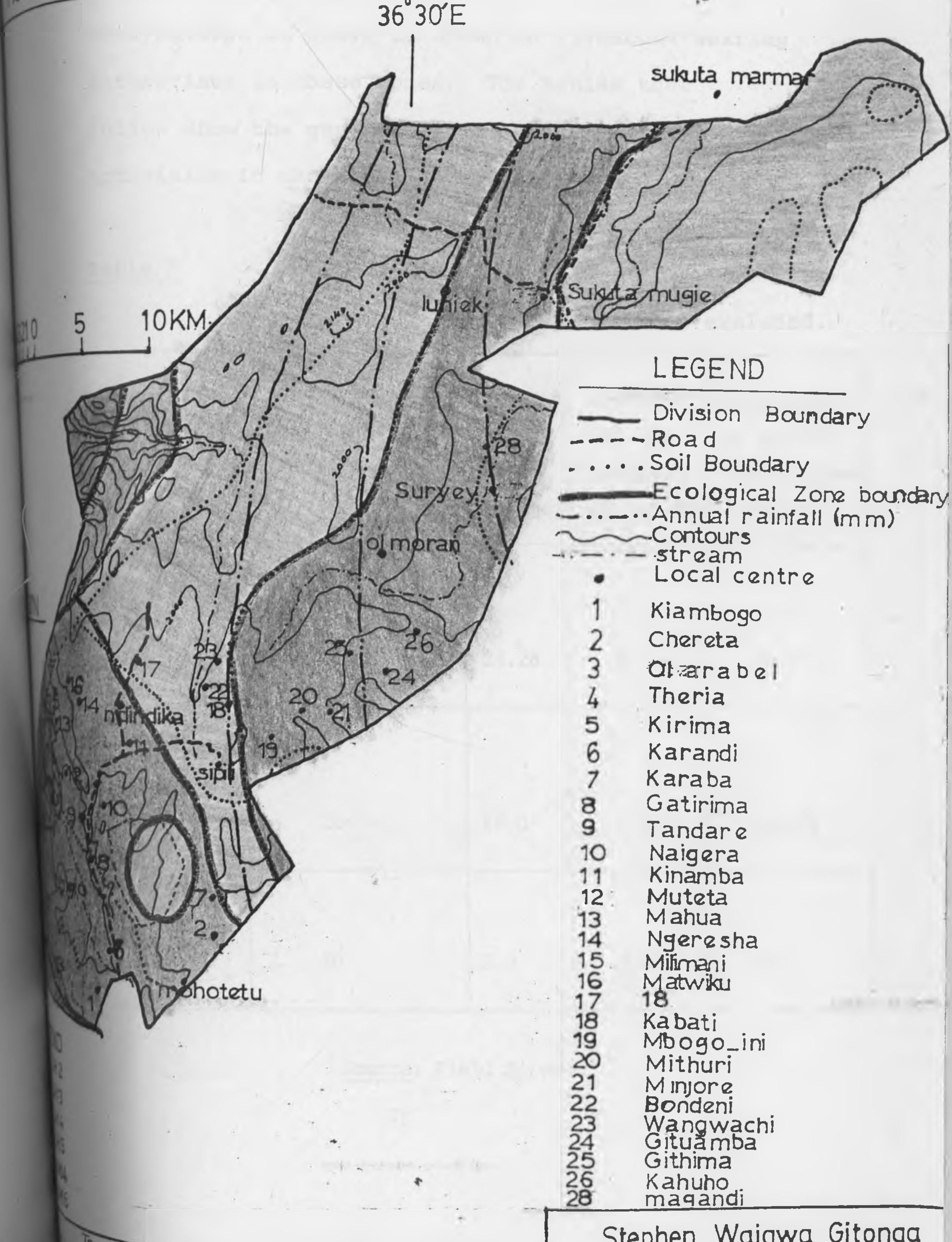
2. Farm management Handbook Jaetzold R. (1983)

Agricultural activities in each of the three agricultural potential areas vary. It has been observed from the previous discussion that evolution of mixed farming in the division originated from the high potential zone now moving towards the less potential zones.. In this respect the high potential zone which is mainly in Gituamba and Mohotetu Locations has more crop (wheat/maize or both) grown for commercial purposes. In the same note, land sizes in this region are bigger averaging 24.28 acres and more; compared with medium potential zone and low potential zone where land size average is 10 and 5 respectively (Ranches included). The area under cultivation also varies and the percentage area cultivated varies from 62%, 58% and 45% for high potential, medium potential and low potential zone respectively. The high percentage of cultivated land in high potential zone is explained by the larger sizes of land in this zone leading to farmers tending to cultivate as much as they can leaving space for the homestead and subsistence livestock enterprise.

ENVIRONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE PLANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT

AGRO-ECOLOGICAL ZONES (AEZ)

FIGURE 12



Jaetzold R.
Farm Management Handbook
1983

Stephen Waigwa Gitonga
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Same pattern as above is shown in livestock rearing enterprises in these zones. The tables that follow show the general variation of various activities in the three potential zones.

Table 5

NB: Ranches excluded.

Potential	No. of respondents	Total land size (average)	cultivated area (average) (in acres)	Percentage of cultivated/cropped area (%)
High Potential zone (AEZ 3)	20	24.28	15	61.77
Medium potential zone (AEZ 4)	20	10.0	5.8	58.00
Low Potential zone (AEZ 5)	20	5.0	2.26	45.2

Source: Field Survey

Average Number of Animals reared: (Ranches not included)

Table 6

Livestock Unit (LSU) (Total)	Region	No. of respondents	Ave. No. of cat-tle	Ave. No. of she-ep	Ave. No. of goats
3.9	High potential zone (AEZ 3 & 4)	20 LSU	6.00 LSU=2.4	15.00 LSU=0.75	15.00 LSU=.75
3.95	-Medium potential zone (AEZ 4)	20 LSU	4.00 LSU=1.6	16.00 LSU=0.8	31.00 LSU =1.55
13.35	Low Pot-ential zone (AEZ 5)	20	20 LSU=8	47 LSU=2.35	60 LSU=3
21.2	Regional	60	LSU-12	LSU=3.9	LSU=5.3

1 LSU = 2.5 cows, 20 goats/sheep, 1.25 camels
LSU = Livestock unit

Source: Field Survey

It can be noted that emphasis is shifted from crop cultivation to livestock rearing as the total livestock units per region increases from high to low potential zones. LSU increases from 3.9, 3.95, and 13.35 as one moves from high potential, medium potential and low potential respectively. This pattern of events is explained by environmental conditions of the regions. However, in the low potential region, most of the plots are not yet settled and the people who are already settled use the unsettled land/plots for grazing.. In this respect, it is expected to change when every plot would be occupied as grazing land will be minimal. This is of paramount importance in environmental considerations.

Below is the estimated livestock population in the division in the years 1985 and 1988.

Table 7

Livestock population	Census	
	1985	1988
Dairy Cattle	2586	4737
Beef Cattle	18600	20460
Goats (meat)	28556	31407
(Dairy)	51	62
Sheep (Hair)	21040	23144
(wool)	2032	2234
Poultry (indigenous)	45111	—
(layers)	1416	—
(Broiler)	225	—
Pigs	75	—
Rabbits	—	—
Donkeys	—	—

Key: (___) no estimates

Source: Divisional livestock extension office; Kinamba

This table indicates that there is general increase in livestock population. In environmental consideration, competition between crop growing and livestock production increase with increase in intensification of farming practices. This situation of events poses more challeges to resource use planners/farmers/and the government for more awareness in the issues partaining to development of agriculture in the region and environmental conservation viz-a-viz exploitation.

The discussions so far have been based on the degree of specialisation whereby predominance of specific crops and animal associations are central. However, their ultimate ditribution has been addressed. At this juncture, it is important to look at some of the indices of intensification as it is in the study area. In general, the Olarabel valley and its environs which includes Ol arabel, mohotetu and Ndindika region is encompassed in the high agricultural potential zone of the division. (see figure 12). In this region, cultivation method involves the use of tractor for opening up the land and preperation of the seedbed. This applies also in the medium agricultural potential zone which includes Sipili regions. However, for the land on the eastern end of Sipili, tractors are only used for land/seedbed preparation.

The propensity for tractor use decreases as one move from Ol arabel across Ndindika, Sipili to Donyoloip, Ol moran regions. For, sowing and planting, farmers use different methods. Tractor drawn planters are usually used for planting of maize and wheat; However, manual planting is done for maize. This is common in Sipili and Ol moran regions.

For clearing of the farms after they were acquired, clearing of the trees/bushes and burning was most common. 90% of the respondents indicated thet they used this method in clearing of their farms.

Table 8

Generalised farming activities per year. (Ng'arua Division)

Month	Activity
January to March	- Land preparation. Maize buying by NCPB. Soil conservation measures in selected places.
April	- Planting of maize and beans. some farms being plowed
May	- wheat planting - weeding of maize and beans - Transplantation of vegetables from nursery to seedbed. - earthing up of potatoes
June	- Weeding and dusting of maize.
July	- Harvesting of green maize for roasting, wheat spraying, weeding and dusting continue in some farms
August	- Wheat spraying confined in some areas — Harvesting of beans
September to December	- Harvesting of maize and wheat. Maize harvesting is continued to the beginning of January.

(contd)

Month	Activity
September to December	- At the beginning of December soil conservation measures start.

NB: NCPB = National Cereals and Produce Board.

Source: 1. Divisional Agricultural office; Kinamba.
2. Field Survey

Table 9

Fertiliser use in the 3 AEZs

Regional/Zone	Number of respondents	Percentage /distribution of fertiliser use.
High potential zone (AEZ 3)	20	45% use both manure and chemical fertiliser; 35% use manure alone; 20% don't use any form of fertiliser
Medium potential zone (AEZ 4,)	20	45% use both chemical and manure fertiliser; 30% use chemical fertiliser alone;

(contd)

Region/Zone	Number of respondents	Percentage/distribution of fertiliser use.
		15% use manure alone; 10% Do not use any form of fertiliser.
Low potential zone (AEZ 5)	20	51% use manure 29% use chemical fertiliser 20% Don't use any form of fertiliser.

Source: Field Survey

It is important to note that use of chemical fertiliser is not very common generally in Ng'arua division. The percentage of use of chemical fertiliser is less than 50% in the three zones. However, an increase in use of fertiliser especially in the high potential area and the medium potential zone has been noted. The reason behind increased use of fertiliser is the decreased productivity of the farms. Productivity per unit of land is lower than it was when the farms were opened for cultivation. This has led to more intensification in production methods that has led in most parts of the medium potential zone, to increased production.

For crop remains (after harvesting), bulky maize stovers are burnt before land preparation. Some crop remains are used as fuel for domestic purposes and usually farms are turned into grazing grounds during the dry period after harvesting the crops. When the land is under crop, livestock is grazed on areas where the land is not cultivated. This include the homestead. For percentage area used for livestock grazing see (table 3).

4.06 SOCIO - ECONOMIC SITUATION AND POLITICAL SYSTEMS OF ENVIRONMENTAL EXPLOITATION:

Introduction

This section look into the historical transformation in regard to socio-cultural, political and economic aspects. In this respect, the interface of privatilisation, land ownership (tenure and landsizes) land-uses, population size and density, environmental awareness among others is examined. However, it is important to mention here that the historical development of agricultural land-use types highlighted most of the historical attributes that are important in this section.

Firstly, it highlighted the change of land ownership from communal grazing in 1911 to privatisation by the white settlers, this did not only change the mode of environmental exploitation but changed the land tenure and size of land. Subsequent years saw an increase in population and change of use of land. In this respect, the community changed from subsistence to a commercial oriented society.

In environmental consideration, this aspect is very important.

In attaining independence, the large scale farms were subdivided and individual owners with freehold tenure system acquired the land. Change in land size from 1000 - 5000 acres to an average of 7 acres in the division is important. Population size increased and population density changed. Land sizes as in table 3 and table 4 give the testimony.

4.06.1 LAND OWNERSHIP AND USE

(A) Small - Scale Farmers:-

There are two forms of small scale farmers in the division; these are:-

(a) Government Settlement Schemmes.

(b) Non-government land-purchase which include land purchased through land buying Companies and Co-operatives.

In these two categories, land is owned in free-hold-(private ownership). Each farmer has got a tittle deed for his plot. The government schemmes in the division are:- Ol arabel settlement scheme, Lariak Settlement scheme and Ndindika (shirika) settlement scheme. The table below show the government settlement schemmes (Marmanet Forest extension is in Rumuruti Division).

Table 10

Scheme	Scheme Number	Number of Settled areas	size of scheme scheme in hectares
Ol arabel	300	288	
Lariak	301	143	6,531
Marmanet Forest extension	302	860	
Ndindika (shiri-ka)	520	790	2,854

Source: 1987 annual report.
Ministry of Lands and Settlement.

among the farm Companies in the division include Tandare, Kiambogo, Lembus Kongasis, Mutukanio, Laikipia West, Njorua and Mwenje.

Table 11

Scheme/Company	Average Land size/Plot size (in acres)
Ol arabel	20 - 30 and more
Mutukanio	3
Laikipia West	5
Njorua	6
Mwenje	5
Ndindika	5
Lariak	25
Kiambogo/Ol arabel	18

Source: 1. Field Survey
2. Divisional Agricultural office.

(B) Large Scale Farms:

One Agricultural Development Corporation farm ADC farm - This is a government property.

(C) Ranching farms:

These are large scale farms leased to individuals and partnerships. The farms are managed privately. In this respect, they are a private property.

Land size depicts population distribution and thus population density in these areas. Land ownership dictates the way the land is managed and therefore how the environment is exploited.

However, the duration the lands were settled is very important in explaining the environmental situation of the division.

Table 12

Scheme/Company/Co-operative	Year of purchase/ settlement
Ol arabel, Ndindika	1969 - 1972
Mohotetu	1960 - 1969
Sipili, Kinamba, Ol moran	1970 - 1979

Source: - Kohlar, 1986
- Divisional Agricultural Office
- Own Investigation

Gazetted forests in the division are Lariak (3,988 ha) and Ol arabel forests (7,724 ha). As can be seen from figure 11, the forest border with the small scale farms. In this respect, it is usually used by the residents of the farms as their source of fuelwood. This is done through the forest authorities. However, forest abuse is a commonplace in the division.

It should be mentioned at this juncture that, part of Ol arabel forest was legally excised to give way to cultivation for the Ol arabel Scheme between the years 1969 - 1972. This indicates competition/conflict between agriculture and forestry (see plate 7 & 8). Forestry is one of the activities in the Division that makes up the broader environment in the division. In this case the common use of it in the expense of the negative impacts to the environment depicts the extent of the "tragedy of commons" in this vicinity.

Plate 7 : Ol Arabel Forest (Thigio/Kirima area)

Plate 8 : Ol Arabel Forest showing the farms on the excised (Thigio) part. Maize/wheat is the main agricultural land-use type.

Plate 9: Lariak forest fridges: Note the extent of human influence on the vegetation.

4.06.2 POPULATION

Ngarua Division population is increasing at a very high rate because of influx of immigration to the area. Coupled with the natural growth rate, it is expected that by the year 2000, the population might increase by twofold from the 1979 census.

Table 13:

Population Profile by sex 1979 (Ngarua Division)

Sex	0 - 14	15 - 59	Over 60
Male	16,094	13,185	1,009
Female	15,382	11,191	1,306
Total	31,479	24,376	2,315

Source: Kenya population census central bureau of statistics 1979.

Table 14:

Population projection (Ngarua Division) 1979 - 1992

1979	1983	1985	1988	1989	1992	Area (km^2)	Density/ (km^2) 1988
34,868	44952	50258	59388	62727	74141	*1070	55.2

*Area currently is 1098 Km^2

Source: Central bureau of statistics;

Kenya population projection 1980 - 2000. March 1983, page 133 - 135

It can be noted from the table that the population has virtually doubled between the years 1979 and 1992. This indicate the expected population by the year 2000. The density of population in 1988 was 55.2. This is expected to increase because of high settlement taking place in the area. In this respect, environmental exploitation is expected to take a new turn as population increases. Intensification of the farming activities is usually followed by high population increase. In this regard, the lands which are used these days for livestock rearing in areas around Ol moran (usually used as a common land) is expected to be occupied by owner families. In this respect more strain to the environment is eminently expected.

The division has several small towns and market centres. These are used for marketing and purchase of domestic and farm requirements. Because this is a farming area and maize/wheat are the main cereals, the National Cereals and Produce Board usually locates itself in these centres during the cereals sales period.

Among the centres are:- Kinamba, Sipili, Mohotetu and Karandi. Others include Thigio, Theria, Tandare, Kiamburi and Ol moran.

Estimate of Urban, small town and market centre populations.

Centre	Number of households actually Resident	number of people attending the periodic market we weekly	number of business premises in the trading centre	maximum number of households in the catchment area
Sipili	250	864	190	6,080
Kinamba	210	350	94	930
Mohotetu	15	128	51	120
Karandi	40	100	33	495

Table 15 Source: Laikipia Rural Development Programme. (1988)

Estimated 1988 population of the three centres are:- Kinamba 792, Sipili 1600 and Mohotetu 550. Kinamba is the Divisional Headquarters. These centres acts as concentration areas where farmers meet with their business partners.

In environmental considerations, the culture of resource, utilization has changed considerably in Ngarua Division. Land has been privatised and individual families are responsible for the environmental exploitation. The economics of resource utilization has changed from subsistence/ social orientation of resource use to commercial orientation of resource use. This has implications as in this case, profit maximisation is the goal to environmental exploitation. Where there is common use of resource (land), tragedy of commons is expected. Such areas include forests, the un-settled plots around Donyoloip, Ol moran and survey regions.

Extension services for agricultural practices are given to all residents and environmental awareness is high in the division. However, measures to conserve the environment are hampered by varying factors in different farms. Some of these factors include, economic handcap, lack of initiative especially where the productivity of land is low (zone 5) among others.-

4.o7 ENVIRONMENTAL SITUATION

The parameters of ultimate importance in the environmental situation of the division are soils and climate. Various aspects of the two perameters are examined. This analysis integrated with the other aspects discussed earlier, help us to assess the environmental situation, trends and management of the same. In this respect, data obtained from secondary sources is incorporated to give more deep insight to the environmental situation of the Division.

Aspects considered in this case include Rainfall, Temperature, altitude as they are exhibited in the various agro-ecological zones (AEZ). The table below show a summary of the general climate condition depicted in the Division.

Table 16

Agro-eco zone (AEZ)	Altitude (m)	Annual mean temperature (^{O}c)	Annual average rainfall (mm)
High potential LH_3 (wheat/ maize/barley zone	2200-2350 2100-2300	15.6-14.9 16.1-15-0	800-900 850-950
Medium potential LH_4 (cattle-sheep barley zone)	1820-2280	17.7-16.5	700-800
Low potential zone LH_5 (Ran-chip zone)	1800-240	17.3-15.3	570-700
UM_6 (Ranching zone	1660-1780 1300-1800	18.6-17.8 20.9-17.8	430-620 380-600

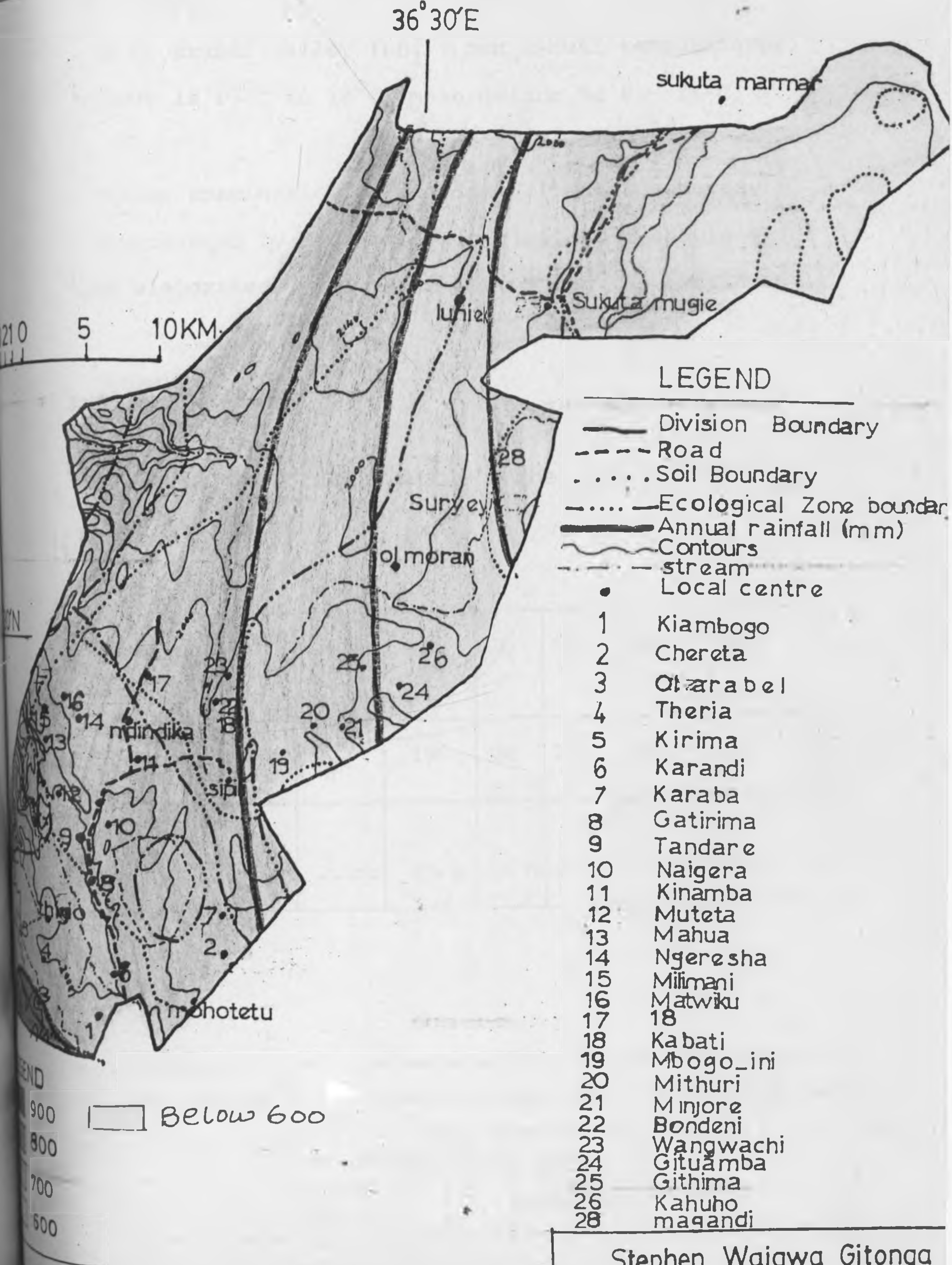
Source: Jaetzold R and Schmidt, eds 1983.
Farm management Handbook of Kenya
Vol. 11/B Central Kenya. NAIROBI

The table indicates that Rainfall in general varies from 500mm to 900mm. However, it is very unreliable especially on the northeastern parts of the Division. Annual mean temperatures range from 15.0^{O}C to 20.9^{O}C.

NVIRONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE
LANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT

NNUAL RAINFALL(MM)

GURE 15



1 Farm Management Handbook 1983

2 Laikipia Research Programme 1987

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In Ol arabel valley (LH_3), mean annual temperatures range is 15^oC to 18^oC, mean minimum is 8 - 11^oC.

Before examination of pertinent climatic aspects, area covered by each agro-ecological zone should be elaborated. The table below gives the breakdown.

Table 17

AEZ area (km^2) distribution in the agricultural land (853 km^2)

Agro - eco zone	LH_2	LH_3	LH_4	LH_5	UM_4	UM_5
Area (km^2)	22	196	390	176	55	14
Percentage total area	2.58%	22.98	45.72	20.63	6.45	1.64

Table 18

Area total (km^2)	Non-agricultural land			Agricultural land
	unsuitable steep slopes	forest	others roads homesteads	
1098	29	106	110	853

Source: Adapted from Jaetzold R. and Schmidt eds 1983 farm management Handbook.

The agricultural land (in ha) per household is 12.05 and the agricultural land per person is 2.45; (jaetzold R and Schmidt 1983).

With the above analysis, it is now possible to examine purposively various environmental aspects of the division. Inthis respect it is important to integrate these aspects with the agricultural land use type examined earlier in the discussion.

Table 19

Agricultural land-use types and climatic characteristics:

Agricultural land use type category / characteristics	maize	wheat	maize/ wheat	Maize/ live-stock	live stock	Ranching
Agro-eco-zone	LH_3 LH_4 LH_5	LH_3	LH_3 LH_4	LH_4 LH_5	LH_5 LH_4	LH_4 LH_5 UM_6
Altitude (m)	2100-2300	2100-2300	2100-2350	1820-2280	1820-2280 1800-2280	1820-2280 1800-2140 1660-1780

Table 19 (contd)

Agricultural land use type category / Characteristics	maize	wheat	maize/ wheat	maize /live-stock	livestock	Ranching
Rainfall (mm)	600-900	700-900	800-900	600-800	600-700	430-800
Annual mean Temperature (^{o}C)	17.7-16.5 15.6-14.9 16.1-15.0	15.6-14.9 16.1-15.o	15.6-14.9 16.1-15.0	17.7-16.5	17.7-16.5 17.3-15.3	17.7-16.5 17.3-15.5 17.9-17.5 18.6-17.8 20.9-17.8

Source: 1. Jaetzold & Schmidt (1983).
2. Fertiliser use recommendation Project (1987) (FURP)
3. Field Survey

From table 17 it is clear that 74.44% of agricultural land in the division lies in low agricultural potential area (AEZ, LH_4, LH_5, UM_4, UM_5). This indicates that most areas of the division are marginal in relation to agricultural production. Only 25.5% of the land can be considered well endowed in regard to agricultutal production. However, as was realised in the discussion of agricultural land-use types, the farmers in the division are practicing inherent agricultural activities which do not necessarily match with the prevailing environmental conditions.

4.07.2 SOILS

Soil characteristics in the division vary spatially. Inthis respect, different soil characteristics and the ultimate distribution is explained in the following discussions. However, it should be mentioned that much of the characteristics of soils in this study are analysed from the exploratory soil map and Agro-climatic map of Kenya by H.M.H. BRAUN in W.G. SOMBROEK et al (1982) and the Fertiliser Use Recommendation Project (FURP) (1987) Laikipia District report. The soil terms used are those of the Soil Map of the world (FAO - Unesco, 1974) with adjustments according to the Kenya Concept (Siderus and Van der Pouw, 1980).

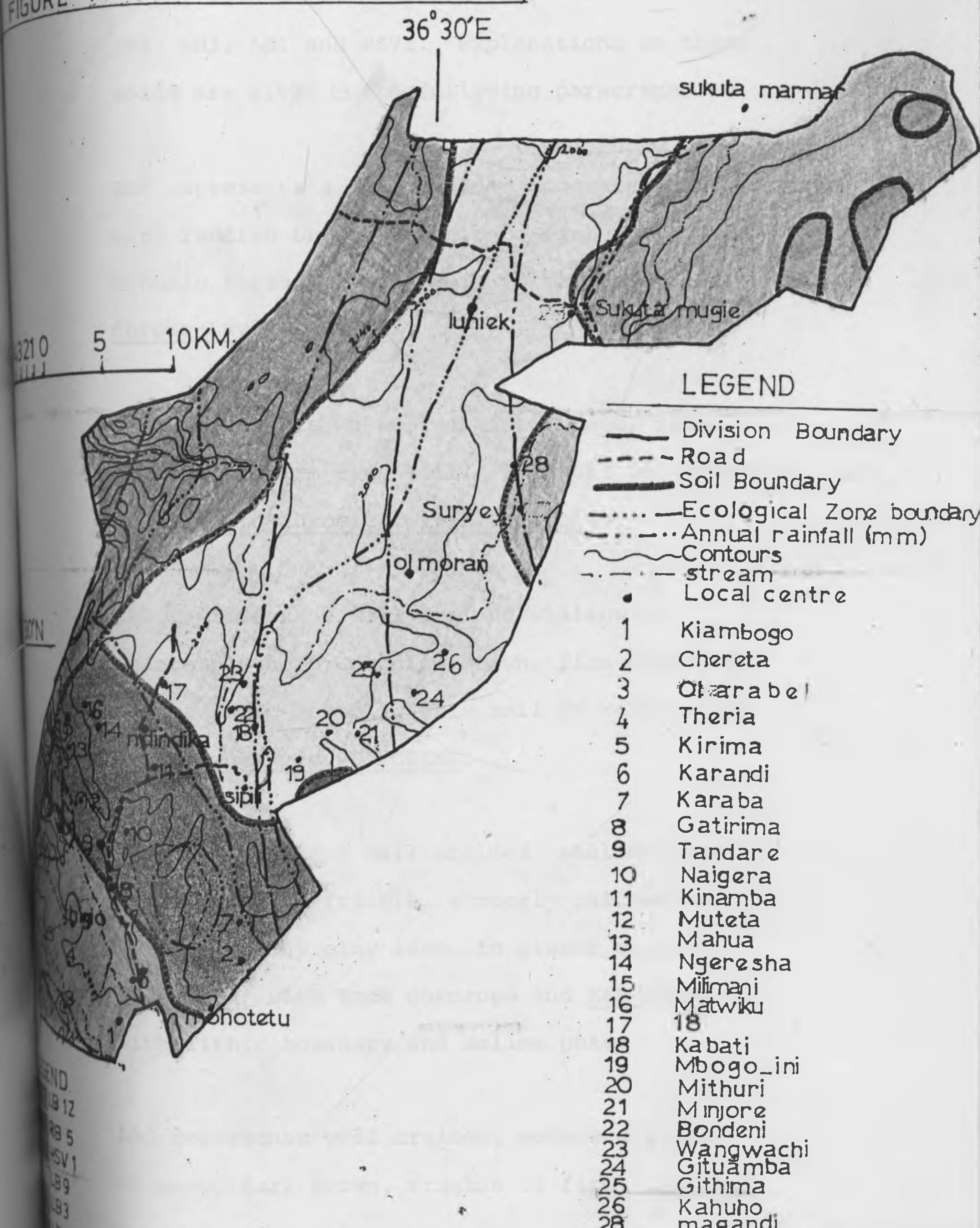
4.07.2.1 Soils in Ng'rua Division

A generalised soil map is shown in figure 15. The soil units represented are LB 12, RB 5,

ENVIRONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE PLANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT

SOILS IN THE DIVISION

FIGURE 14



SOURCE: Fertilizer Use Recommendation Project 1987

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LB9, LB3, LB1 and HSVI. Explanations to these soils are given in the following paragraphs.

RB5 represents a well drained moderately deep, dark reddish brown, friable to firm clay, with a humic topsoil. This soil is referred to as Chromo-Luvic PHAEZEMS.

LB12 represents a well drained, deep, red, friable to firm clay soil. The soil is referred to as Nito-chromic/ferric Luvisols.

LB9 represents a well drained shallow to moderately deep, reddish brown, firm clay loam, with a humic topsoil, this soil is referred to as Chromo-luvic PHAEOZEMS.

HSVI represents a well drained, shallow, dark reddish brown, friable, strongly calcereous, rocky or stony clay loam, in places saline LITHOSOLS; with Rock outcrops and XEROSOLS, with lithic boundary and saline phase.

LB3 represents well drained, moderately deep to deep, dark brown, friable to firm, clay loam to clay, predominantly with a thick humic topsoil. This soil type is referred to as Ortho-luvic PHAEOZEMS with Chromic LUVISOLS.

LSB1 represents well drained, moderately deep, dark reddish brown to reddish brown, friable to firm and slightly smearly, boulderly and stony, clay loam to clay; in places celcareous. This is referred to as ando-Chromic CAMBISOLS, sometimes with bouldery phase; with calcic XEROSOLS.

LEGEND TO THE SOIL MAP OF NGARUA DIVISION:

Explanation of the first character (Physiography)

HS	Step - faulted scarps of the Rift Valley
L	Plateaus and High-level structural plains.
R	Volcanic Footridges
LS	Step-faulted floor of the Rift Valley

Explanation of second character (Lithology)

B	Basic and Ultra-Basic Igneous Rocks (basalts, nepheline, phonolites, older basic tuffs included)
V	undifferentiated or various igneous Rocks.

(adapted from FURP 1987, Laikipia report)

These generalised soil classification can be integrated with the spatial distribution of agro-ecological zones as they occur in the local areas in the Division.

Table 20

Area	Agro-eco-zone	General soil Classification
Ol arabel Valley	LH_3	RB5, LB 12
North Western	LH_4	LB9, HSVI
Eastern side	LH_5	LB9
North-Southern	UM_6	LB3 with intrusions LB1
Muktan area (Muktan Gorge)	UM_4 UM_5	HSVI LSB1

Source: 1. FURP 1987
2. Jaeltzold R and Schimdt 1983
3. Field Survey

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North-Southern	UM_6	LB3 with intrusions LB1
Muktan area (Muktan Gorge)	UM_4 UM_5	HSVI LSB1

Source: 1. FURP 1987
2. Jaeltzold R and Schimdt 1983
3. Field Survey

Table 21

Local Areas represented

Ol arabel Valley AEZ LH_3, Soils RB5, LB12	- Kiambogo, Theria, Karandi Mohotetu, Thigio, Kirima, Tandere, Gatirima, Karaba Chereta, Kinamba, Kiamburi, Matuiku, Mrimatatu, Ngeresha, Ndindika
North western AEZ LH_4, Soils LB9, HSVI	Ndindika (18), Wangwachi, Bondeni, Sipili, Kabati, Ol arinyiro Ranch
Eastern Side ($AEZ\ LH_5$) soils LB9	Ol moran, Mithuri, Mbogo-ini, Minjore, Gituamba, Kahuho, Githima, Survey, Magandi, Sukuta mugie, Luniek
North-Southern ($AEZ\ UM_6$) soils LB3 with LB1	P and Day Development Ranch and environs (extreme north-southern part of the division
Muktan area and Muktan Gorge (UM_4 & UM_5) soils HSVI LSB1	Includes areas surrounding the Muktan Gorge.

Source: Field Survey

Major Soil Characteristics and Climatic Conditions:

Agro-eco-zone	Soil properties
(A) LH_3 and transition zones to LH_4	1. drainage - well drained 2. Effective depth - deep (80-120cm) 3. Nutrient availability - moderate Top soil - non- humic 4. moisture storage - moderate to high (80 - 120 mm to 120 - 160 mm) soil classification = Nito-chromic and nito ferric LUVISOLS
(B) LH_4 & LH_5	drainage = well to moderately well grained. Effective depth = deep 80 - 120 cm, in places moderately deep 50 - 80 cm Nutrient availability = high to moderately high. Top soil = non-humic to 30-60 cm humic. moisture storage capacity = high to moderately high (120 - 160 mm) soil classification = verto - luvic PHAEOZEMS and chromic LUVISOLS

Other areas mainly LH5 = chromic and ferric LUVISOLS including Um5 and UM6 (adapted from FURP 1987, Laikipia Report).

From the foregoing analysis it is clear that soil fertility differs considerably in the division. However, it is important to note that low potential zone of the division has soils with high fertility, the medium potential zone has soils with variable fertility and the high potential zone of the division has soils with moderate to high fertility.

This phenomenon displayed by the three agro-potential zone concurs closely with the evolutional development of crop production in the Division. Areas where crop production practices were started earlier tend to have moderate to high fertility. Fertility tend to increase as the agro-potential decreases. However, apart from the duration of time the land has been subjected to crop production, other climatic/physical factors influence this phenomenon. It can be concluded therefore that agricultural productivity in Ng'arua Divisions is more influenced by climatic conditions especially rainfall rather than the fertility of the soil. The crop/vegetation and water interface dictates the resouce potential or the biomass production.

Soil depth is very important in environmental consideration. In Ngarua Division it is clear from the analysis that the low potential region of the division (Olmoran, Luniek, Sukuta mugie, and surrounding areas) have moderatly deep soils compared with the deep soils found in the medium and high potential zones. In Ol arabel for instance, the soils are extremely deep, it displays eutric NITOSOLS with nitochromic CAMBISOLS. However, as we move towards the central parts of Ol arabel, that is areas around Gatirima, the soils are imperfectly drained with deep, dark greyish brown, firm clay (hard plan), abruptly underlying a top soil of sandy clay loam. This soil is classified as eutric Planosols. As we move to Kinamba, Ndindika and Sipili zones, the soils are well drained. The effective depth range from moderately deep to deep (50 cm - 120 cm). Soils are reddish - brown. However some areas have shallow soils interupted by rocky areas. The major soil classification in these areas is Chromo - Luvic Phaeozems. In Mlimatatu, There are extended rocky areas.

In Ol moran and surrounding areas, the soils are well-drained but depth varies from shallow to moderately deep. It is reddish brown, firm clay loam with humic top soil. This soil is classified as chromo-luvic Phaeozems but partly has a lithic phase.

Soil depth determines the sensitivity of an area to trampling and cultivation and therefore erosion/deterioration. In shallow soil environment, the soil-water regime can easily be affected by exposing the soil.

The NOrth-Western part of the Division which includes, Muktan Gorge area and the extreme North of ari-nyiro Ranch, the soil fertility is variable. However, the area is frequently interupted with steep slopes which are unsuitable for cultivation and has shallow soils which make the area extremely important for environmental considerations. Subsequently, pockets of steep slopes unsuitable for cultivation extend as far as Ndindika and Mlimatatu environs. These steep slopes continues through Matuiku and Ngeresha region, Muteta, and areas bordering the Baringo District off Muchongoi (in Baringo District). These areas have shallow soils marked with rocky areas and characterised with rugged steep slopes and valleys.

4.08 VEGETATION

The vegetation of the Division varies in accordance with the agro-ecological potential. In Ol arabel valley, the vegetation is Montane acacia vegetation (from Sclerophyll forest). This kind of vegetation decreases as one moves towards the agro-ecological zone 4 where the montane acacia forests are replaced by cedar forest before agro-ecological zone 3 characteristics dimishes. In agro-eco-zone 4, the main vegetation is extended bush-land interupted in places by grass. The bushland extends until bush and thicket dominates the vegetation to the North - Western part of the Division. However, agro-ecological zone 5 and 6 is dominated by scattered bushes with grass and the vegetation becomes scarce in agro-eco-zone 6.

It is imperative to mention that, prolonged grazing has modified the existing vegetation in the Ranches leading to Xerophytisation of the dominant vegetation. In areas where small scale farmers have settled, the vegetation is cleared and only in few patches where the land is left for grazing that the original vegetation is found. Woodfuel and charcoal burning has decreased the prolificacy of bushes and thickets.

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CHAPTER FIVE

The chapter gives an account of the syntheis of the findings of the study. In this context it integrates the findings with the planning implications as reflected from the data analysis.

It is in the outline of the data synthesis that mapping of environmental thresholds are done. Maps depicting the environmental situation delineated in the context of negative environmental consequences are given. In every environmental dimension, a map showing the threshold ratings expressed in every negative environmental consequence is given.

A sub-topic;planning decision and implication examine how environmental threshold studies fit in the overall land-use planning process and planning implications that are important in use of the concept are highlighted.

The chapter incorporates the issues in application of environmental threshold approach to agricultural land-use planning. This underscores the fact that, the study from the onset was an experimental effort to test the applicability of the threshold concept in agricultural land-use planning. In this context, an account of the pros and cons of the concept is made.

In summary, the chapter attempts to apply the environmental threshold concepts and in the process attests to the applicability of the same in agricultural land-use planning.

CHAPTER FIVE

DATA SYNTHESIS AND PLANNING IMPLICATIONS

5.00 Introduction

From the data analysis, the relationship between agricultural land-use types and agro-ecological potential is clear. However, close to this relationship is the manner in which the environment is utilized. In the previous discussion, it was highlighted that the human impacts to the environment is determined by the political systems of environmental exploitation in the area in question. The whole art of resource utilization is very much influenced by the resource potential of the area and the sensitivity of the ecosystem to mans' labour activities. In this regard agricultural land-use planning is intended to harmonise directly/indirectly the ecological utility and the economic utility of this region taking into consideration the socio-cultural aspects of resource utilization.

5.00.1 Political Systems in Environmental Exploitation

The analysis gave us a clear picture of the political systems of environmental exploitation in Ngarua Division. The culture of resource utilization in this division is based on commercial orientation at the same time serving the subsistence requirement.

The density of population is expected to increase from 55.2 (1988) as a result of migration and natural population growth. In this respect, competition of scarce resources of the environment is expected to increase posing a challenge to resource use planners. Consequently, the negative impacts to the environment are on the increase. This trend of events is further enhanced by the fact, that the tenure system is freehold making the lands and operation therein private.

However, use of government gazetted forest is bordering the "tragedy of commons", as the users do not take any responsibility for environmental considerations. In this respect, demand for wood-fuel and timber is expected to play a major role in the sustainability of this resource. It should be mentioned here that resource rehabilitation measures are spearheaded by the Kenya Government through the Ministries of Agriculture; Environment and Natural Resources and that of Livestock

Development. The individual/private concern of rehabilitation of the environment vis-a-vis conservation/protection is limited to the farm level.

A constraint that the individual farmers face is the small sizes of land under harsh climatic conditions. This form of limitation in many cases renders some areas especially Sipili and Ol Moran regions to experience temporary shortage of food.

The spatial variation in agricultural land-use type is closely related to the spatial variation of land sizes and agro-ecological potential. Land ownership play a greater role in determining the agricultural land-use type. Where the land is leased by individual owners to other prospective farmers, little is put in terms of environmental consideration and choice of crop and thus, operations in the farm are limited. This reflect clearly how politics of resource utilizations affect the use and therefore, the environmental impact of that use.

5.00.2 Agricultural Land-Use Types

Following the analytical discussion on the evolution of agricultural practices in Ngarua Division, it is clear that the spatial variation of agricultural land-use types in the Division is as a result of many factors. Firstly, where the land was under large scale food crop production in the colonial era, the same trend continued when small scale crop production started. However, it is quite remarkable to realise the importance of the climatic conditions and plot sizes (farm sizes). Where farm sizes are relatively small especially the Njorua-Sipili-Ol Moran matrix, it is found uneconomical by farmers to grow crops like wheat because of equipments and husbandry requirements. This influences therefore, the agricultural land-use type in this region.

In areas where Ranching had been the common practice since the colonial era, mixed agricultural land-use types has emerged on what can be called "experimental" farming practices. In this respect, with time, farmers have changed the agricultural land-use practices from mixed crop farming to crop-livestock enterprises. In some parts of the Division, especially in Ol Moran, Survey and Magandi areas, farmers have settled in livestock rearing. These changes are responses to the environmental status of these regions and the land sizes not forgetting the land ownership. In this respect, the system of environmental exploitation is very much related to the resource potential and sensitivity of the environment to human activities.

5.00.3 Environmental Situation

The analysis reveals that over 70 percent of the Division lies in the marginal agricultural area. In this respect, except for the 25 percent of agricultural land that lies in the sub-humid agro-climatic regime, the rest agricultural land suffer from low unreliable rainfall effects.

However, it can be concluded that the Division receives a range of 480 mm to 950 mm of rainfall per annum. This mean that the regions bordering Marmanet Forest is the wettest in the Division followed by the Ol Arabel Valley and Mohotetu regions. The rest of the Division receives rainfall less than 800 mm per annum.

Ironically, the same region is characterised by small farm sizes, ranging from 3-10 acres and has the highest population density in the Division. In environmental considerations, the semi-arid area of the Division requires special attention.

It however, has fertile soils marred by their shallowness thus, very sensitive to human activities. In this respect, wind and water erosion is liable to provoke more menace in areas where the vegetation is denuded.

Ol Arabel region has deep soils but relatively moderate in fertility as compared with the semi-arid region of the Division. However, it is characterised by clay hard pans in some areas. This kind of environmental situation has influenced the agricultural land-use types spatially in the Division and the manner of resource utilization.

3.01 Environmental Consequences

Consequences to the environment are very much related to the resources potential and the sensitivity of the land to man's labour activities. In case of Ngarua Division, the resilience and fragility of the ecosystem is more crucial in determining the consequence resulting from resource utilization. Integrating the major aspects considered in the analysis namely, the socio-economic attributes, the agricultural land-use types and the aspects of the physical environment, it is possible to assess the environmental consequences as a result of the manner of environ-mental exploitation in the Division.

At this juncture, the author wishes to point out that the analysis display a clear picture of the trend the environmental situation is following, and the management aspects thereof. In this respect, it is possible to assess the situation of the environment as it is and by extrapolating experiences from one region to the other or extra-porating the present experiences to the future; expected/probable situation in future can be predicted.

In light of the above, environmental situation in this respect will be assessed on the basis of the impacts to land and/or vegetation by man's labour activities in the process of resource utilization.

5.02 Environmental Situation, Trends and Management

Analysis of environmental situation, socio-economic situation and the political systems of environmental/ resource exploitation was aimed in giving the trends/ tendencies and management aspects of land. In this respect, attributes such as land ownership, land sizes, population size/density laid the framework under which resources are ...zed. However, factors such as prolonged use of certain farm implements, length of cropping season, length of the dry period, landforms and soil types dictates the impacts of agricultural activities in the Division. Subsequently, factors such as the intensity of land-use; number of cropping seasons, type and amount of fertilizer use, crop varieties and animal types, type of implements used in the farm and in general, level of mechanisation dictates the management and thus, future environmental implications of the Division.

