HUMAN IMPACT ON FOREST RESOURCES:

A CASE STUDY OF MUKOGODO FOREST, LAIKIPIA DISTRICT, KENYA.

BY

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DECLARATION

This thesis is my original work and it has never been submitted for a degree in any other University.

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

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PROF. ELIAS H.O. AYIEMBA

DEDICATION

To my beloved husband Ongong'a and son Alvin. I say thank you to my husband for his patience and tireless support to make my piece of work a success.

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ABSTRACT

The current study focuses on the two-way relationships between population and natural resources with specific emphasis on forest-cover change, particularly in east Laikipia. The study a rea, Mukogodo Forest, o ffers a field-laboratory type of conditions for studying the relationships between population pressure and natural resources.

In addition it offers unique ecological conditions, as it is mainly inhabited by a pastoral community whose "cattle-complex culture" has traditionally been portrayed to have serious implications on the forest resources. The study therefore examines the influence of human activities on Mukogodo Forest on which several sub-communities depend. It will emphasize demand for wood-fuel including charcoal, timber supply for construction, medicinal value of the forest, honey harvesting as well as livestock rearing.

Data for this research has been collected both from primary and secondary sources. Sources of primary data included questionnaire, observations as well as focused group discussions. The later includes both published and unpublished materials. The tests administered were based on the hypotheses that there were significant relations existing between aspects such as wood-fuel consumption, timber for construction, extraction of traditional herbs, honey harvesting and animal rearing, and forest cover change on the other hand.

The population targeted for this study comprised of all household heads located within 15 kilometers from the forest, the local forest officers and the chiefs of the area. A total of 521 households were located within this area. A random sampling was done on the household heads whereby about ten (10) percent was picked for interviews.

The analysis was done using Correlation and Regression techniques, Fisher's Test and a number of population and demographic analysis techniques. Geographical information systems (G.I.S.) was used to analyze data on forest cover change, the data on forest cover change was got from aerial photographs, satellite imageries and topographical maps covering the area.

From the correlation analysis results, it was established that the household size influences the volume of wood fuel and number of poles used for the construction of Manyattas and fencing. Education levels of both sexes were found not to have any significant impact on the above. From the analysis of forest cover change, it was established that the forest cover has reduced over the years.

This reduction is attributed to environmental changes that have seen rainfall decrease over the years wile temperatures increase over the same period (increase in aridity) as well as the nomadic way of life of the Masaai. In the light of research findings and conclusions made, a number of recommendations were drawn to the government, future researchers as well as the general public:-

It was recommended that alternative sources of energy such as solar and kerosene should be provided to alleviate the overdependence on wood fuel which threatens the existence of the forests.

Also, there is need to advice the Masaai pastoralists to adopt a rather settled kind of lifestyle. This calls for the government's commitment to provide boreholes to enable them to have water both for domestic and livestock use. For this to be practical, the pastoralists need to be encouraged to reduce the size of their heads of cattle, while other economic activities need to be initiated by government and non-governmental organizations.

An attempt may be made to improve on both the forest management and conservation policies so as to ensure sustainability in the forest resources. There may be more campaigns on the conservation of resources. This can be done through the media, seminars and barazas.

Studies may be undertaken on all the three main components of population change, that is fertility, mortality and migration inorder to appreciate these changes and show how they affect forest cover change either individually of collectively in the study area. There is need to study the impact of forest cover change on the socio-economic life of the Masaai people in the study area. Researchers and scholars can find it interesting to make a detailed study of households income in relation to woodfuel consumption in this area

ACRONYMS

WCED	-	World Commission on Environment and Development
FAO	-	Food and Agriculture Organization
UNEP	-	United Nations Environmental Programme
IUCN	-	International Union for the Conservation of Nature.
NGO	-	Non-Governmental Organizations
G.O.K	-	Government of Kenya
D.D.P	-	District Development Plan

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CHAPTER ONE

INTRODUCTION

1.0: Introduction

Humans have always interacted with natural ecosystems and have created artificial ecosystems to fit their needs. Their goal in dealing with nature has been to obtain the materials and foods that are immediately necessary for survival. However, these activities have made survival more difficult. In an attempt to turn a greater part of the earth's productivity to satisfy human needs, there is need to avoid acting in ways that will make that productivity less available to mankind in future.