Integrating the results of analysis of the above factors form the basis under which negative environmental consequences are assessed. It was mentioned briefly earlier on that negative environmental consequences are to be used as manifestations of environmental thresholds of the area under study. This is possible under the premise that negative environmental consequences are as a result of overstepping of environmental threshold (refer to Figure 1).

The high agro-ecological potential region (agro-eco-zone 3) in the Division displays/exhibits the following aspects; rainfall ranges from 800 mm to

900 mm annually; temperature ranges from 16.5°C to 17.7°C (annual mean), general soil characteristics are; well drained moderately deep to deep, friable to firm clay, moderate fertility and with humic top soils. In this respect, clay loam characteristics are displayed. These general characteristics of the region help us in assessing the environmental situation.

However, to focus on the trends and management, the following characteristics are important; land sizes ranges from 18 to 30 (on average) in Ol Arabel Valley and 10 to 18 (on average) on its environs which includes Mohotetu; land tenure system is freehold and borders with Ol Arabel Forest and Lariak Forest.

One notable trend is that the soil fertility is liable to be lower than it is today if replenishment measures are not intensified. However, this area is usually characterised by growing of maize and/or wheat for commercial purposes. In this respect, soil compaction because of tractor use, combine harvester and associated impliments is certain. In some places soil destructurization through pulverisation by poorly adjusted ploughs is already manifested in Thigio and Theria parts of Ol Arabel

Valley. In Gatirima in particular, the problem of soil compaction is too serious such that soil boulders are a common-place during land preparation period. Subsequently, Kiambogo, Tandare and Karandi regions show trends of soil exhaustion. This is mainly because of the prolcnged use of land under similar farming practices from the colonial era to date. Other trends and management aspects of the environment as concerns the high potential zone are soil erosion especially in Lembus Kongasis and Mlimatatu regions. Localised sheet erosion in Thigio and Gatirima is also common. (See Plate 10 and 11)

Plate 10: Erosion in the Gatirima area. Note the fence post that has been knocked down by erosion.

Plate 11: Sheet erosion is common in selected places in Ol Arabel Valley.

Medium potential zone (AEZ4) is characterised by two form of agriculture. Ranching to the north and small scale crop production to the south. However, this region exhibitis the following characteristics; rainfall ranges from 600mm to 800mm per annum, temperatures ranges from 15.6°C to 17.7°C (annual mean), soils are well drained, shallow to moderately deep, moderately fertile, reddish brown clay loam, with humic top soil. In places the soil is strongly calcareous, rocky and stony clay loam. Rock outcrops are common in isolated areas. Land sizes ranges from 5 to 10 acres on average and land tenure is freehold. However, in Ranches land size varies from 1000 to 5000 acres. Maize is the main crop grown in the area but wheat is found in isolated places.

Livestock rearing mainly goats and sheep is also common. The region has high density of population compared with the high potential zone becuase of the small land sizes. Tractors are used for land preparation. Jembes and pangas are used for tilling of land and weeding.

Environmental trends and management aspects include increased use of manure and chemical fertilisers. At the same time, crop production is usually playing almost the same role as livestock production. In many places especially in the Ranches, over-grazing is common. Vegetation destruction leading to its denudation is common in the settled areas. Where the soils are shallow, wind erosion has taken its toll. This include areas around Sipili, Kabati and Wangwachi. The following plates show some of these aspects.

Low potential zone (agro-ecological zone 5 and 6)

Plate 12: Overgrazing in the Ranching zone. Note the effects of sheet erosion. (Ol Ari Nyiro Ranch)

Plate 13: Denudation of vegetation cover is common in the settled areas. Note the scarce soil vegetation cover. (Wangwachi)

Plate 14: New families are settling despite the the already scanty vegetation cover. (Sipili)

is characterised by the following; rainfall ranges from 480mm to 600mm per annum. Annual mean temperatures ranges from 17.3°C to 20.9°C, soils are well drained shallow to moderately deep, friable to firm clay loam with a humic top soil, the vegetation is extended bushland interrupted by grasses. Land sizes vary from 3 to 5 acres on average and is on freehold tenure system. In ranches, land sizes range from 1000 acres to 5000 acres. The main activity is livestock production. However, maize/livestock enterprises are practiced in some areas especially Githima and Kahuho. In Ol Moran, Survey and Magandi, livestock is the main agricultural activity.

There is marked environmental trend and management aspects. In the settled areas, trends towards livestock rearing is evident. However, this trend is bound to hit a drawback when all the land owners settle in the region. Most land/ plots of land are not settled and the residents who are already settled use this land as common grazing grounds. In this respect, the land is liable to suffer from the effects of tragedy of commons. Overgrazing is common both in the ranches and in the small scale farms. Vegetation destruction and soil erosion is evident and combined effect of human influence and trampling by livestock is destructurizing the soil. Wind erosion is common in Ol Moran especially in the dry period.

5.03 Environmental Threshold Assessment

Environmental threshold assessment in this study is done on the premise that negative environmental consequences are manifestation of overstepping of the environmental threshold. (Figure 1 show a graphical hypothetical representation of the

Plate 15: Where the Ranches/Livestock farms are looked after, the environment can sustain a highly productive enterprises. (A farm in Ol Moran)

Plate 16: Low environmental considerations can however lead to destruction of the environment.

environmental threshold concept). In this respect, negative environmental consequences as identified by analysis of the resource potential and sensitivity of the ecosystem to man's labour activities (agriculture) is very crucial.

The four principles outlined by Kozlowski J. (1985) for rational exploitation of natural resources are used to determine the negative environmental consequences. However, it should be mentioned that to assess the resource potential and sensitivity of the ecosystem, the findings of all aspects considered in the analysis namely, socio-economic situation/political systems of environmental exploitation, agricultural land-use types and the environmental situation which addressed itself to climate and soil aspects are integrated. In essence, the culture of resource utilization, the politics of resource utilization and the economics of resource utilization vis-a-vis - the resource potential and the sensitivity of the natural environment to agricultural activities are the main factors/components that are used to assess the environmental threshold as manifested by the negative consequence.

However, several assumptions are made in the use of every environmental dimension. The four environmental dimensions used are; quantitative dimension, qualitative dimension, territorial dimension and temporal dimension.

Quantitative dimension requires that agricultural land-use activities be developed upto certain levels determined by the resource potential and the degree of tolerance of the ecosystem to negative side-effects. Qualitative dimension requires that agricultural activities be developed at the quality of input which either directly or indirectly will not cause any significant environmental degradation. Temporal dimension requires that agricultural activities should be developed at a rate or time period that conforms with the rythm of the natural processes. Territorial dimension requires that agricultural activities be developed where there are the required resources and where negative side-effects of the activities do not impinge on a sensitive facet of the environment.

These four environmental dimension for environmental threshold consideration are used in this study with drawn-out assumptions. Overstepping of each environmental threshold dimension will result to negative side-effects to the environment. These side-effects referred to as negative environmental consequences are used as manifestation of over-stepping of the environmental threshold of the area in question.

In Ngarua Division, negative environmental consequences as revealed by the data synthesis are; soil exhaustion and/or lowered soil fertility, overgrazing, loss of soil vegetation cover, soil erosion and soil destructurization (pulverisation/compaction). However, these consequences vary in degree of manifestation. In this respect, threshold rating as discussed earlier has been developed to help in environmental mapping/threshold mapping. The ratings are outlined thus;

Threshold/Consequence rating level	Explanation
Level 1	Not significant: This implies that no significant manifestation of the negative environmental consequence. However, the area is vulnerable to negative environmental consequences in future if the current agricultural trend continue.

Level 2 — Significant: This implies that the area has significant manifestation of negative environmental consequences. However, if the present agricultural trends continue, more serious consequences are eminent if conservation measures are not intensified.

Level 3 — Serious: Implies that serious negative environmental consequences are manifested and urgent measures need to be taken to reverse the situation.

Level 4 — Very serious: Implies that serious negative environmental consequences are manifested. However, under the present technology, the consequence has reached an irreversible situation. However, heavy investment is required in any attempt to reverse the situation.

These ratings are "coded" on a map to come up with an environmental threshold map. However, before these consequences are mapped, delineation of boundary thresholds is done. In this study, individual thresholds from each of the four environmental dimensions are made and finally all the four dimension threshold maps are combined to form the combined regional environmental threshold map.

5.04 Mapping of Environmental Threshold: The Process

After the data analysis, attempt to make judgement of the resource potential and sensitivity of the region to human labour activities is made. In this respect, attempt is made to make judgement of the negative environmental consequences in the study area. To make a comprehensive and in depth judgement, the four environmental threshold dimension namely, the qualitative, quantitative, territorial and temporal dimensions are used.

Reasoned estimates of/and judgement of the existing negative environmental consequences are made for each dimension. However, extrapolation of experiences learned from different areas in the region was used to make valuable judgement of the predicted consequences if the current agricultural trends continue.

In essence, environmental situations are established by integrating all aspects in the data analysis. To be able to map the negative environmental consequences, ranking of the consequences depending on magnitude of manifestation and/or expected intensity of manifestation is done on a level scale of 1 to 4. Rating scale has been discussed in the previous discussions. Ratings for each negative environmental consequence are combined to establish the environmental threshold for every environmental dimension. The four environmental dimension thresholds are combined to make the overall judgement. The overall judgement is used to make the final environmental threshold map of the region.

However, it should be mentioned that while making each individual consequence map (partial environmental threshold maps) for a particularl environmental dimension, a "partial" judgement of negative environmental consequences in their rating levels is made for each local area. This exercise help the user of the environmental threshold map to interprete consequences as they occur in the local areas in the division.

Because negative environmental consequences are used as manifestation of overstepping of environmental threshold of the area, a negative environmental consequence map is a priority in making of the environmental threshold map. In this respect, threshold rating levels show the magnitude to which environmental exploitation has exceeded the environmental threshold level. (compare with Figure 1)

5.04.1 Quantitative Dimension

This requires that agricultural land-use activities be developed upto certain levels determined by the resource potential and the degree of tolerance of the ecosystem to negative side-effects. In defining this dimension, the following assumptions are made; that the technological knowledge of the farmers remain unchanged for the planning period. Other assumption is that agricultural land-use intensities continue to increase as far as population pressure increase.

Overstepping of this environmental threshold dimension in Ngarua Division result to the following negative environmental consequences; soil exhaustion/lowered fertility, overgrazing, loss of vegetation cover, loss of soil moisture and soil erosion.

The spatial distribution of these consequencies are shown in figures 16, 17, 18, 19, 20 and 21.

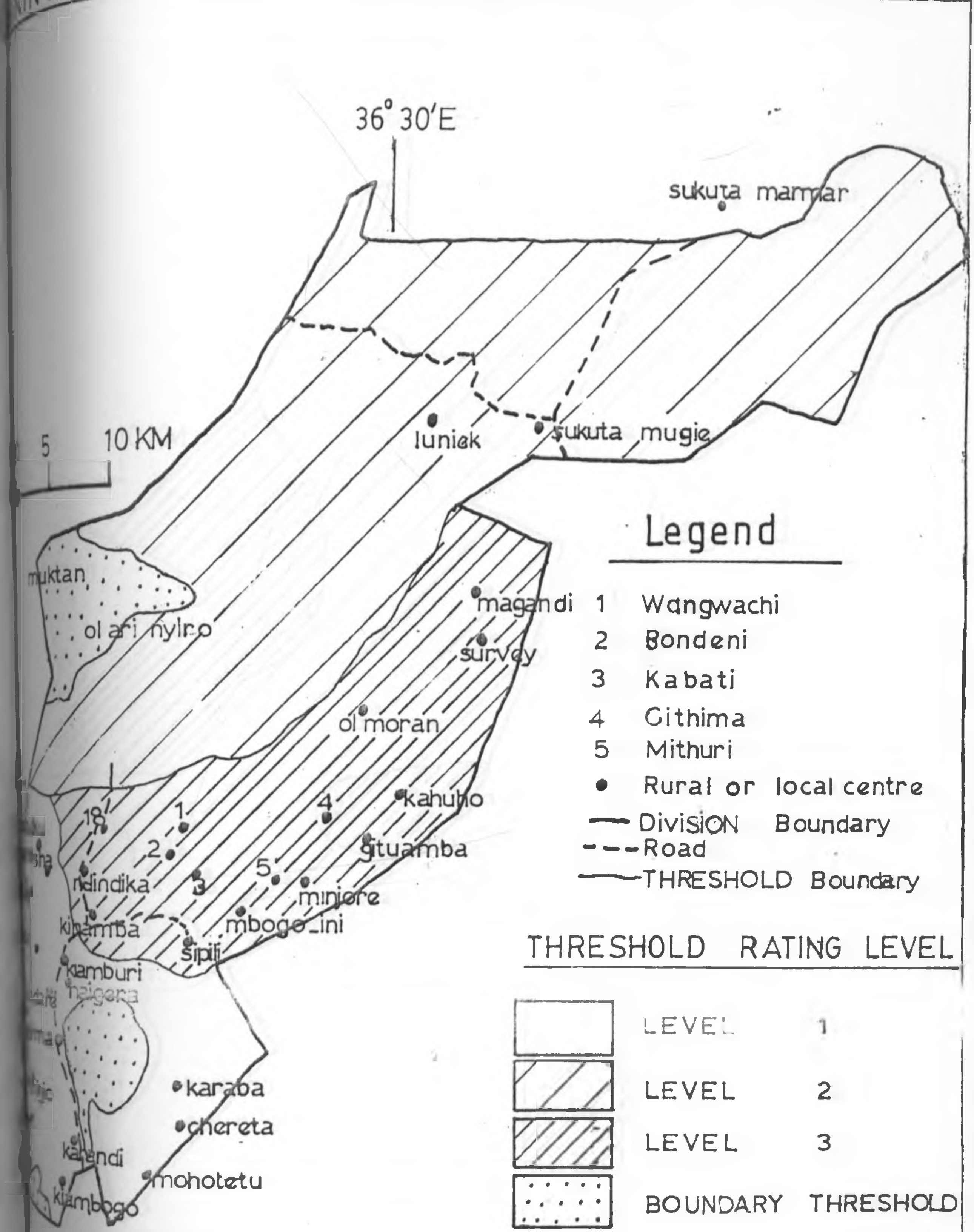
Each negative environmental consequence is mapped to give the spatial partial environmental threshold. Eventually, the partial environmental thresholds are combined to form the combined environmental threshold of Ngarua Division in qualitative dimension considerations.

The combined environmental threshold displays the environmental context of agricultural development in qualitative environmental dimension.

<u>Quantitative Dimension: Map Key to Major Negative Environmental Consequences</u>

Region/ Area	Consequence/ Threshold Rating	Nature of Consequence(s)
Thigio	1	Overgrazing
	1	Soil erosion
	1	Loss of soil moisture
	1	Loss of vegetation cover
	2	Soil exhaustion/ lowered fertility
Kirima	- do -	- do -

ENTAL THRESHOLD IN AGRICULTURAL LAND-USE
NING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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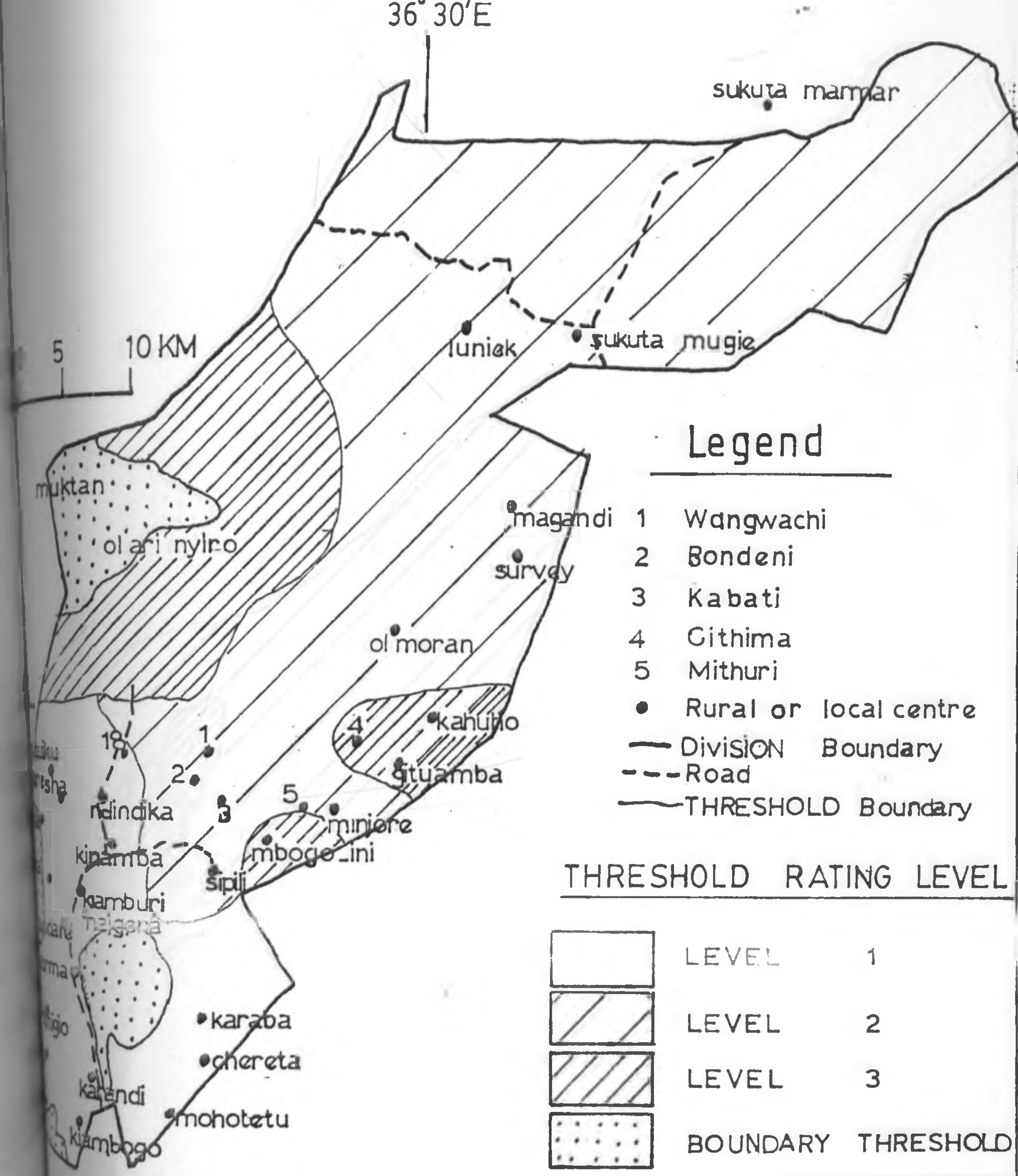
ATIVE ENVIRONMENTAL DIMENSION

ENVIRONMENTAL
NCE: Loss of soil moisture
(partial threshold)

FIGURE 16

...ONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE
...NNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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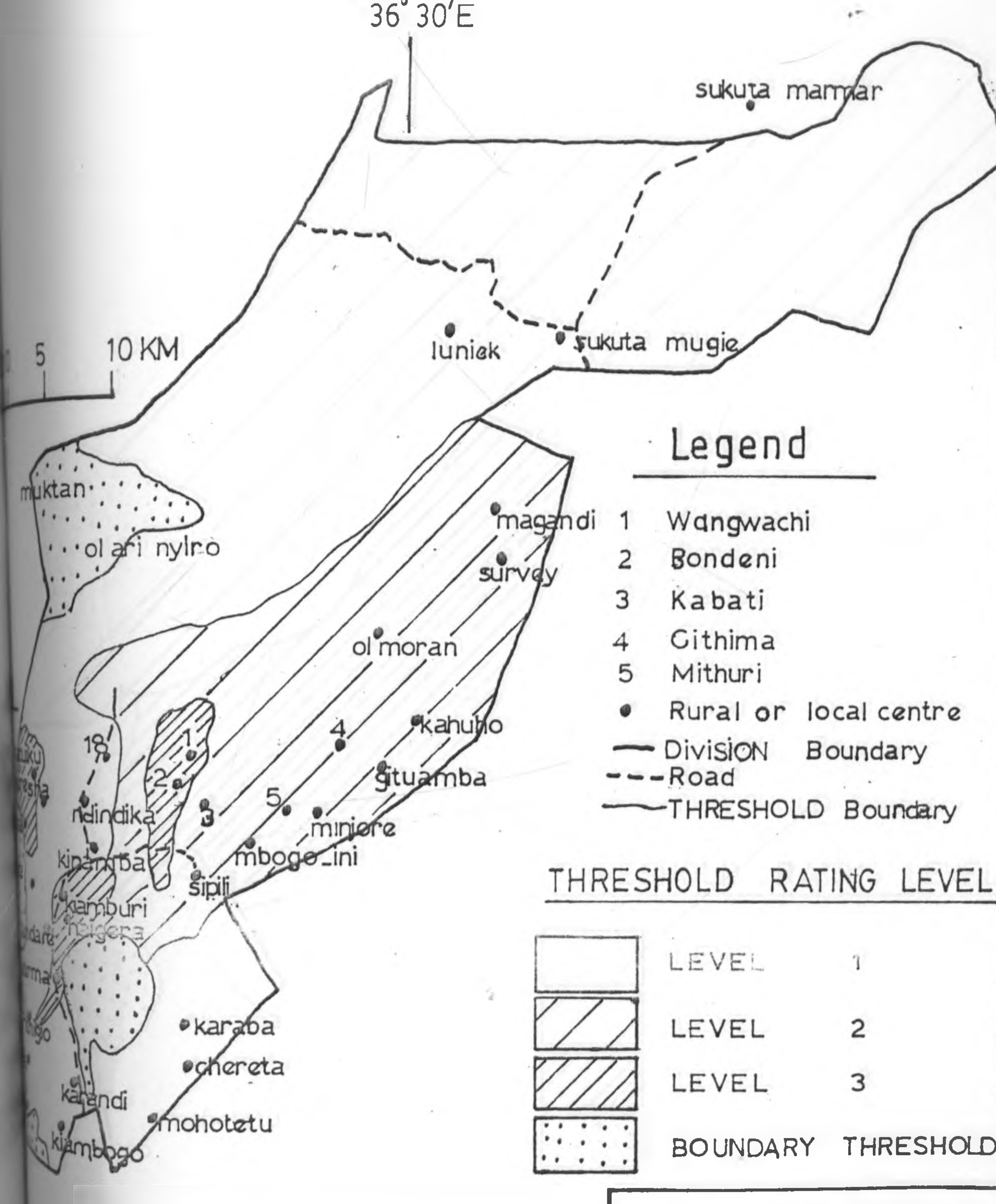
...ENVIRONMENTAL
...NCE: Overgrazing (partial threshold)

FIGURE 17

NMENTAL THRESHOLD IN AGRICULTURAL LAND-USE
NING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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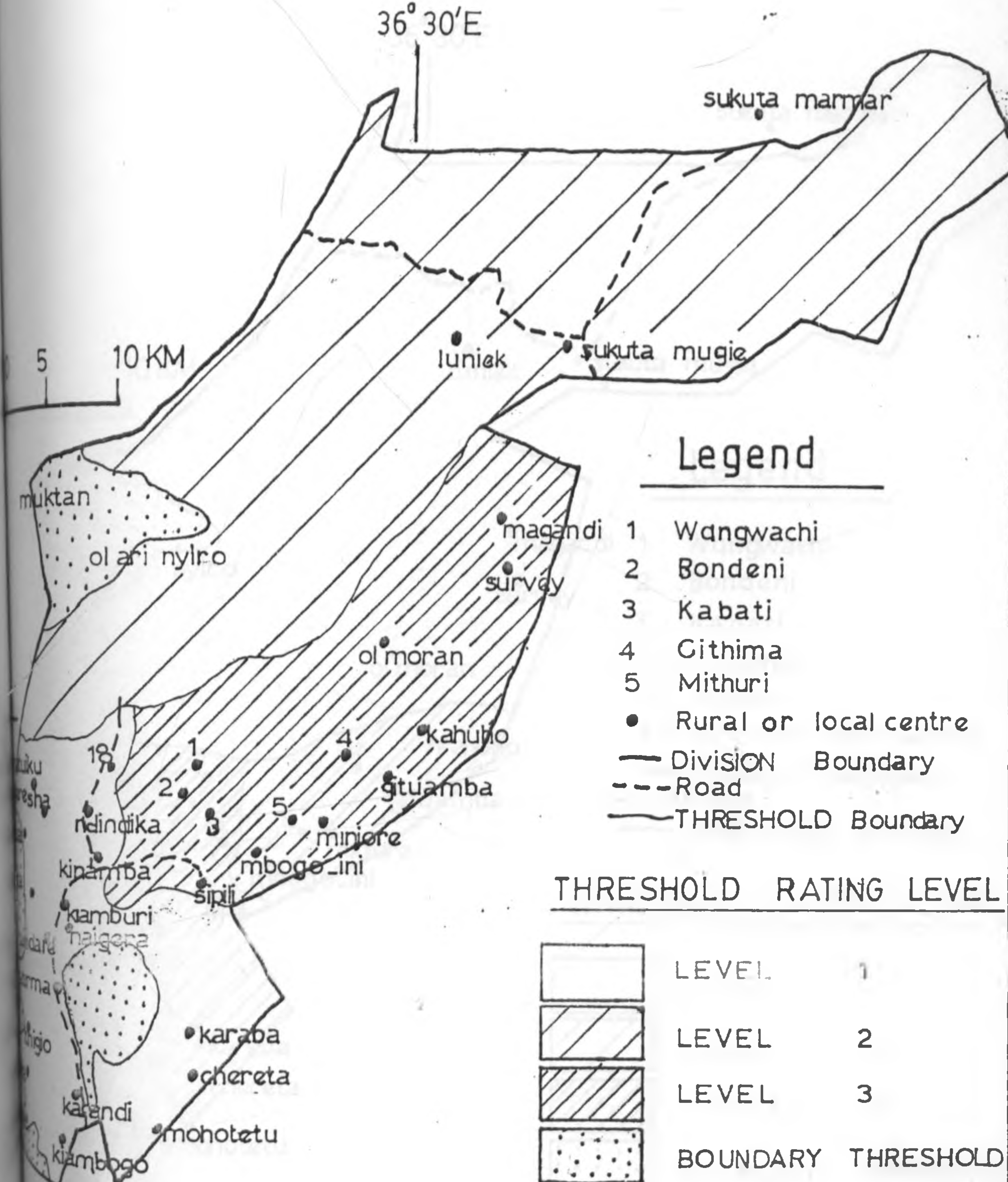
...TIVE ENVIRONMENTAL DIMENSION

ENVIRONMENTAL
...NCE: Soil erosion (partial threshold)

FIGURE 18

...NMENTAL THRESHOLD IN AGRICULTURAL LAND-USE
...NING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



...TIVE ENVIRONMENTAL DIMENSION

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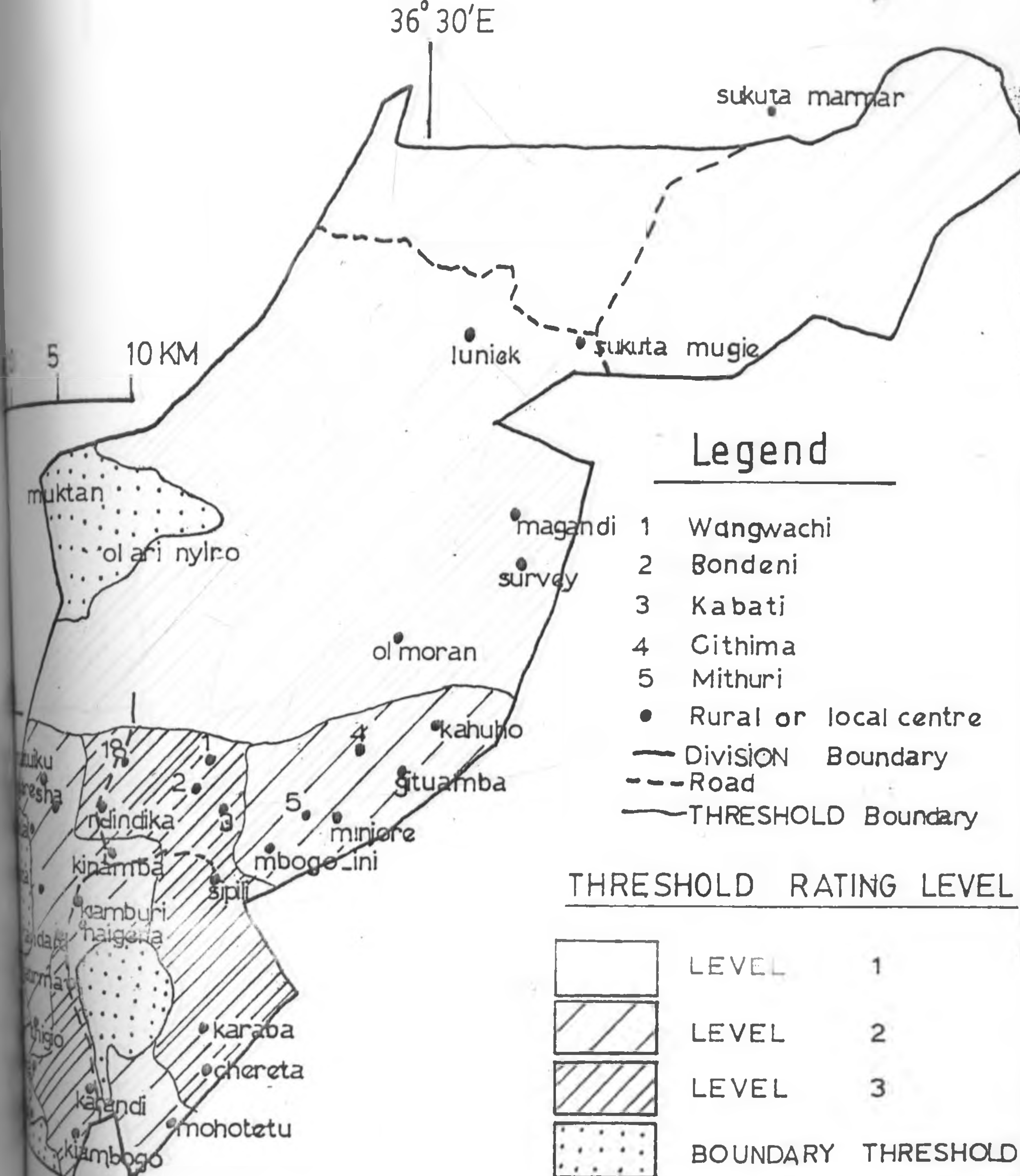
ENVIRONMENTAL
...NCE: Loss of vegetation cover (partial threshold)

FIGURE 19

NMENTAL THRESHOLD IN AGRICULTURAL LAND-USE
NING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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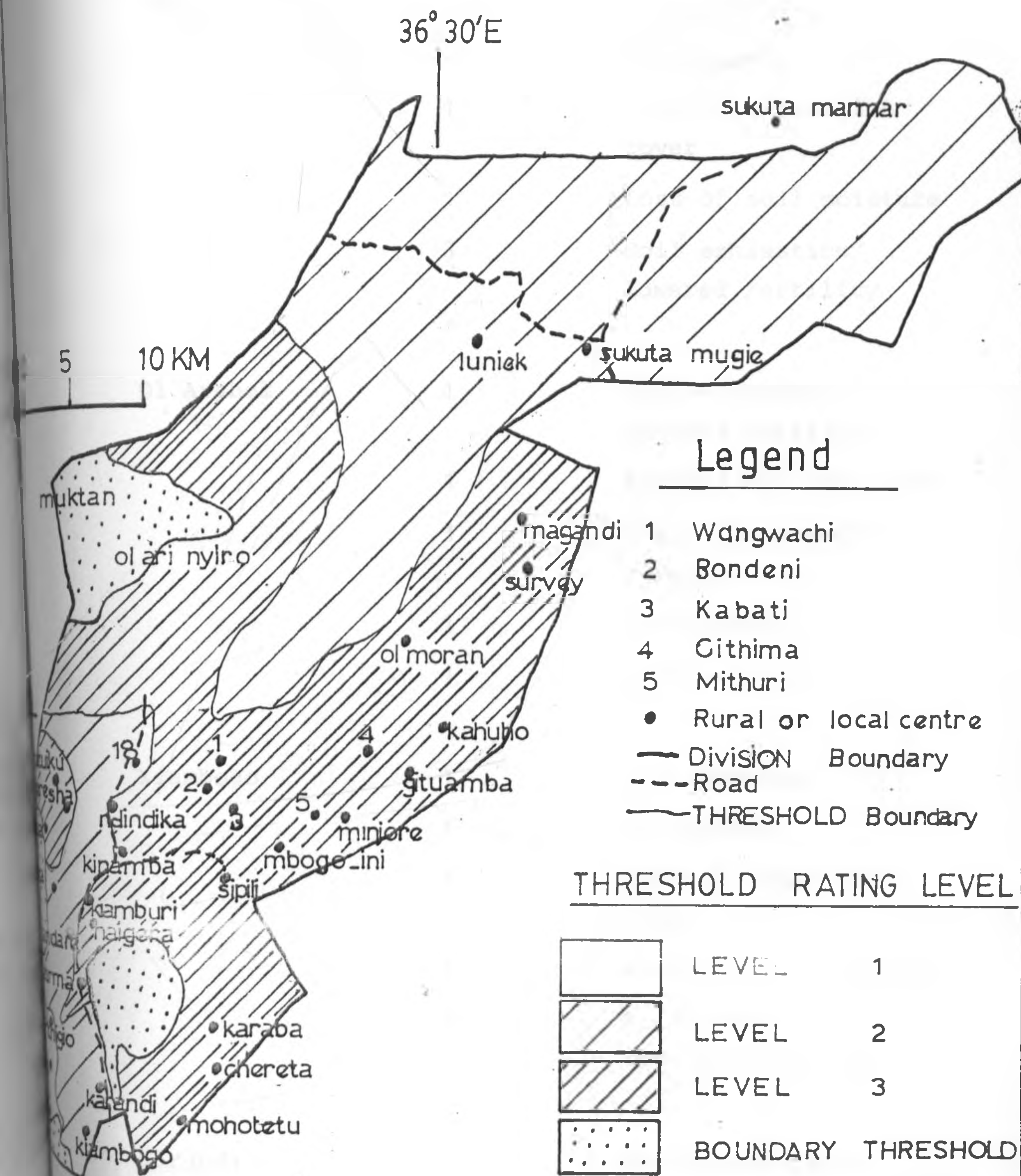
...TATIVE ENVIRONMENTAL DIMENSION

...E ENVIRONMENTAL
...ENCE: Soil erosion/lowered fertility
(Partial threshold)

FIGURE 20

...ONMENTAL THRESHOLD IN AGRICULTURAL LAND-USE
...NNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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...ATIVE ENVIRONMENTAL DIMENSION

...ED THRESHOLD

FIGURE 21

Theria	1	Soil erosion
	1	Overgrazing
	1	Loss of vegetation cover
	1	Loss of soil moisture
	3	Soil exhaustion/ lowered fertility
Ol Arabel	1	Soil exhaustion/ lowered fertility
	1	Loss of soil moisture
	1	Loss of vegetation cover
	1	Overgrazing
	1	Soil erosion
Kiambogo	1	Soil erosion
	1	Overgrazing
	1	Loss of vegetation cover
	1	Loss of soil moisture
	3	Soil exhaustion/ lowered fertility
Karandi	3	Soil exhaustion/ lowered fertility
	1	Loss of soil moisture
	1	Loss of vegetation cover

Karandi (contd)	1	Overgrazing
	1	Soil erosion
Gatirima	1,2	Soil erosion
	1	Overgrazing
	1	Loss of Vegetation cover
	1	Loss of soil moisture
	3	Soil exhaustion/ lowered fertility
Mohotetu	2	Soil exhaustion/ lowered fertility
	1	Loss of soil moisture
	1	Loss of vegetation cover
	1	Overgrazing
	1	Soil erosion
Chereta	1	Soil erosion
	1	Overgrazing
	1	Loss of vegetation cover
	1	Loss of soil moisture
	3	Soil exhaustion/ lowered fertility
Karaba	- do -	- do -

Tandare	1	Soil erosion
	1	Overgrazing
	1	Loss of vegetation cover
	1	Loss of soil moisture
	2,3	Soil exhaustion/ lowered fertility
Muteta (Mithiga)	1	Overgrazing
	1	Loss of soil moisture
	1	Soil erosion
	1	Loss of vegetation cover
	2	Soil exhaustion/ lowered fertility
Mahua	2	Soil exhaustion/ lowered fertility
	1	Loss of vegetation cover
	3	Soil erosion
	1	Loss of soil moisture
	1	Overgrazing
Mlimatatu	1	Overgrazing
	1	Loss of soil moisture
	3	Soil erosion
	1	Loss of vegetation cover

Mlimatatu (contd)	2	Soil exhaustion/ lowered fertility
Kiamburi	2	Soil exhaustion/ lowered fertility
	1	Loss of vegetation cover
	3	Soil erosion
	1	Loss of soil moisture
	1	Overgrazing
Naigera	1	Overgrazing
	1	Loss of soil moisture
	3	Soil erosion
	1	Loss of vegetation cover
	2	Soil exhaustion/ lowered fertility
Ngaresha	2	Soil exhaustion/ lowered fertility
	1	Loss of vegetation cover
	1	Soil erosion
	1	Loss of soil moisture
	1	Overgrazing
Matuiku	1	Overgrazing

Matuiku (contd)	1	Loss of soil moisture
	1	Soil erosion
	1	Loss of vegetation cover
	2	Soil exhaustion/ lowered fertility
Ndindika	3	Soil exhaustion/ lowered fertility
	1	Loss of vegetation cover
	1	Soil erosion
	1	Loss of soil moisture
	1	Overgrazing
18	1,2	Overgrazing
	3	Loss of soil moisture
	1,2	Soil erosion
	1,2	Loss of vegetation cover
	3	Soil exhaustion/ lowered fertility
Wangwachi	3	Soil exhaustion/ lowered fertility
	3	Loss of vegetation cover
	2,3	Soil erosion

Wangwachi (contd)	3	Loss of soil moisture
	2	Overgrazing
Bondeni	2	Overgrazing
	3	Loss of soil moisture
	2,3	Soil erosion
	3	Loss of vegetation cover
	3	Soil exhaustion/ lowered fertility
Kabati	3	Soil exhaustion/ lowered fertility
	3	Loss of vegetation cover
	3	Soil erosion
	3	Loss of soil moisture
	2	Overgrazing
Mbogoini	3	Overgrazing
	3	Loss of soil moisture
	2	Soil erosion
	3	Loss of vegetation cover
	2	Soil exhaustion/ lowered fertility
Minjore	2	Soil exhaustion/ lowered fertility

Minjore (contd)	3	Loss of vegetation cover
	2	Soil erosion
	3	Loss of soil moisture
	2	Overgrazing
Mithuri	2	Overgrazing
	3	Loss of soil moisture
	2	Soil erosion
	3	Loss of vegetation cover
	2	Soil exhaustion/ lowered fertility
Sipili	3	Soil exhaustion/ lowered fertility
	3	Loss of vegetation cover
	2	Soil erosion
	3	Loss of soil moisture
	2	Overgrazing
Kinamba	1	Overgrazing
	3	Loss of soil moisture
	1,2	Soil erosion
	1	Loss of vegetation cover
	2	Soil exhaustion/ lowered fertility

Gituamba	2	Soil exhaustion/ lowered fertility
	3	Loss of vegetation cover
	2	Soil erosion
	3	Loss of soil moisture
	3	Overgrazing
Githima	3	Overgrazing
	3	Loss of soil moisture
	2	Soil erosion
	3	Loss of vegetation cover
	2	Soil exhaustion/ lowered fertility
Kahuho	2	Soil exhaustion/ lowered fertility
	3	Loss of vegetation cover
	2	Soil erosion
	3	Loss of soil moisture
	3	Overgrazing
Ol Moran	2	Overgrazing
	3	Loss of soil moisture
	2	Soil erosion
	3	Loss of vegetation cover

Ol Moran (contd)	1	Soil exhaustion/ lowered fertility
Survey	1	Soil exhaustion/ lowered fertility
	3	Loss of vegetation cover
	2	Soil erosion
	3	Loss of soil moisture
	2	Overgrazing
Magandi	- do -	- do -
Ol Arinyiro Ranch	1	Soil exhaustion/ lowered fertility
	2	Loss of vegetation cover
	1,2	Soil erosion
	2	Loss of soil moisture
	2,3	Overgrazing
Luniek (ADC)	2	Overgrazing
	2	Loss of soil moisture
	1	Soil erosion
	2	Loss of vegetation cover
	1	Soil exhaustion/ lowered fertility
Mugie	- do -	- do -

5.04.2 Qualitative Environmental Dimension

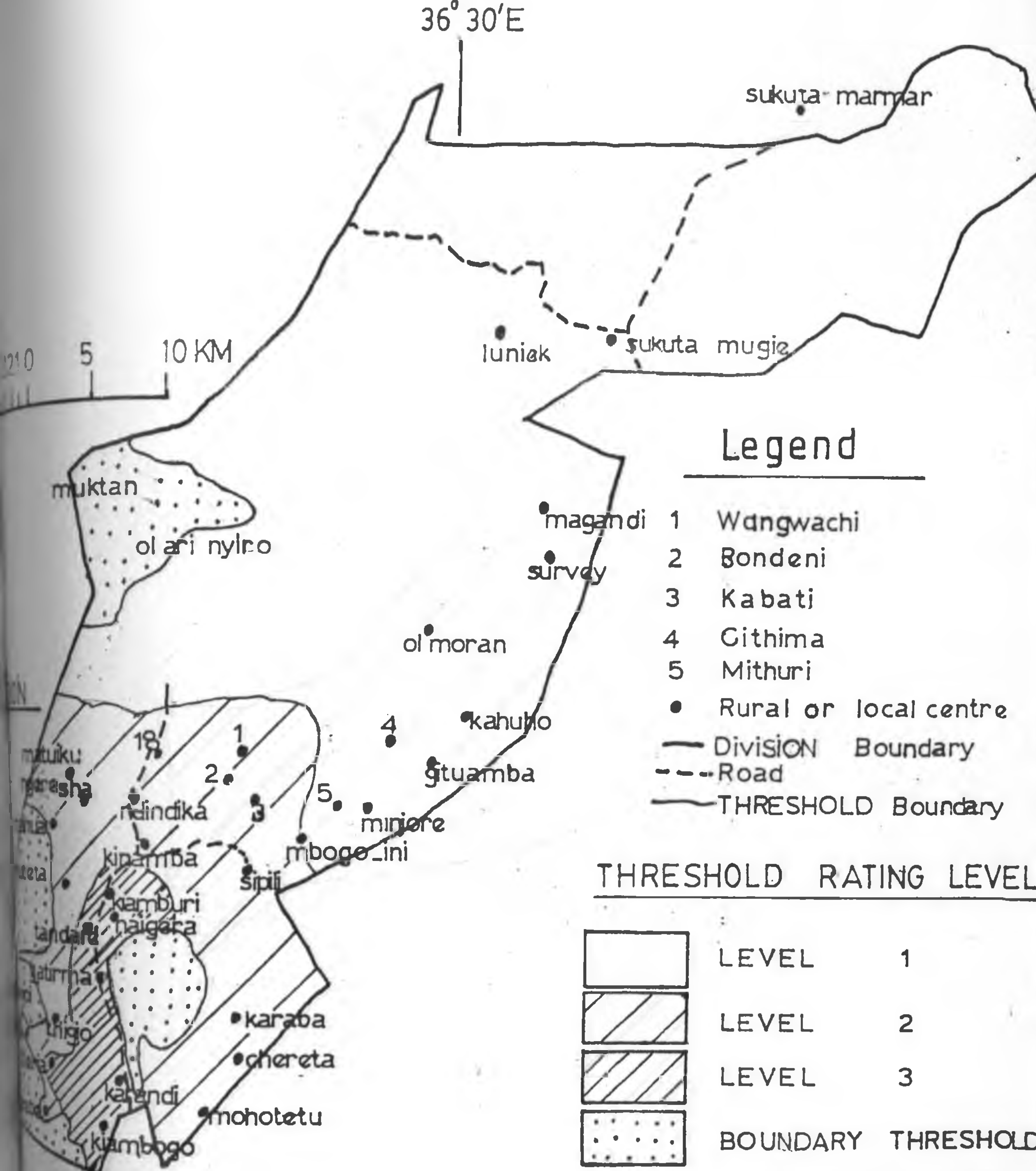
This requires that agricultural activities should be developed at the quality of input which either directly or indirectly will not cause any significant environmental degradation. Assumptions considered in this case are; that farmers objective is to increase the productivity of their farms and its stock and they use to their capability the available or existing technology. The other assumption is that although the technological knowhow is imparted to them, environmental implications caused by these inputs are not well versed to/and therefore by the farmer.

Negative environmental consequences resulting from overstepping this dimension of environmental threshold in Ngarua Division are; overgrazing, and soil destructization which includes pulverization and compaction of soil. The spatial variation of these consequences are shown in figure 22 and 23.

Qualitative Dimension: Map Key to Major Negative Environmental Consequences

Region/ Area	Consequence/ Threshold rating	Nature of Consequence(s)
Thigio	2	Soil destrucrization

...NNING: NGARUA DIVISION, LAIKIPIA DISTRICT



...ATIVE ENVIRONMENTAL DIMENSION

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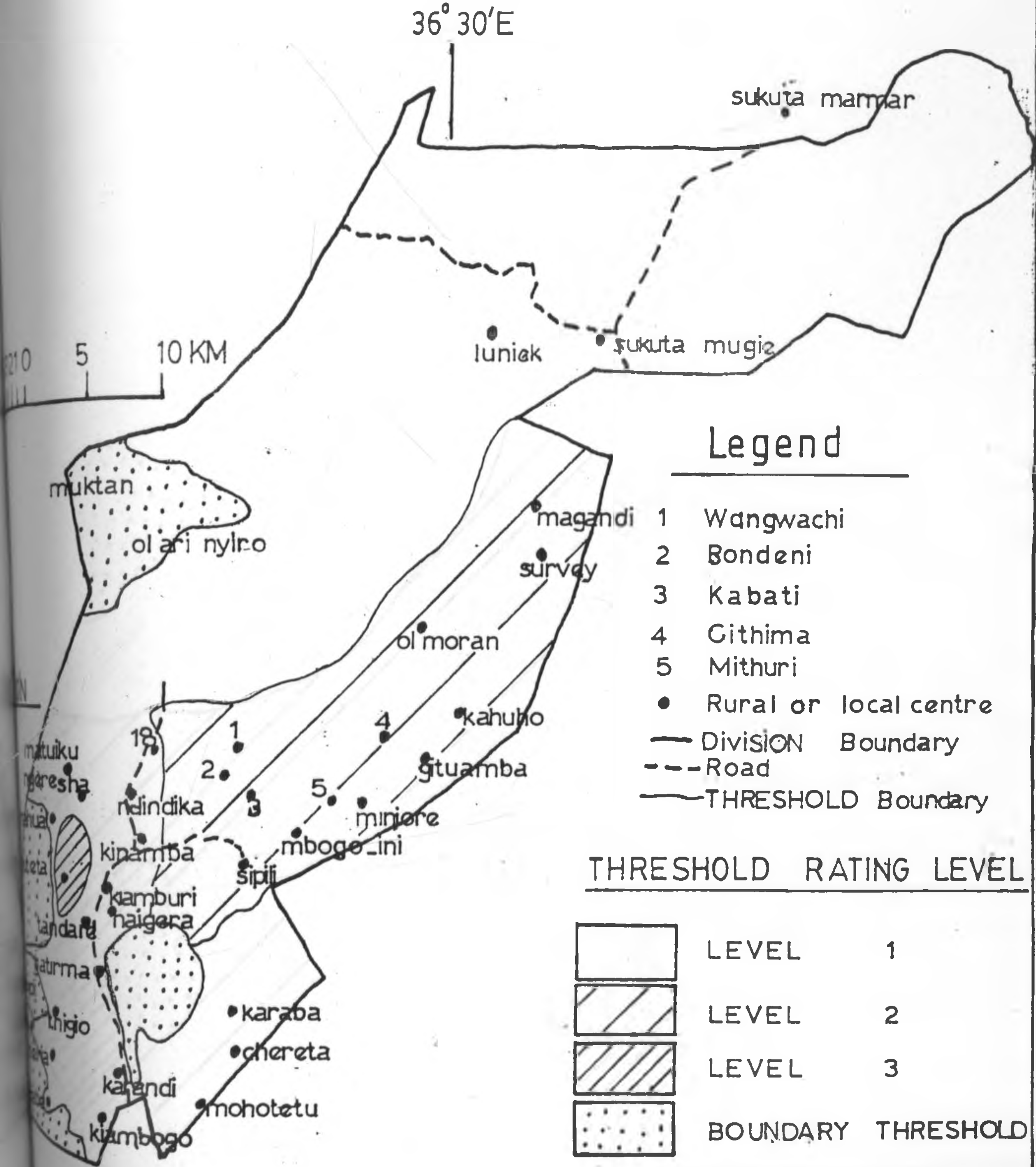
...VE ENVIRONMENTAL ...QUENCE : Soil destructurization (pulverisation/ compaction)[partial threshold]

FIGURE 22

NNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



ITATIVE ENVIRONMENTAL DIMENSION

E ENVIRONMENTAL
UENCE : Overgrazing (partial threshold)

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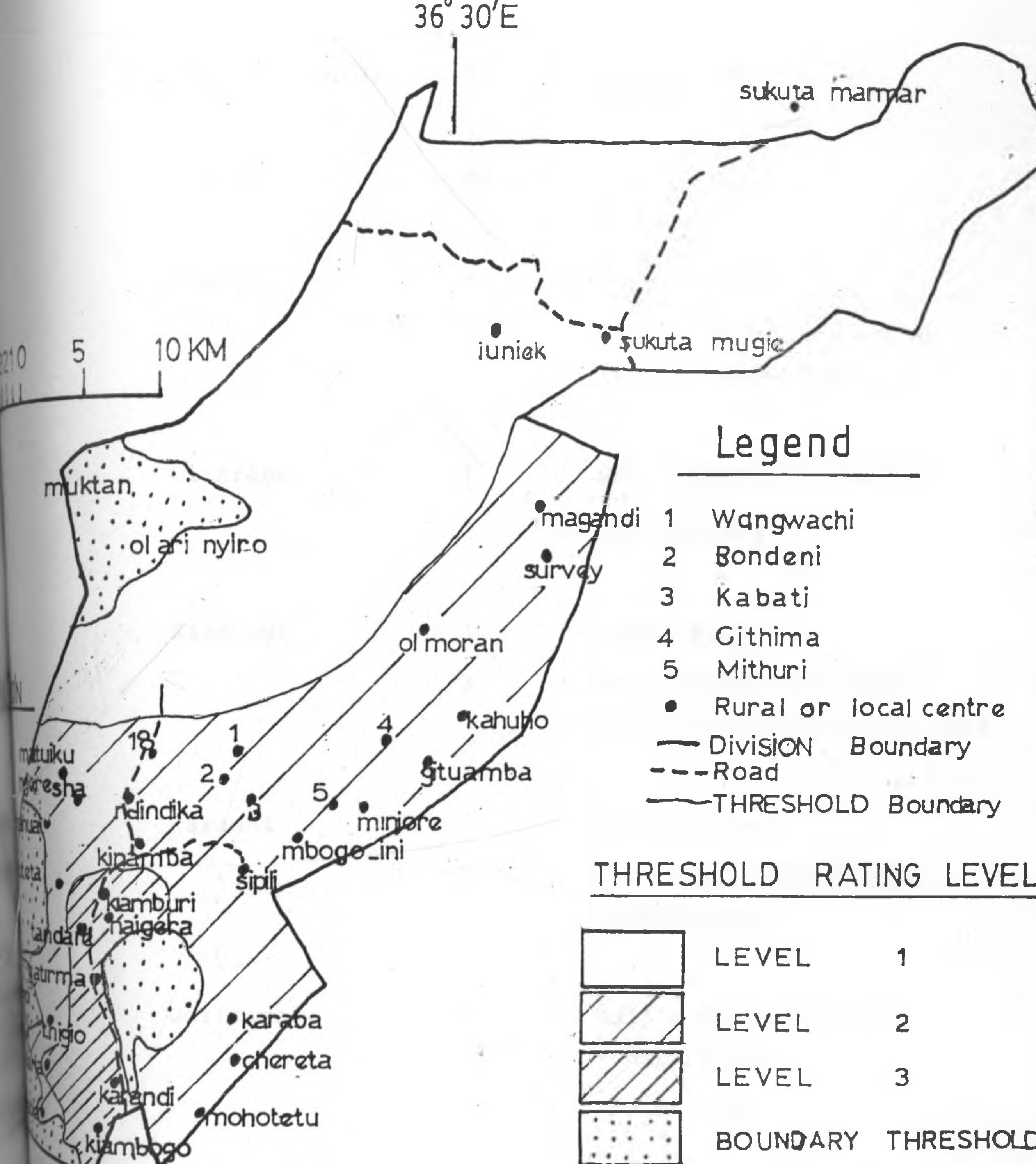
FIGURE 23



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...TATIVE ENVIRONMENTAL DIMENSION

...MBINED THRESHOLD

FIGURE 24

Thigio (contd)	1	Overgrazing
Kirima	- do -	- do -
Theria	1	Overgrazing
	3	Soil destructurization (soil compaction)
Ol Arabel	1	Soil destructurization
	1	Overgrazing
Kiambogo	1	Overgrazing
	3	Soil destructurization (Pulverisation/compaction)
Karandi	1	Overgrazing
	3	Soil destructurization (compaction)
Gatirima	3	Soil destructurization (compaction)
	1	Overgrazing
Mohotetu	2	Soil destructurization (pulverisation/compaction)
	1	Overgrazing
Chereta	1	Overgrazing

Chereta (contd)	2	Soil destructurization (compaction)
Kareba	1	Overgrazing
	2	Soil destructurization (pulverisation/compaction)
Tandare	2,3	Soil destructurization (pulverisation/compaction)
	1	Overgrazing
Muteta (Mithiga)	1,2	Overgrazing
	2	Soil destructurization
Mahua	1	Overgrazing
	2	Soil destructurization (Puliverisation)
Mlimatatu	1	Overgrazing
	2	Soil destructurization (pulverisation)
Kiamburi	1	Overgrazing
	2,3	Soil destructurization (pulverisation)
Naigera	1	Overgrazing
	2,3	Soil destructurization (pulverisation)

Ngeresha	1	Overgrazing
	2	Soil destructurization
Matuiku	1	Overgrazing
	2	Soil destructurization (pulverisation)
Ndindika	1	Overgrazing
	2	Soil destructurization (pulverisation/compaction)
18	2	Soil destructurization (pulverisation/compaction)
	1	Overgrazing
Wangwachi	2	Overgrazing
	2	Soil destructurization (pulverisation)
Bondeni	2	Overgrazing
	2	Soil destructurization (pulverisation)
Kabati	2	Overgrazing
	2	Soil destructurization (pulverisation)
Mbogoini	2	Overgrazing
	1,2	Soil destructurization

Minjore	2	Overgrazing
	1	Soil destructurization (pulverisation)
Mithuri	2	Overgrazing
	1	Soil destructurization
Sipili	2	Overgrazing
	2	Soil destructurization (pulverisation)
Kinamba	1	Overgrazing
	2,3	Soil destructurization (pulverisation/compaction)
Githima	2	Overgrazing
	1	Soil destructurization
Kahuho	2	Overgrazing
	1	Soil destructurization
Ol Moran	2	Overgrazing
	1	Soil destructurization
Survey	2	Overgrazing
	1	Soil destructurization
Magandi	- do -	- do -

Ol Arinyiro Ranch	1	Overgrazing
	1	Soil destructurization
Luniek	- do -	- do -
Mugie	- do -	- do -

5.04.3 Territorial Dimension

In this dimension of environmental considerations, agricultural activities are required to be developed where there are the required resources and where negative side-effects of activities do not impinge, on a sensitive facet of the environment. To operationalize this, the assumption made is that choice of any farming area by the farmers is determined by availability of land and farmers engaged in any farming activity regardless of land conditions/climatic conditions.

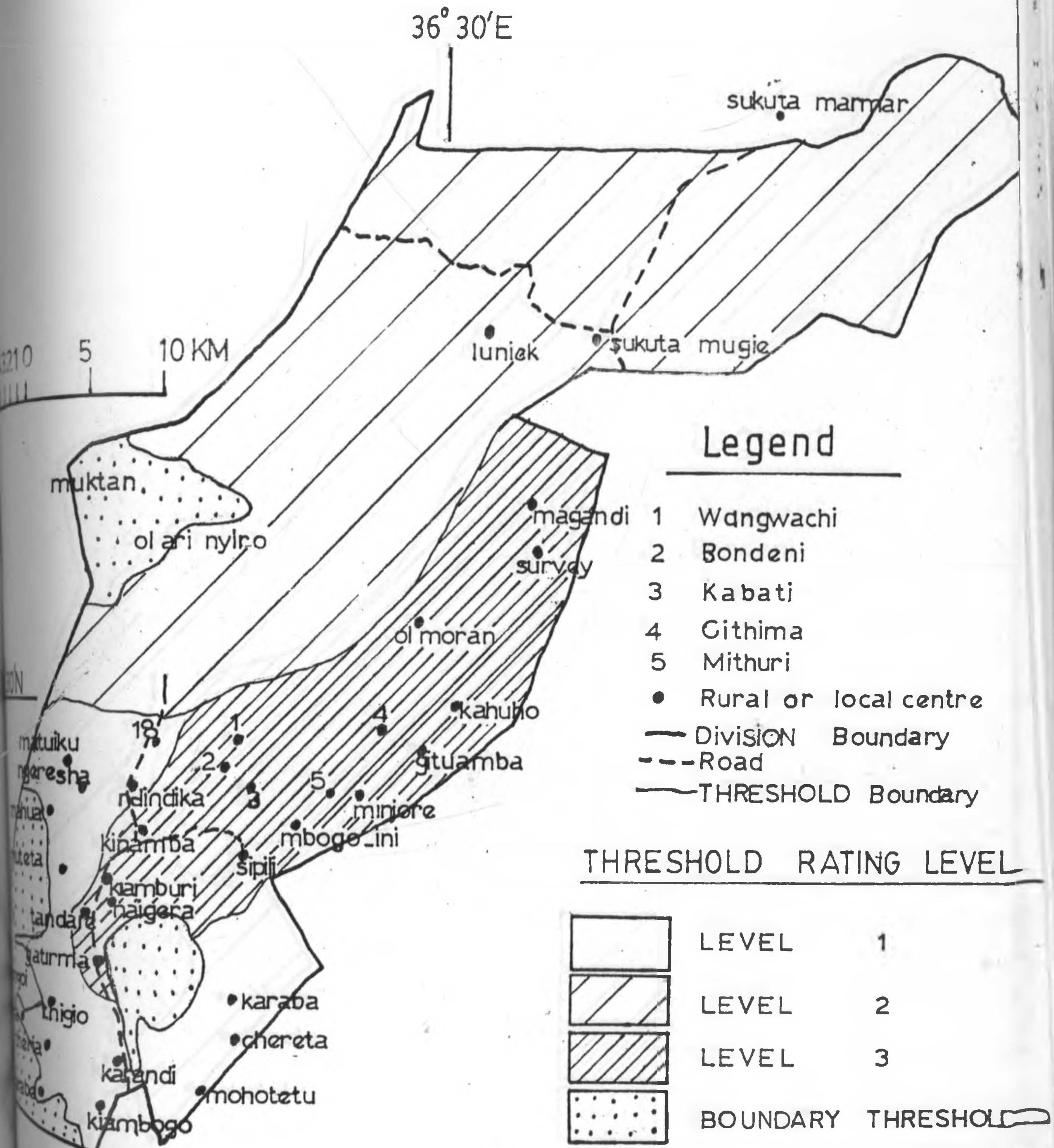
In Ngarua Division, analysis has come up with the following negative environmental consequences after this environmental threshold dimension has been overstepped; soil exhaustion/lowered fertility, loss of vegetation cover, soil erosion and soil destructurization.

Each of these consequences is "coded" on a map. After all consequences are mapped (which constitutes partial environmental thresholds) a combined threshold map is made. This forms the territorial environmental dimension threshold map.

Territorial Dimension: Map Key to Major Environmental Consequences

Region/local Area	Consequence/ Threshold Rating	Nature of Consequence(s)
Thigio	2	Soil destructurization (pulverisation/compaction)
	1	Soil exhaustion/lowered fertility
	1	Loss of vegetation cover
	1	Soil erosion
Kirima	- do -	- do -
Theria	1	Soil erosion
	1	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	2,3	Soil destructurization (pulverisation)
Ol Arabel	2	Soil destructurization (pulverisation)

...NNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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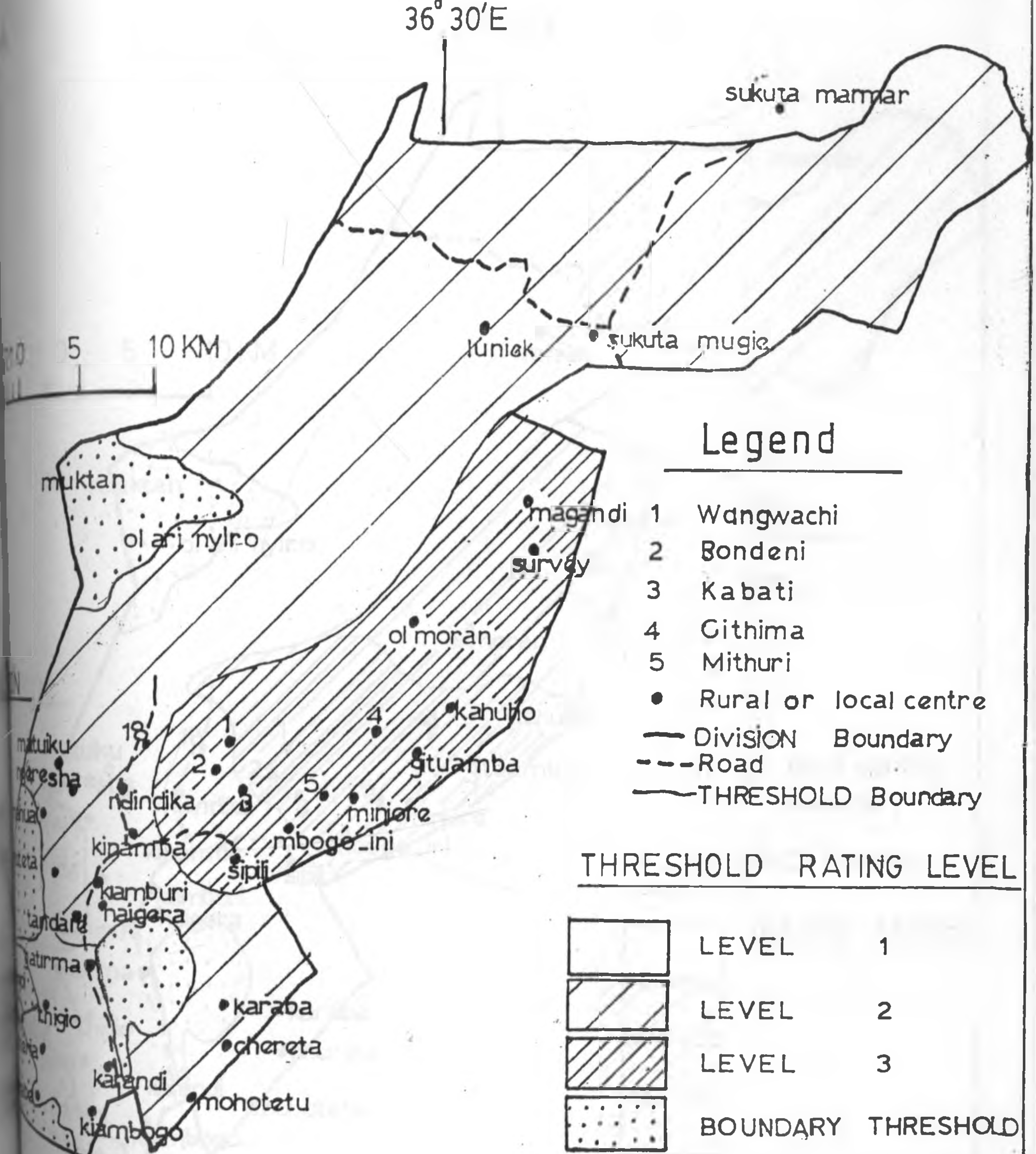
...RITORIAL ENVIRONMENTAL DIMENSION
...IVE ENVIRONMENTAL
...EQUENCE: Soil erosion (partial threshold)

FIGURE 25

NNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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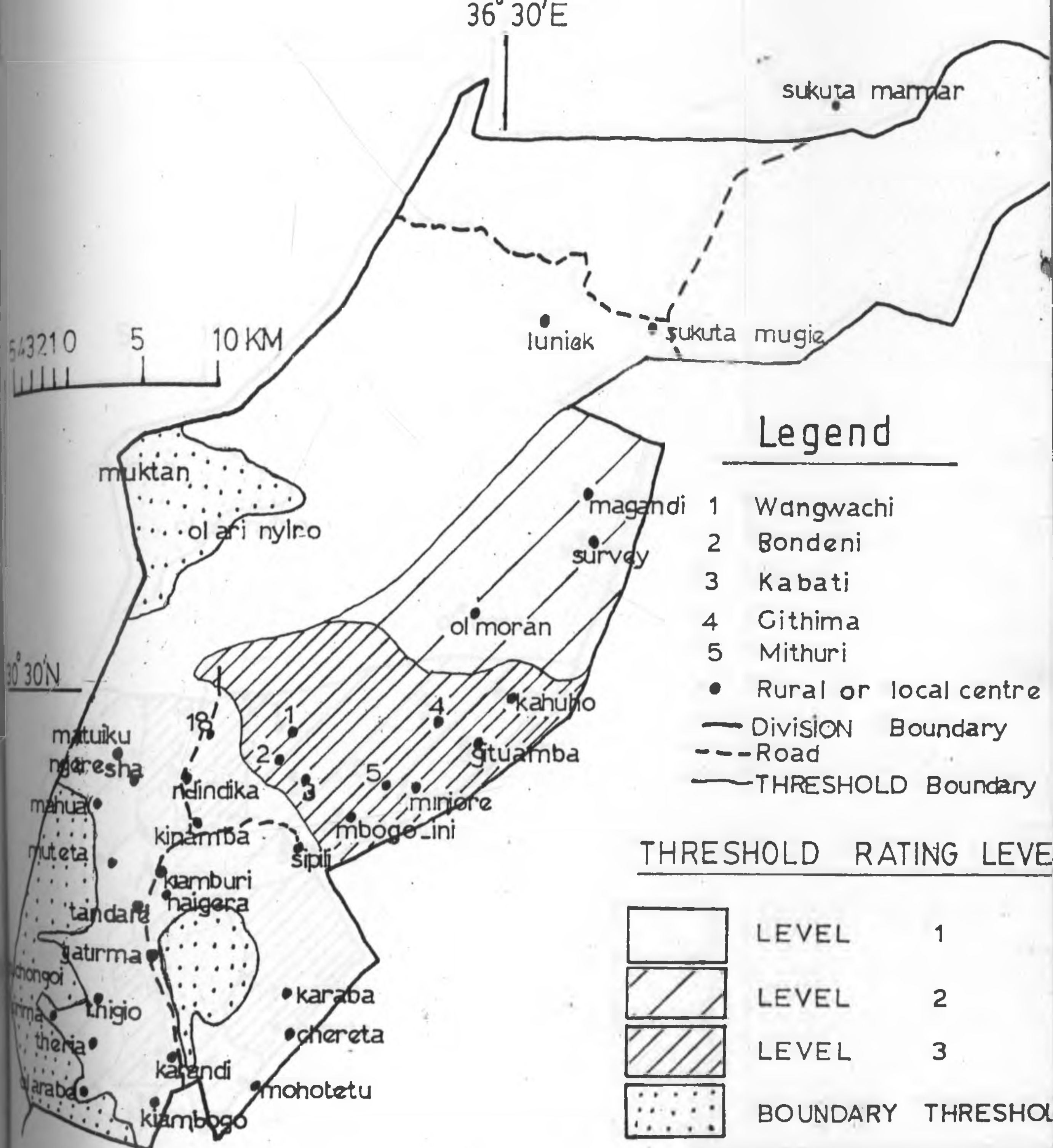
TORIAL ENVIRONMENTAL DIMENSION

VE ENVIRONMENTAL
UENCE : Loss of vegetation cover (partial threshold)

FIGURE 26

…THRESHOLD IN AGRICULTURAL LAND-USE
PLANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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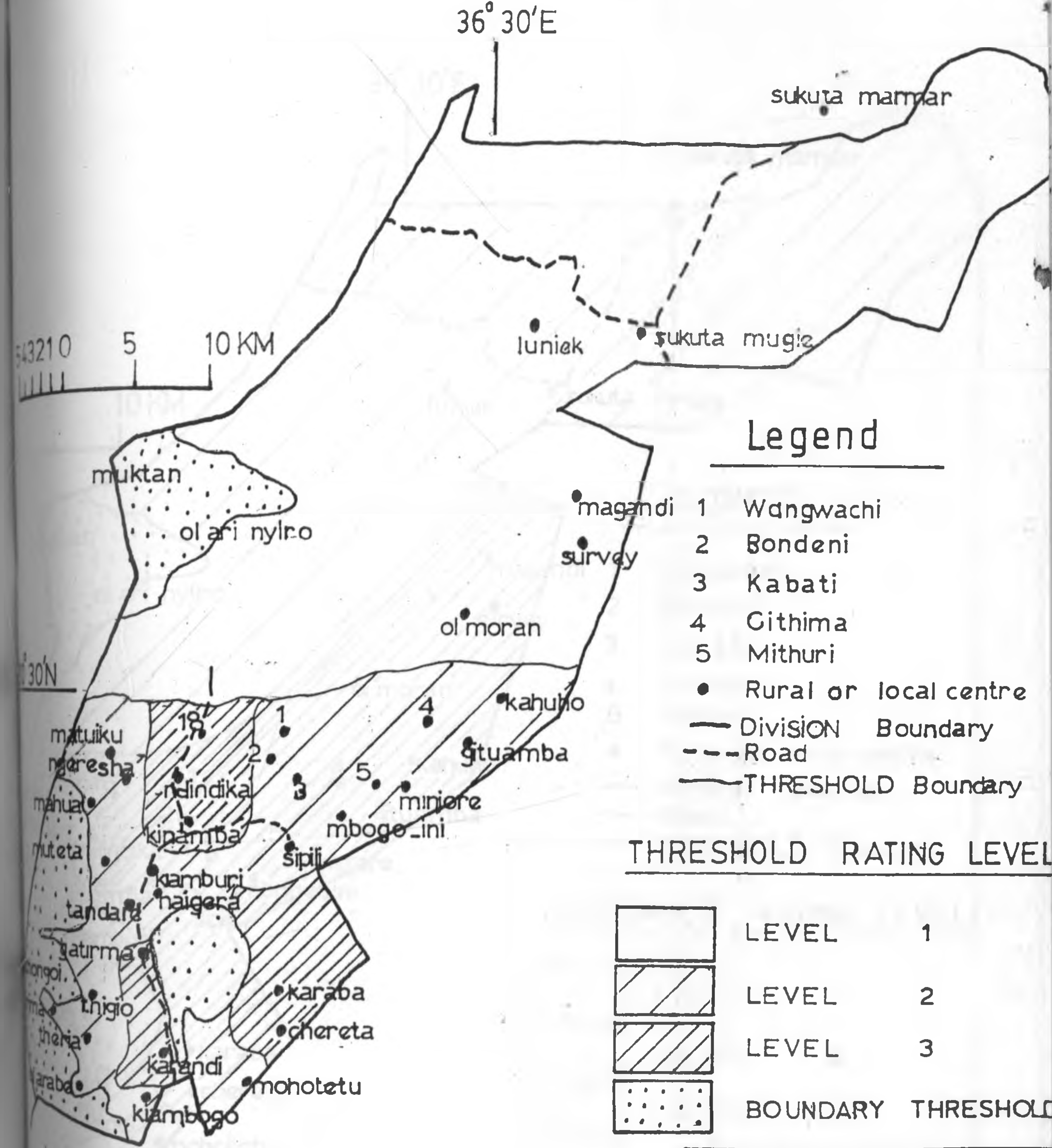
ERRITORIAL ENVIRONMENTAL DIMENSION

ATIVE ENVIRONMENTAL
NSEQUENCE : Soil exhaustion/lowered fertility
tial threshold)

FIGURE 27

LANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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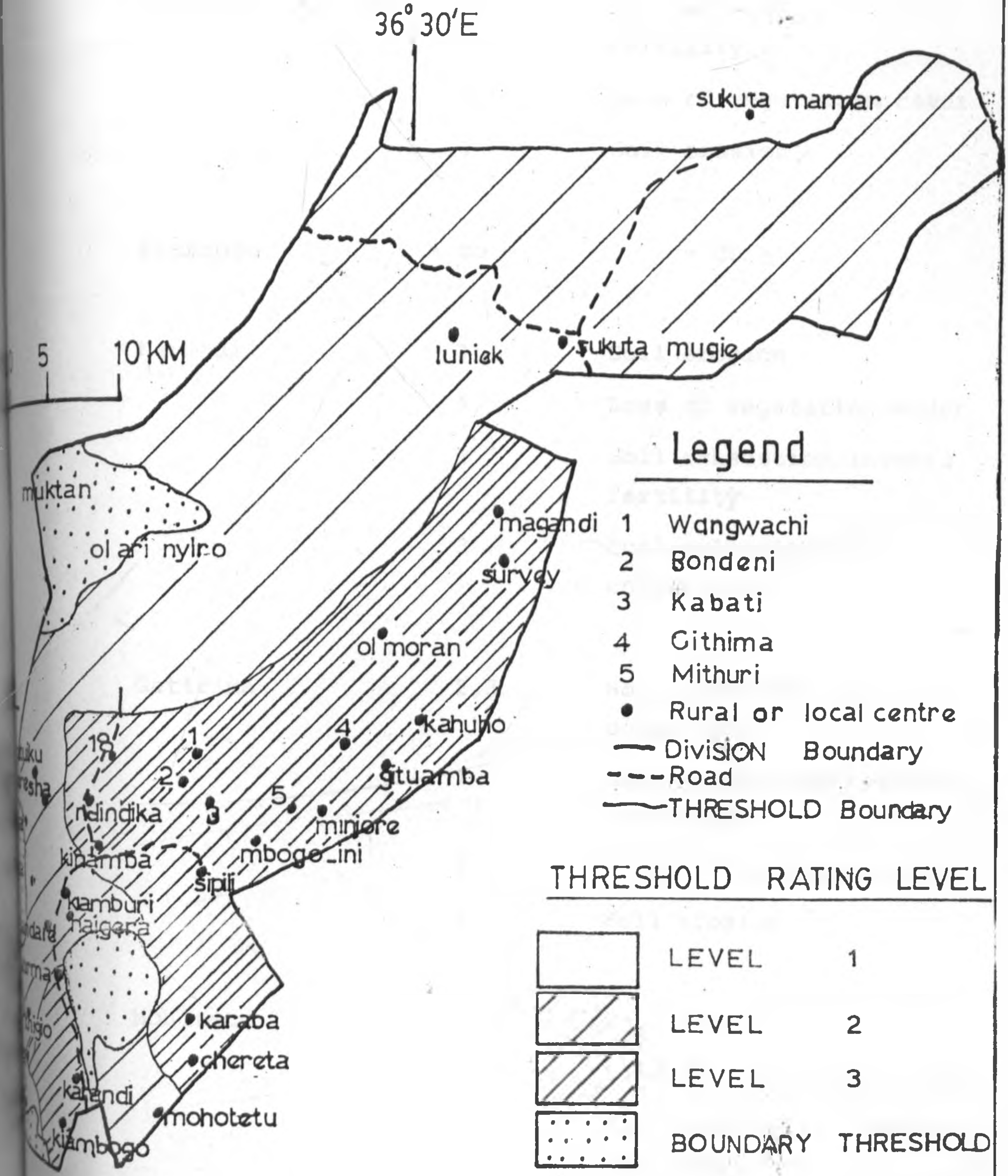
ERRITORIAL ENVIRONMENTAL DIMENSION

STIVE ENVIRONMENTAL
SEQUENCE : Soil destructurization(pulverisation/ mpaction) [partial threshold]

FIGURE 28

NMENTAL THRESHOLD IN AGRICULTURAL ... -USE
NING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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AL ENVIRONMENTAL DIMENSION

NED THRESHOLD

FIGURE 29

Ol Arabel (contd)	1	Soil exhaustion/lowered fertility
	1	Loss of vegetation cover
	1	Soil erosion
Kiambogo	- do -	- do -
Karandi	1	Soil erosion
	1	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	3	Soil pulverisation/ compaction
Gatirima	2,3	Soil pulverisation/ compaction
	1	Soil exhaustion/lowered fertility
	1	Loss of vegetation cover
	3	Soil erosion
Mohotetu	1	Soil erosion
	2	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	2	Soil destructurization
Chereta	3	Soil pulverisation/ compaction

Chereta (contd)	2	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	1	Soil erosion
Karaba	- do -	- do -
Tandare	1	Soil erosion
	2	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	2	Soil destructurization (pulverisation)
Muteta (Mithiga)	2	Soil destructurization (pulverisation)
	1	Soil exhaustion/lowered fertility
	2	Loss of vegetation cover
	1	Soil erosion
Mahua	1	Soil erosion
	2	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	2	Soil pulverisation
Mlimatatu	2	Soil pulverisation
	1	Soil exhaustion/lowered fertility

Mlimatatu (contd)	2	Loss of vegetation cover
	1	Soil erosion
Kiamburi	3	Soil erosion
	2	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	2	Soil pulverisation
Naigera	- do -	- do -
Ngeresha	2	Soil destructurization (pulverisation/compaction)
	1	Soil exhaustion/lowered fertility
	2	Loss of vegetation cover
	1	Soil erosion
Matuiku	- do -	- do -
Ndindika	1	Soil erosion
	2	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	3	Soil destructurization (pulverisation/compaction)
18	- do -	- do -

Wangwachi	2	Soil destructurization
	3	Soil exhaustion/lowered fertility
	3	Loss of vegetation cover
	3	Soil erosion
Bondeni	- do -	- do -
Kabati	- do -	- do -
Mbogoini	- do -	- do -
Minjore	- do -	- do -
Mithuri	- do -	- do -
Sipili	3	Soil erosion
	3	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	2	Soil destructurization
Kinamba	1,3	Soil erosion
	2	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	3	Soil destructurization
Gituamba	2	Soil destructurization
	3	Soil exhaustion/lowered fertility
	3	Loss of vegetation cover
	3	Soil erosion

Githima	- do -	- do -
Kahuho	- do -	- do -
Ol Moran	3	Soil erosion
	3	Loss of vegetation cover
	2	Soil exhaustion/lowered fertility
	1	Soil destructurization
Survey	1	Soil destructurization
	2	Soil exhaustion/lowered fertility
	3	Loss of vegetation cover
	3	Soil erosion
Magandi	- do -	- do -
Ol Arinyiro Ranch	2	Soil erosion
	2	Loss of vegetation cover
	1	Soil exhaustion/lowered fertility
	1	Soil destructurization
Luniek	- do -	- do -
Mugie	- do -	- do -

5.04.4 Temporal Dimension

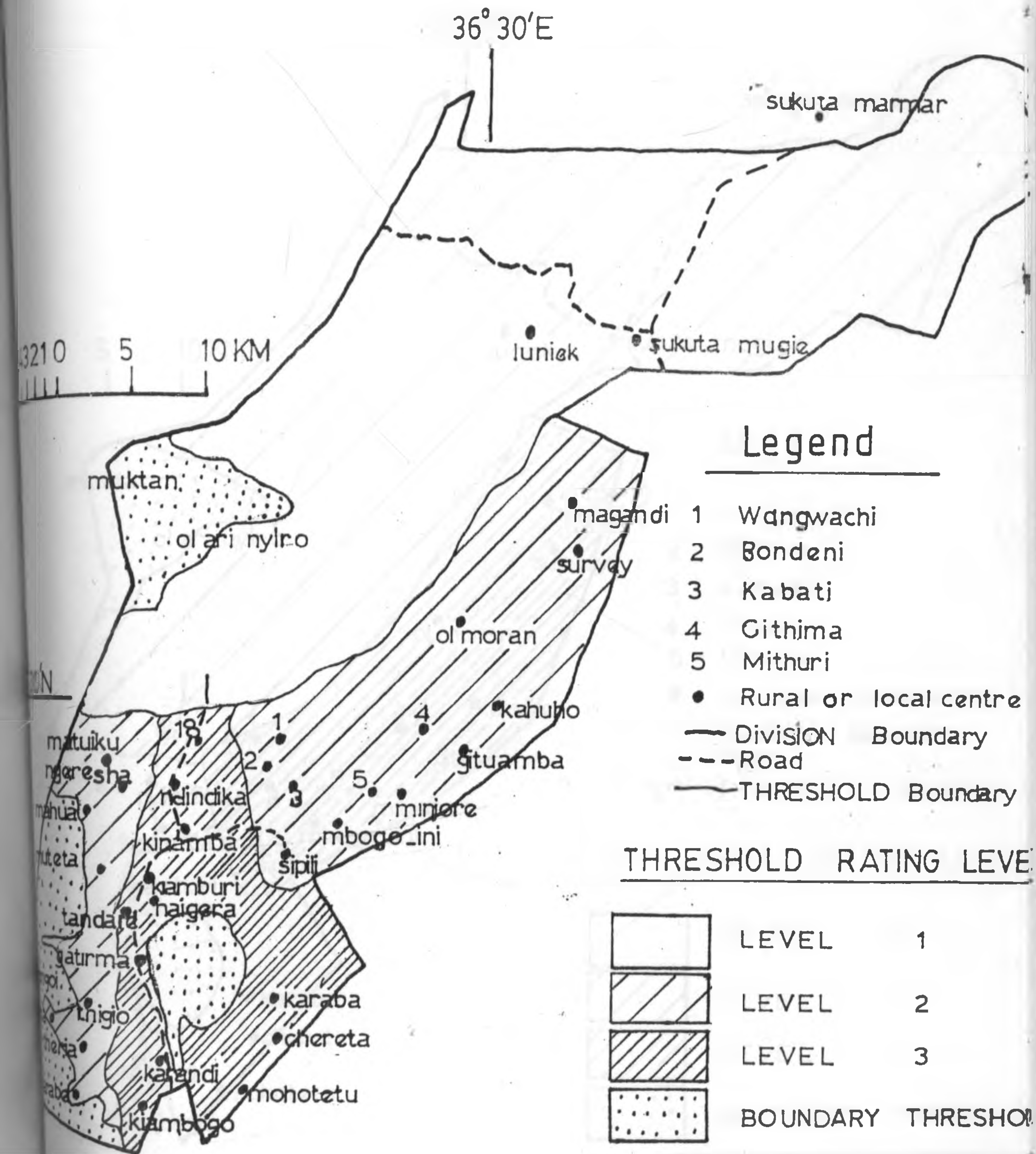
Temporal dimension of environmental consideration requires that agricultural activities should be developed at rates or time periods that conform with the rythm of the natural processes. In order to define this environmental dimension, an assumption that all land under farmers' disposal is exploited for agricultural activities provided that benefits however little accrued from the activity is made.

Major negative environmental consequences as a result of overstepping of this environmental dimension are; soil exhaustion/lowered fertility and loss of vegetation cover. These consequences are mapped to show their spatial distribution in Ngarua Division.

Temporal Dimension: Map Key to Major Negative Environmental Consequences

Region/local Area	Consequence/ Threshold Rating	Nature of Consequence(s)
Thigio Kirima	1	Loss of vegetation cover
Ol Arabel Tharia	2	Soil exhaustion/lowered fertility
Kiambogo	1	Loss of vegetation cover

LANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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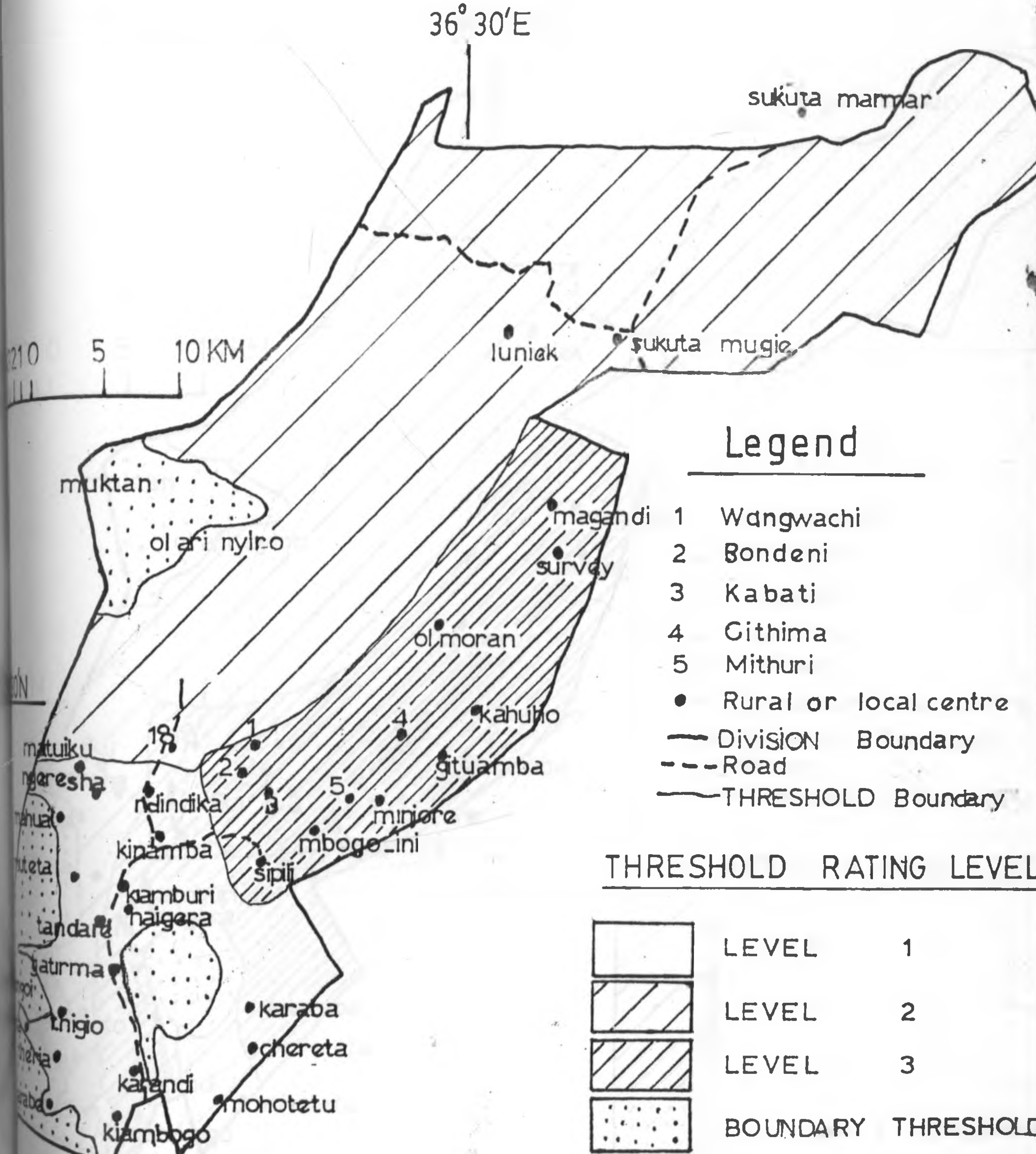
...ORAL ENVIRONMENTAL DIMENSION

...IVE ENVIRONMENTAL
...QUENCE: Soil exhaustion/Lowered fertility
(partial threshold)

FIGURE 30

NNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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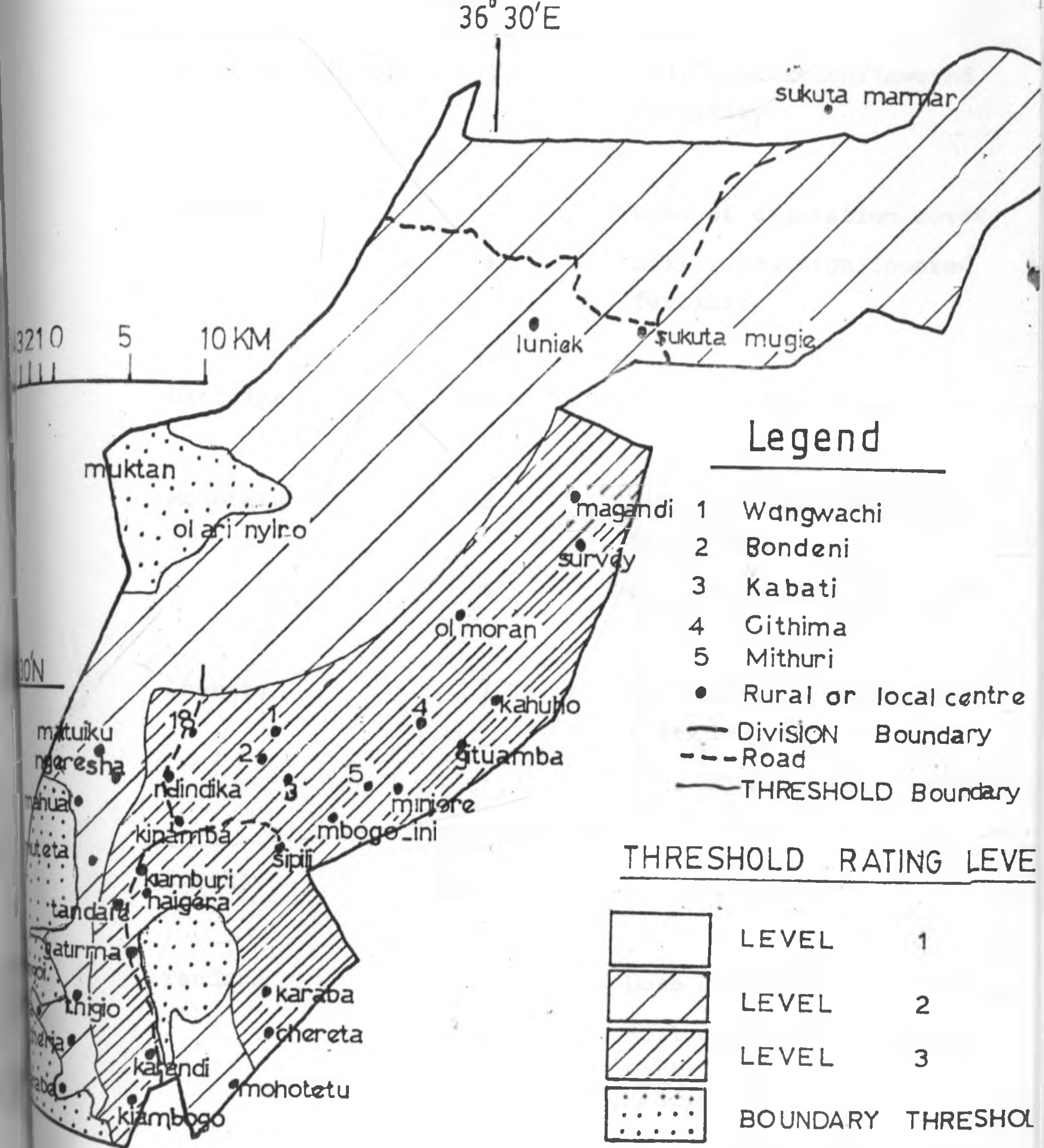
PORAL ENVIRONMENTAL DIMENSION

VE ENVIRONMENTAL
EQUENCE Loss of vegetation cover(partial threshold)

FIGURE 31

... AGRICULTURAL LAND USE
LANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



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..MPORAL ENVIRONMENTAL DIMENSION

..MBINED THRESHOLD

FIGURE 32

Kiambogo (contd)	3	Soil exhaustion/lowered fertility
Karandi	1	Loss of vegetation cover
	3	Soil exhaustion/lowered fertility
Gatirima	- do -	- do -
Mohotetu	2	Soil exhaustion/lowered fertility
	1	Loss of vegetation cover
Chereta	3	Soil exhaustion/lowered fertility
	1	Loss of vegetation cover
Karaba	- do -	- do -
Tandare	1	Loss of vegetation cover
	2,3	Soil exhaustion/lowered fertility
Muteta (Mithiga)	1	Loss of vegetation cover
	2	Soil exhaustion/lowered fertility
Mahua	1	Loss of vegetation cover

Mahua (contd)	2	Soil exhaustion/ lowered fertility
Mlimatatu	- do -	- do -
Kiamburi	2,3	Soil exhaustion/ lowered fertility
	1	Loss of vegetation cover
Naigera	- do -	- do -
Ngeresha	2	Soil exhaustion/ lowered fertility
	1	Loss of vegetation cover
Matuiku	- do -	- do -
Ndindika	3	Soil exhaustion/ lowered fertility
	1	Loss of vegetation cover
18	- do -	- do -
Wangwachi Bondeni Kabati Mbogoini Minjore Mithuri	2	Soil exhaustion/ lowered fertility
	3	Loss of vegetation cover
Sipili	3	Loss of vegetation cover

Sipili (contd)	2,3	Soil exhaustion/ lowered fertility
Kinamba	1	Loss of vegetation cover
	3	Soil exhaustion/ lowered fertility
Gituamba Githima Kahuho	3	Loss of vegetation cover
Ol Moran Survey Magandi	2	Soil exhaustion/ lowered fertility
Ol Arinyiro Ranch	1	Soil exhaustion/ lowered fertility
	2	Loss of vegetation
Lumiek Mugie	- do -	- do -

5.04.5 <u>Final Environmental Threshold Map</u>

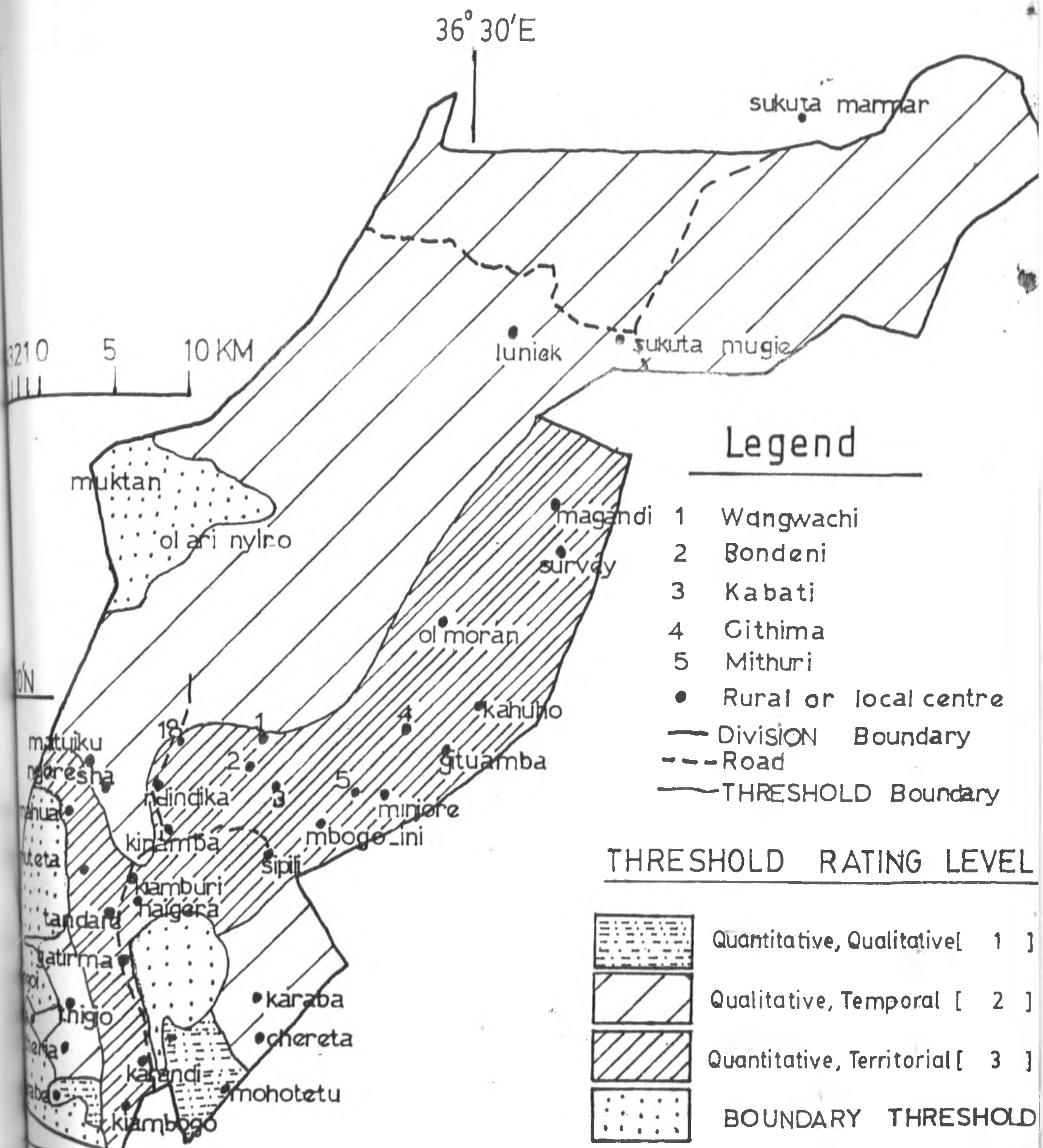
The map is a composite of the four environmental dimension threshold maps. It is made from overall reasoned estimate and judgement of the negative environmental consequences. In the integration of the four environmental threshold maps, pertinent negative consequences as they are manifested in the area spatially are considered. Rating levels are adapted from the levels in the dimensional threshold maps. However, some environmental dimension threshold overshadow the others and that is the reason why the composite threshold map makes the overall judgement of the region's environmental threshold estimates. The overriding factor or nature of consequence and the dimension of environmental consideration forms the basis of the final environmental threshold map.

The final environmental threshold map show the context under which sustainable agricultural development in Ngarua Division should take place.

Environmental Threshold: Map Key to Environmental Considerations in the Context of Agricultural Development in Ngarua Division, Laikipia District

Region/local Area	Threshold Rating	Main Environmental Considerations
Thigio Kirima Thaeria	2	Main environmental considerations is in regard to quality of inputs in agricultural development: • Loss of soil structure because of maladjustments in tractor use is on the increase;

ANNING: NG'ARUA DIVISION, LAIKIPIA DISTRICT



...ONMENTAL THRESHOLD IN THE CONTEXT OF ...LTURAL DEVELOPMENT IN NG'ARUA DIVISION

...ding environmental dimension is :-

...vels	Qualitative	Quantitative	Territorial	Temporal
1				
2				
3				

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FIGURE 33

		• Soil conservation endeavours should be in the forefront in environmental considerations; • Lowering of soil fertility is a threat to high productivity.
Ol Arabel Mohotetu	1	Main environmental consideration is in regard to quality of inputs and intensity of land-use (quantity): • Loss of soil structure and lowered soil fertility are important consideration in these areas.
Karaba Chereta	2	Main consideration is in regard to rate of development/period of development and quality of input of agricultural development: • Loss of soil structure especially compaction of soil is an important consideration; • Lowering of soil fertility in the context of temporal consideration is crucial in the region.

Mlimatatu Mahua Muteta Tandare Gitirima Karandi Kiambogo Kiamburi Naigera	3	Environmental considerations are in regard to quantitative, and territorial dimensions: • Soil erosion especially in Mlimatatu and Naigera is an important consideration; • Loss of soil structure, pulverisation in Kiamburi, Kiambogo, Naigera and Mlimatatu; and compaction in Tandare, Gatirima and Karandi is important.
Matuiku Ngeresha	2	Main environmental consideration is in regard to qualitative dimension: • Loss of soil structure is an important consideration; both pulverisation and compaction.
Ndindika Kinamba Sipili Kabati Bondeni Wangwachi Mbogoini Mithuri Minjore Githima Gituamba Kahuho Ol Moran Survey Magandi 18	3	Main environmental consideration is in regard to quantitative and territorial dimensions: • Soil erosion, loss of vegetation cover and subsequent lowering of soil fertility are important aspects in environmental considerations in these areas;

		• Loss of soil structure in Kinamba, Ndindika and 18 is a crucial consideration.
Ol Arinyiro Ranch Luniek ADC Mugie	2	Main environmental consideration is in temporal dimension of environmental considerations: • Loss of vegetation cover, and soil erosion are very important environmental aspects to be considered.

5.05 Boundary Thresholds

By definition, boundary thresholds are thresholds imposed by specific features of the natural environment limiting agricultural development in an area. For instance, swampy areas, steep slopes, gullies, among others. The other form of boundary threshold is artificially made through policies that prevent all forms of agricultural development in a region in order to protect the existing natural environment. In this respect, gazetted forest reserves, river catchment areas, game parks and game reserves are among the boundary thresholds of this kind. In a nutshell, areas which are considered unsuitable for agricultural development due to specific features of the existing natural environment and areas where agricultural development is prohibited by law or policy are considered as boundary thresholds.

These areas limit the expansion of agricultural activities and thus, forms a boundary of agricultural development in a given locality.

In Ngarua Division, they form about 12.00% of the total land area leaving about 88.00% as agricultural land. Among the categories identified include, very steep slopes, rugged escarpments and deep sharp valleys, gorges and gazetted forest reserves. Their spatial distribution is shown on the environmental threshold maps. Unsuitable steep slopes occupies an area of 29 km^2 while forest occupy an area of 106 km^2 in the Division. However, about 11% of the remaining land is occupied by roads and settlements (homesteads), leaving 77.6% of land for agricultural development. It is on the 77.6% of land that environmental threshold assessment was done. The Plates below show some of the boundary thresholds in the Division.

Plate 17 : Muktan Gorge (Muktan area in Ol ari nyiro Ranch)

Plate 18 : Steep stonny slopes (Gatirima)

Plate 19 : Ol Arabel Forest (Thigio/Kirima region)

Plate 20 : Steep slopes and a pond (along the
Ol Arabel River stream - Gitirima)

Plate 21 : Deep valleys are a common feature along the western boundary of the Division.

5.06 Planning Decisions/Implications

After the assessment of environmental threshold of the Division and identifying the agricultural land-use types, environmentally sound policies of the Division can be made. However, as mentioned in the introductory chapters, the study is not a problem solving one, rather is problem identifying. In this respect, it is a tool to other problem solving oriented methods. In this regard, the spatial variation of natural resources and sensitivity of the environment in Ngarua Division can be under-stood.

When making agricultural development decision, it is important that the natural resources in each locality are appraised. This help in making accurate decisions and formulating the facilitating policies as required. However, it should be mentioned that sound agricultural development policies cannot be realised unless they are sound environmentally. This is because, sustainable agriculture leads to sustainable productivity, sustainable producti-vitiy leads to sustainable sources of income and sustainable sources of income leads to sustained participation of the beneficiaries to development activities. This simple phenomenon is in this study summarised by the assessment of environmental thresholds which can be used for rationalizing the overall planning and policy making process of development in the Division.

The planning implications emerging from this study is that, not only do existing policies of agri-cultural development encourage more intensification and production capacity but also they accelerate "deterioration" of the environment. This is an indirect phenomenon that inevitably result from misinterpretation of the environmental sitatuions in different areas. It is true that policy makers have all the knowledge of the resource potential of different areas but the aspect of sensitivity of the ecosystem to agricultural development activities is never given priority in the planning decisions.

In assessment of environmental threshold and keeping in track of the changing trends in agricultural development, different areas can be given different priorities in the development process. The theme in this case is of conservation of the environment so as sustainable agricultural development can suffice.

In making conservation decisions, the resource use planner/the conservationist can use the criterion of rating of the threshold levels such that areas scoring the highest in the conservation considerations can be mapped and special involvement introduced. However, integrated conservation programmes can be planned in the Division especially in the small scale low agro-ecological potential zones. This is because, these areas are more fragile and less resilient comparatively.

In the same context, predictions of what can befall the large scale ranching farms if they undergo subdivision can easily be inferred from the environmental threshold analysis. In this respect, the threshold analysis acts as an early warning to planners involved in agricultural development. In the same note, a land size limit can be set for any large scale farm undergoing land subdivision so as to minimize environmental implications of such aspects and to improve the economic viability of new settlement in the marginal areas.

It is clear from the environmental threshold studies that although sound policies concerning the environment are formulated and implemented, and although studies have been done on the best animal or crop mix in particular areas in the country, these efforts are always overtaken by the simple fact that environmental threshold is always overstepped. This aspect is important in agricultural land-use planning and development because land is a major resource in agricultural development and its degradation mean degradation of the rural economy. The above phenomenon exist because the qualitative, quantitative, territorial and temporal dimensions of agricultural land-use and development have never been comprehensively interpreted or integrated in the decision making process. In this respect, it implies that, the levels, the volume, the time period and the location of agricultural development activities should always be defined in the planning and in the policy making process.

From the foregoing discussion, it is clear that if environmental threshold studies are undertaken in agricutural land-use planning and decision making process, it would not only improve the productivity of land and sustainability of production, but will also conserve the existing natural environment and in the process improve its status.

5.07 Application of Environmental Threshold Approach to Agricultural Land-use Planning

One of the main objective of this study was to come up with an agricultural land-use type map and an environmental threshold map. The two maps are to act as a guide to agricultural land-use planners, resource use planners and other groups in their environmental conservation endeavours. Implicitly, the two maps help the above persons in analyses of environmental trends in Ngarua Division. However, the most important aspect of environmental threshold approach is the presentation of substantial data in a clear and easily readable form. This one advantage make it quite useful by all resource use planners at all levels.

The study from the onset however, was designed as an experimental effort to test the applicability of environmental threshold approach in agricultural land-use planning. In this respect, apart from helping to answer or find an answer to the question of how overstepping of the environmental thresholds of various parts of the Division can be avoided, the environmental threshold approach help to identify the relative intensity of negative environmental consequences and also the relative environmental situation in the Division. However, the most important aspect of the appraoch is to assess the possible negative environmental consequence under particular agricultural land-use type. In this respect, policy makers and decision makers can be able to assess the interraction between agricultural land-use types and environmental status and therefore, formulate sound agricultural land-use policies.

In light of the foregoing discussion, it is important to examine the application of environmental threshold approach to agricultural land-use planning.

In doing this, we are examining how environmental threshold approach in agricultural land-use planning is linked in the overall land-use planning process.

At the outset, environmental threshold approach is involved in indicating and defining the purpose of undertaking it. This involves identification of the problem. In this respect, it "specifies the main questions to be answered in the course of analysis". (Kozlowski J. 1977) This undertaking defines the aims and objectives of the study. After this, identification of difficulties to the approach is done. However, assumptions are formulated and the required degree of accuracy of the analysis is specified by defining the level of significance of each threshold parameter.

Surveying and projection which involves observation, collection and analysis of data to assess the present situation and designing of various assumptions to project the future situation is the most important aspect of threshold analysis. It gives a picture of how the future could be if the problem is not solved today.

At this juncture, it is important to mention that in use of environmental threshold in agricultural land-use planning; the agricultural land-use type/ natural environment interface and the agricultural land-use type/natural environment continuum is underscored. In this context, the dynamic nature of agricultural development is stressed. It is on these basis the author wishes to express that the concept of environmental threshold in agri-cultural land-use planning is a useful tool to guide in description of the environmental situation so long as it is not assigned permanent value.

From the foregoing discussion, it can be proposed that environmental threshold approach in agricultural land-use planning links very well in the overall planning process especially in the surveying and projection of environmental situations and the ultimate identification of environmental problem areas.

The two maps of agricultural land-use types and the environmental threshold map cannot be divorced in decision making. It is by assessing and under-standing the future trends of agricultural land-use and assessing their management that accurate and firm decision can be reached. In this context, it is a prerequisite to always use the two maps together if policies concerning the Ngarua Division environment and any other areas are to be made.

However, there are limitations on the applicability of environmental threshold approach in agricultural land-use planning. These limitations are related to the dynamic nature of agricultural development. In this respect, implementation of policy decision emanating from environmental threshold studies are limited to public decision making machinery. In this context, it is the author's opinion that, successful environmental threshold approach to agricultural land-use planning can more or less be in the marginal lands which are not yet settled by sedentary farmers. This means that when such marginal lands are earmarked for sedentarisation, prior environmental threshold studies would help to understand the environmental situation, predict the possible negative environmental consequences and subsequently, underline policy recommendations and planning decisions on the perceived use of that environment. This could include designing the minimum hecterage to be allowed for a farm at such an environment, recommending suitable forms of agricultural practices before the farmers settle in farms and providing important indirect farm exploitation packages to facilitate initial conservation endeavours and create initiative to environmental conservation and consideration among the farmers and the technical experts.

However, when environmental threshold analysis is applied in an already settled area, it plays a crucial role in helping resource use planners to incorporate piecemeal conservation measures which after progressive integration with policy decisions may prove a very healthy undertaking in agricultural development.

Basically, comprehensive and thorough research on the resource potential and consequently making worthwhile assessment of the sensitivity of the ecosystem is a precursor to the environmental threshold approach in agricultural land-use planning. Understanding the political system of environmental exploitation and how they interract in agricultural land-use, form the basis of predicting the future environmental situation based on the resource potential and the sensitivity of the ecosystem to man's labour activities. In this respect, the author wish to emphasize that application of environmental threshold approach to agricultural land-use planning is an important aspect if not a prerequisite in the overall agricultural land-use planning process and decision making. It's use is both important to settled and unsettled marginal environments intended for agricultural use. At this juncture the author wishes to underscore the conclusive statement made by Kowlowski Jerzy (1985) in the artilce entitled, "Threshold Approach in Environmental Planning", that "it is almost certain that this approach can also be applied to other human activities and to other, not necessarily protected areas". (Kowzlowski J. 1985:152)

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CHAPTER SIX

This chapter gives the policy recommendations and the conclusion from the study. These aspects are addressed under the following sub-headings; recommendations, role of environmental threshold studies in agricultural land-use planning, suggested process of applicability and a conclusive note.

The above sub-headings, their content and context give the general policy recommendations as derived from the study.

The chapter is concluded by the statement of further areas of research in environmental threshold studies in agricultural land-use planning.

CHAPTER SIX

POLICY RECOMMENDATIONS AND CONCLUSION

6.00 Recommendations and General Aspects

The majority of environmental threshold studies have been done in protected areas such as national parks and in urban systems. However, this study as an experimental effort to attempt prior application in agricultural land-use planning has revealed various pertinent issues that need mention.

In the course of carrying out this study, it became evident that such kind of study would require a team of interdisplinary experts. This is so because, the agricultural environment is heterogenous and utilizes many aspect of both natural and human resources. In this respect, it is the author's feeling that the following groups of experts are important if the resource potential of an area and the sensitivity of the environment has to be assessed. These are; soil scientists who include soil chemists, soil physicist, soil microbilogists, agriculturists, biologists, ecologists, economists and sociologists. Such kind of interdisplinary teams are able to comprehensively analyse the resource potential of an area and assess the sensitivity of the ecosystem to man's labour activities.

However, studies by the above mentioned experts are only useful if after integrating the findings and interpreting it, worthwhile accurate conclusions are drawn and prior application attempted. However, involving the local people especially in the process of problem identification is important such that technical experts notes can be compared with experiences from the local people. In this respect, it is the author's wish to underscore the above aspect as one of the most important recommendation from this study.

In light of the above, for environmental threshold studies in agricultural land-use planning to comprehensively and progressively play a great role in the overall land-use planning process, the following researches need to be undertaken.

(A) Research on soil characteristics - This would involve analysis of the soil conditions. In this respect, studies of the soil maps and field work is important. Laboratory analysis of soil taken at different intervals from the field is important. Both chemical and mechanical analysis in the assessment of soil fertility, soil stability, alkalinity and acidity, infiltration and permeability tests, among others, will help to define accurately the soil types, soil structure and texture and thus, its agricultural potential.

(B) Research on climatic conditions - This include establishing the; (i) minimum, maximum, and mean monthly and annual rainfall; (ii) rainfall intensity and periodicity in the region is equally important; (iii) minimum, maximum and mean monthly and annual temperature, among other characteristics; (iv) the prevailing direction of wind, its seasonal changes, wind velocity and pollution (sand and dust). This would establish the cooling effect, erosion and shelter aspects of the area; (v) solar radiation in regard to intensity is an important climatic aspect.

Other climatic aspects include minimum,

maximum, and mean monthly humidity levels. Evapotranspriation figures in regard to crop water requirement and evaporation losses are important aspects to be researched on.

(C) Topographical aspects in regard to ground slope is one component to be studied.

(D) Geological studies - These would include studies on the parent stock, to establish whether it is igneous, matamorphic or sedimentary to help in determing soil fertility, salinity and erosion potential (erodibility and erosivity of the soil). Depth of bedrock to establish soil thickness, erosion potential and suitability of cultivation are some of the geological factors that need to be studied.

(E) Ecological studies would involve studies on plant and animal association, propagation techniques and planting techniques, among other aspects.

(F) Human factors - This requires comprehensive studies on population studies including size and structure and its dynamism, settlement patterns, density of population, location and community type, culture, education, land-use, land sizes, land ownership, infrustructure, fuel use, standard of living, among many other human aspects that needs consideration.

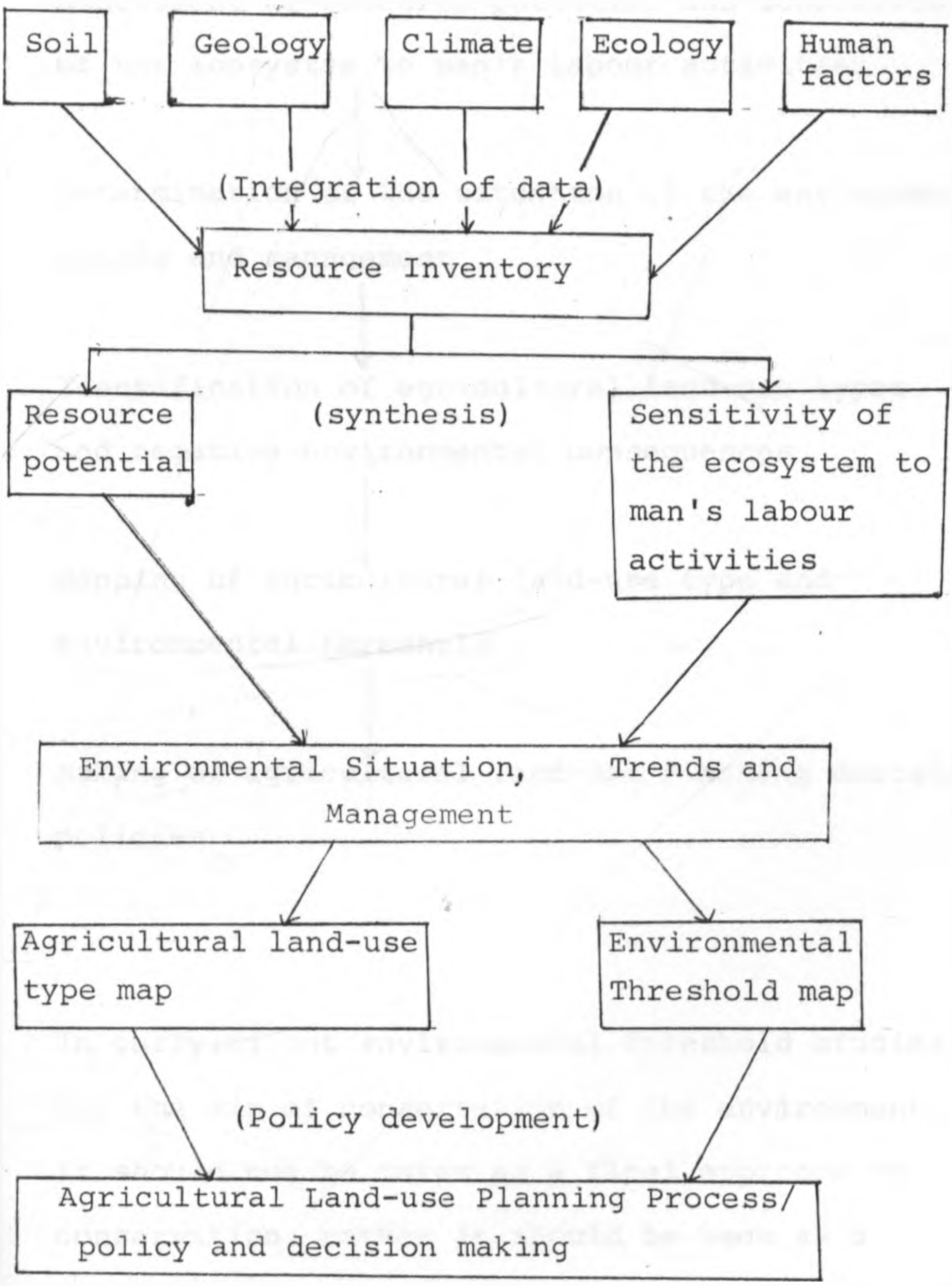
In this respect, comprehensive and accurate resource potential estimates can be established and sensitivity of the environment to man's labour activities assessed. Integration of all the information of the factors analysed is the most important aspect in the use and identification of the environmental threshold of an area.

In light of the above, a temporary research station on site is a prerequisite in environmental threshold studies if the cost of research work is to be reduced.

The following figure shows the procedures as conceived from this study for environmental threshold studies in agricultural land-use planning.

Figure 34

Proposed Procedure of Environmental Threshold Studies for Agricultural Land-use Planning



Source: Author

Summary

Field Survey, Data Collection and Inventory

↓

Assessment of resource potential and sensitivity of the ecosystem to man's labour activities

↓

Determination of the situation of the environment, trends and management

↓

Identification of agricultural land-use types and negative environmental consequences

↓

Mapping of agricultural land-use type and environmental threshold

↓

Making of agricultural land-use planning decision/ policies

In carrying out environmental threshold studies for the aim of conservation of the environment, it should not be taken as a final approach of conservation, rather it should be seen as a supplementary tool to other conservation approaches.

In this respect, environmental threshold studies for agricultural land-use planning could be part of an integrated approach towards sustainable agriculture. This was expressed implicitly in the study especially where land ownership was considered. However, where other tools of conservation are ineffective, environmental threshold studies may act as an eye-opener to partinent issues that in many instances are overlooked but ought to be considered.

In the final analysis, it was noted that environmental threshold in agricultural planning gives a useful description of the environmental situation. The author wishes to retariate the statement by emphasizing that this can be true if only no parmanent value is assinged to it. This is because of the fact that agricultural development is dynamic and the interface of the environment and agricultural activities is a continous phenomena. In this respect, the environmental/agricultural land-use activities continuum should be seen in the light of changing technology in environmental exploitation, changing political systems of environmental exploitation vis-a-vis environmental threshold of that particular region in regard to those changes.

Another policy recommendation which emerged from the study is that problems faced by small scale farmers in the marginal agricultural land is linked with plot sizes (farm sizes). In this regard, where new land needs to be subdivided, such problem can be avoided by carrying out environmental threshold studies to determine the "reconciling" land size between man and nature. This can be very helpful in the fact that not only will land sizes be controlled but also the population settling in the new farms. Such kind of control can be done by the public machinery playing a big role on matters relating to private land purchase and sub-division.

In any environmental threshold analysis, boundaries of the study area as they relate to the scope of the study should be drawn. These would help to formulate enabling assumptions and designing of the expected degree of accuracy in matters under consideration. Environmental threshold map will only be meaningful if the above aspects are well articulated by the implementing agency. In this respect, clear definition of the above aspects is important in environmental threshold studies.

The theme of carrying out environmental threshold studies should be spelled-out clearly to enable accurate identification of negative environmental consequences. However, with equal importance, it should be noted that environmental threshold approach in agricultural land-use planning is <u>an instrument for policy development</u> but not for policy implementation or policy evaluation. In this context, completion of an environmental threshold studies should be followed by other policy implementation and evaluation instruments <u>as dictated by the developed policy</u> emanating from <u>environmental threshold studies</u>. However, consecutive comparative environmental threshold studies may be done to follow up with a previous one to evaluate the end-state of the environment after policies/decisions have been implemented.

From the foregoing discussion, it is clear that environmental threshold analysis may be used at an evaluation process to determine whether the established policies need modification.

6.01 <u>Role of Environmental Threshold Studies In Agricultural Land-use Planning</u>

It is clear from the study that environmental threshold study is very important in agricultural land-use planning. Agriculture if dissected into its components can be said to be:-

(a) a political activity;

(b) an economic activity; and,

(c) a social activity.

In this respect, various persons are involved in making agricultural development decisions. In this context environmental threshold studies help to make all the agricultural development decision-makers aware of the consequences their decision pose to the environment. At this juncture, it is important to mention that the political decision-makers aim at helping the population achieve their goals in the most effective manner, the economic decision maker aims at raising the profits of the population by utilizing their resources to the maximum and in the most economic way. The sociological decision-maker aim at improving the social welfare of the communities in the most effective manner. All these decision-makers hope that their decision proposals after implementation will have a sustainable effect. However, sustainability cannot be achieved without sustainable environment to carry out agricultural activities. In this respect, environmental threshold studies play a great role towards achievement of this goal.

It should be noted however, that not only does environmental threshold studies in agricultural land-use planning help to achieve the goal of conservation of the environment but also help the planner achieve the most important goal in planning; the goal of improving the human welfare.

Environmental threshold studies play a great role in helping the agricultural land-use planner focus his/her attention critically on the factors that define the relationship between agricultural development and the natural environment. In essence this help the agricultural development planner to identify the causes of persistent problems of the environment that readily affect the progressive improvement of agricultural production.

It is a well known fact that prevention is better than cure. Therefore, environmental threshold studies in agricultural land-use planning are more preventive than curative of the chronic problems as regards the agricultural environment. In this respect high costs incurred in measures to conserve the environment such as building of gabions, terracing, among others, can easily be avoided if all the environmental threshold dimensions are well defined and applied. This is a very important role that environmental threshold studies should play in agricultural development.

In a nutshell, the agricultural land-use planner can meet all his/her planning goals namely, social, economic, political and environmental by application of the environmental threshold approach.

It should be mentioned here that data generated by environmental threshold studies serve as a baseline information for other studies that may be carried out in the region. In this respect, environmental threshold studies do not only help the agricultural land-use planners but also help other specialists interested in search of knowledge of the region. This in essence aid other development projects and indirectly raises the standard of living of the communities.

However, one important role that environmental threshold studies play is to give development planners the basis for control of development activities taking place in a region. In this respect, control of land subdivision is an example of the critical consideration of development matters that need control to avoid future environmental or developmental consequences in the study area.

Implicitly, environmental threshold studies help in informing the community the pertinent problems that face them in future or currently if environmental considerations are not incorporated in their decisions to develop their farms.

Agricultural land-use planning is always concerned with sustainability of agricultural projects/ programmes. This is hampered and in many cases impaired by lack of in depth insight towards the environmental problem. Environmental threshold studies help to solve this problem by providing easily and clearly the environmental issues that hamper sustainability of agricultural development.

In exposing the environmental situation and the negative environmental consequences prior to threshold analysis in a region; environmental threshold studies initiate awareness and thus, provoke interest in environmental issues consequently mobilizing the local community and technical experts to intensify environmental conservation measures.

It is evident that environmental threshold studies for agricultural land-use planning need to include studies on settlement patterns and carrying capacity and initiation of feasibility studies on the viability of other crops/methods of cultivation. In this respect, environmental threshold studies would not only facilitate the formation of base-line data on resource potential but the data inventory generated in the process would act as an information resource base for future references.

Finally, in carrying out the environmental threshold studies for agricultural land-use planning, different experts, scientists, administrators, politicians, social workers and the community have a forum where they can exchange ideas for development of agricultural activities, among many.

6.02 Suggested Process of Applicability

After experimentally testing the applicability of environmental threshold approach in agricultural land-use planning, the author would wish to suggest a process of applicability. The process is an end-result of the analysis and consideration of pertinent issues that appeared evidently needed in a comprehensive environmental threshold study.

It is important to mention that the theme of using environmental threshold approach in agricultural land-use planning should be well defined before any attempt is done towards the move. It is after defining and interpreting the theme that prior arrangement should start for carrying out the study.

Following the definition of the theme, the area/region where the study is to be carried out should be delimited clearly because the outcome of the study is a physical plan showing thematically environmental threshold levels in different areas of the region.

After the regions have been delimited, the problem should be set and well stated such that all the specialists involved in the study clearly understand all the intricacies involved.

The above aspect should be followed by defining goals and objectives of the study. However, problems/constraints that may hamper achievement of the stated goals and objectives should be identified.

At this juncture, the planning team is getting set to the environmental threshold studies. Subsequently, before further steps are taken in the process, the assumptions should be formulated based on the goals and objectives and the constraints envisaged. However, this should be followed closely by clarifying the degree of accuracy required in the definition of parameters in the study process.

After the above aspects are considered, environmental dimensions to be used in the identification of the environmental situation should be spelled-out and well versed to all those involved in the study. All attributes pertaining to every environmental dimension should be clarified. Environmental dimensions forms the "backbone" of environmental threshold studies because they define the scope of the environment and the study and become the basis under which negative environmental consequences are measured. After this step, the study is "moulded" and what remains is putting the "pieces" together to the planners satisfaction.

This step is followed by field surveys and data collection. It is here that the specialists dealing with various aspects go on their own. Depending on the aspects each specialist is handling, the process might require further definition of goals and objectives for the particular aspect being studied. The end-result of these individual studies is a data inventory that would be up-dated occasionally after consultations from various specialists. It is expected that after the data inventory has been set, up-dated and studied on seminars, every member of the planning team will learn from the other members and decisions regarding the resource potential and the sensitivity of the ecosystem to man's labour activities assessed.

In this context, this stage is done together despite the individual studies done afterwards. The team at this stage identifies various agricultural land-use systems/types depending on the objectives, assesses the resource potential in regard to agricultural production and the methods of resource or environmental exploitation, and assesses the sensitivity of the environment to all agricultural development activities. However, it is at the same stage that the planning team identifies the boundary thresholds of the region. In this respect, the process of identification of environmental threshold is started. In this context, the team re-examines its theme, goals and objectives and the environmental dimensions are revisited. At this point, determination of the environmental situation, trends and management starts. This is done in reference to the identified agricultural land-use systems/types. The next task is to assess the negative environmental consequences (both the existing and the predicted ones). Assessment is based on the assumption and degree of accuracy outlined in relation to each environmental dimension.

This stage is followed by delineation of agricultural land-use systems/types and environmental threshold. The number of maps defining the partial threshold levels of the region are determined by the environmental dimensions used and the negative environmental consequences identified before the final environmental thres-hold map is compiled.

The final environmental threshold map of the region is a composite map got by integrating all the partial thresholds maps defined by the environmental dimension used. In this respect, it displays the overriding environmental thres-holds and therefore it is very useful for making broad generalisation of the environmental status of the area.

After this stage is over, agricultural land-use planning decisions for the area can be made including policies to achieve the goals and objectives of agricultural development in the region.

However, the theme, goals and objectives as formu-lated from the beggining should should guide the planning decisions in respect to identified environmental problems of the area.

The following is the summary of the process of applicability of environmental threshold approach in agricultural land-use planning.

Figure 35

Summary

Formulation of the theme of undertaking the Study

↓

Delimiting the Study area

↓

Problem setting/stating

↓

Define goals and objectives of the Study

↓

Identification of problems/ constraints

↓

Formulation of assumptions

↓

Clarification of degree of accuracy expected

↓

Spelt-out the environmental dimension to be used

↓

Field survey and data collection (by each specialist)

↓

Making of a data inventory (from findings of various specialists)

↓

Updating of the data inventory (through seminars/workshops)

...contd

Identification of various agricultural land-use systems/types, assessment of resource potential and assessment of sensitivity of the ecosystem and identification of boundary threshold

↓

Determination of the environmental situation, trends and management of the region

↓

Assess the negative environmental consequences

↓

Delineation and mapping of agricultural land use systems/types and environmental threshold

↓

Making of agricultural land-use planning policies/decisions

Source: Author

6.03 Conclusive Note

It can be concluded from the study that the functional relationship between land-ownership and the environmental status in Ngarua Division spell out the fate of the farmers both in gaining the economic utility and ecologic utility. In this regard, problems being faced by farmers in Ngarua

Division especially in its medium and low agricultural potential frontiers (AEZ 4, 5, and 6) is related to the inherent agricultural resource utilization systems.

The majority of immigrant settlers originated from high agricultural potential areas in the country, in this respect, their farming methods/ activities are not well related to the prevailing climatic or environmental status of this marginal environment.

However, despite the above phenomenon, the farm sizes which ranges from 3 to 5 acres in the low potential areas of the Division are not only uneconomical in such harsh environment but are the crux of all the problems that are faced by the farmers. Unfortunately, the same farm sizes are ramifying these problems into environmental consequences which are manifested in form of land degradation. It is in this connection that it can be concluded that in future, before any large scale farm is subdivided, attempts to establish the most viable land sizes defined in both economic and ecological terms should be a priority if gainful small scale agriculutral development is to suffice. Studies geared into establishment of the above aspect should be stressed so that future land purchase/subdivision in marginal lands can be controlled.

The above task can be done by use of environmental threshold studies in agricultural land-use planning where Government would take a leading role in advicing any persons involved in subdivision and consequently control the number of people that can be settled in one particular environment.

Environmental consideration in the division should be directed more to the low potential zone of the Division (AEZ 4, 5 and 6) than to the high potential zone (AEZ 3).

It is evident that Ngarua Division is under agricultural land-use changes . These agricultural land-use changes are more evident in Ol Moran, Survey and Magandi regions. However, these changes of resource exploitation are towards better adaptation of agricultural practices and the environmental conditions. The changes can be enhanced by providing baseline information to the technical experts involved in decision making. In this respect, comprehensive threshold studies and other planning tools can be used to enhance the process of change. However, the process may in near future be hampered by settling of the current absentee farmers.

Planning is done for the people and development is geared to giving the beneficiaries more control of decisions affecting their lives. In this respect, findings of environmental threshold studies can be used to improve the ecological utility of the farmers so as to help sustain the economic utility. Both these utilities will help in raising the welfare of the people and improve their ways of life.

Development of existing centres namely Kinamba and Sipili among others, can be used as a pressure release device where in their functions as service and trade centres, they could also reduce the density of population residing in the agri-cultural areas (surplus labour). In so doing, there would be indirect contribution towards increasing the threshold levels of certain parts of the Division.

Considering the main factors that determine agri-cultural land-use types in the Division, namely, political systems of environmental exploitation, culture of resource exploitation, economies of resource utilization, climatic conditions and soils; it is clear that systems of environmental exploitation where land sizes are important are more liekly to change. This is under the premise that climatic conditions and soils are naturally defined. In this respect, policies should be directed towards systems of resource exploitation especially in regard to land sizes and agricultural land-use types adopted. This can only be done after studies have been done to explain pertinent attributes of development in Ngarua Division.

Given the situation of the environment and the apparent deterioration of the agricultural land in the Division, the formulation of new initiatives capable of matching agricultural land-use guidance with various spatial environmental thresholds is anticipated to become an issue of high-level policy discussions and planning process decisions.

In the above respect, for a search of an agricultural land-use planning framework, debate in this course should be directed to revolve around the manner of formulation of an agricultural system which would facilitate access to marginal lands for the expanding population, intensification of agricultural practices in view of creating more employment opportunities and at the same time effectively guarding against undesirable/ negative environmental consequences of agricultural development.

The study has revealed that it is a reality that agricultural land-use planning and policy decision making remains fragmented among a number of government agencies having both divergent spatial visions of the future of the marginal lands and widely varying interpretation of the role of the state in agricultural land-use management and planning. This leaves the actors in agricultural land-use planning in disparate views on their role in environmental management/planning. In Ngarua Division, the Ministry of Livestock Development, the Ministry of Agriculture, Ministry of Environment and Natural Resources, and many Non-Governmental Organisations (NGO), among others, reflect views expressed in the latter paragraph.

To mitigate the above mentioned problem, environmental threshold approach in agricultural land-use planning appears to be an enabling forum for reducing that fragmentation in decision making and policy development.

6.04 Areas for Further Research

The study used manifestations of negative environmental consequences as indicators of overstepped environmental thresholds. This lead to consequent delineation and mapping. However, where manifestations of negative environmental consequences were not well defined, extrapolation of experiences from other areas was used to predict environmental thresholds. It would be more helpful for further research to be done to establish the criterion of developing an environmental threshold value system, where values of causal factors at which significant or critical change begins to manifest, in the measures against environmental degradation. This would enable the formulation of an "operation" formula in the use of the threshold approach in agricultural land-use planning.

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Appendix

General Information Questionare

Note: Information given is confidential and will, only be used for academic purpose.

1) Name of Interviewer ....
2) Date of the Interview ....
3) Questionnaire Number ....
4) Name of Location ....
5) Relation of Respondent to head of household ....
6) Sex: (male/female) ....
7) Household details

Sex	Religion	Original area of living	Length of stay in Ngarua	Level of education	Place of work	Farm income

8) Crops grown -

	type	yield	Amount of hectarage	problems
Staples				
Vegetables				
Cash crops				
Others				

9) What is the total area under cultivation?

....

10) What crops were you growing where you came from?

11) What made you migrate to Ng'arua?

12) What activities were on this farm before you came?

Details of the farm

13) What is the size of your farm? ....

14) What animals do you keep?

ANIMAL	TYPE	NUMBER

15) What method did you use to clear your farm?

16) What method do you use to till your farm? (eg. ox-hire, ox-own, tractor-hire, tractor-own, etc.).

17) What implements do you use to cultivate your farm?

18) What fertilizers do you use to cultivate your farm?

Chemical (type) .... Amount/Acre ....

Manure (organic) .... Amount/Acre ....

Why do you use it?

19) When did you plant and harvest your previous crop?

Plant ....

Harvest ....

20) After harvesting your last crop, what activities did you carry on your farm till the next planting season?

21) What problems do you face in your farming activities?

22) In your opinion, is the rainfall enough for your farming activities?

23) Where do you get your drinking water from?

24) What do you do with the crop remains? eg. maize, stovers, (burning, mix it in cultivation, animal feed,etc).

25) Where do you get your fuel wood from?

26) How many workers do you employ in the farm?

27) What are your future plans as regards to the farm?

28) Constraints in cultivation, weeding, harvesting, etc. (tick and explain)

Knowledge/education

Resources

Labour

Time

Weeds

Soils

Others -

29) Where do you graze your livestock?

30) What are the common problems you face in keeping of livestock and grazing?

31) Have you noticed any decline/increase in production in your farm?

Technical information Questionnaire

Note: This information is confidential and will be used for academic purposes only.

1) Name of the Interviewer ....

2) Date of Interview ....

3) Questionnaire Number ....

4) Name of Location ....

5) How many farmers are there in this location? ....

6) Crops grown -

Crop	Type	Av. yield/acre	Problems
Staples			
Vegetables			
Cashcrops			

7) Animals Kept -

Animal	Type	Number

8) What constraints in farming do farmers face?

9) In your opinion, is there changes in productivity since farmers settled here? Explain.

10) Does the location have any areas prone to soil degradation?

11) What are the predominant cultivation methods?

12) What implements do farmers use for cultivation?

13) Do the area receive enough rainfall?

14) Do the location have any project to curb soil degradation?

15) What types of fetilizer are used in this location?

16) In your opinion, has the use of fertilizer increased? Why?

17) What major inputs are used for agricultural production in the location?

18) What is the average size of farms?

19) What type of soil is found in the division?

20) In your opinion, is there any conflicting agricultural practices with environmental conservation endeavours?

21) What is the carrying capacity of land in this location?

22) What agricultural practices used to be in this location before the new farmers?