Many environmental problems, including elimination of tropical forests, desertification, and reductions in bio-diversity, are most clearly evident in third world countries, and Kenya is not an exception. Ancient Greek scholars such as Plat and Aristotle first postulated this nexus by observing that land and property could not increase to match population growth. On the same subject, the first authored debate on the relationship is noticeable in the works of Malthus, R. T. (1798) in his treatise: "The Principle of Population" of the 18th Century. According to Malthus, man's capacity to increase his means of subsistence is much less than his capacity to multiply. While rapid population growth is often considered an important factor in environmental degradation, solid empirical evidence on its role is almost non-existent. Understanding the effects of population on the environment requires careful consideration of the full range of factors responsible for environmental deterioration. The nature of this relationship is heavily determined by land-use patterns and agricultural polices adopted by governments.

Rural population growth is resulting in growing land fragmentation, rural underemployment and out migration. Clearing of new land for agriculture is a response to pressures on the land, increasing land fragmentation and the lack of adequate off-farm rural employment opportunities. The present high rates of population growth are putting tremendous pressures on the global environment that could have irreparable consequences for future food production; overgrazing, large-scale erosion and encroaching deserts provide evidence of strain on the ecosystem.

The interaction between the components of population change and the rate and pattern of use of the forest as a natural resource is critically central to the development and management of sustainable environmental use. That forests play an important role in maintaining an ecological balance and improving the livelihood of people, especially in the arid and semi-arid areas, is no longer an issue of debate (FAO, 1989).

For the past few years, the International Science and Technology Institute, through its close interaction with people from both developed and developing countries has facilitated exchanges of ideas about renewable resources. Most people are aware of the general importance of trees but few seem to understand the importance of forests as living systems. For instance, if trees are cut and not replaced, the lost habitats will bring about the extinction of plant and animal life, which will decrease the genetic pool available for mankind's survival.

At global level, forests and other woodlands cover about 8.4 percent of the earth's land surfaces and supplies humans with basic products such as wood, meat and milk (Ehrlich 1968). When it is considered that forests in part determine such far-reaching factors as climate weather patterns, food production, soil loss, soil nutrients and animal habitats, it is realized that their alteration is a grave matter of concern to all as effectors and recipients of

responsible action towards renewable resources. Furthermore, these long term effects are not always easily observed or immediate. It is therefore better to readily perceive an entreaty to stop the blind and irreparable destruction of a life-filled areas, the forest, with its irreplaceable form of plant and animal life, its exquisite biotic communities and the last survivors of a unique and once great human culture.

Environmental issues provided the population debate with a new dimension during the 1980s and the main issue was the concept of sustainable development of which the most important components was the protection of the environment (WECED, 1987). This encompasses the capability of the biological systems to accommodate the multitude of human activities (World Women Congress for a Healthy Planet, 1991). There is a great uncertainty and concern about the ability of the biosphere to accommodate our present use of both renewable and non-renewable resources. Besides other factors, the carrying capacity of the earth is already under stress because of population growth.

In Kenya, with a total land area of 56,925,000 hectares, and a population density of 428 persons per square kilometre (1989), the area under forests and woodlands (3,297,000 hectares) had reduced by 23.5 percent as from 1966 (Robert, R 1988). This reduction has possibly been due to clearing for agriculture and settlement, smallholder encroachment, mining, urban development and other related human needs and activities.

By 1996, the total forested area in Kenya was 2.35 million hectares with 1.66 million hectares falling under government gazetted forests and 0.69 million hectares under ungazetted forests. 10 percent of the gazetted forests comprise industrial plantation forests of which 45 per cent is Cypress, 35 percent Pine, 10 percent Eucalyptus and 10 percent other species.

Kenya gives the matters of environment very high priority and it is the intention of the government of Kenya to take into consideration environmental matters in the process of national planning in order to ensure that development and growth and alleviation of poverty is consistent with the enhancement of the environment for the well being of present and future generations.

UNEP has made commendable efforts in spearheading the campaign to arouse and generate global awareness on the dangers inherent in mankind's exploitative activities as he/she extracts natural resources of the earth for his/her own survival. In his/her effort to eke out a living from the environment, he/she has tended to overburden the environment that one wonders whether he/she infact cares about the children of tomorrow. It is in this context that Kenyans have to associate themselves with the international consensus of opinion on the world's living resources that are threatened by degradation in the face of an over increasing population whose livelihood is dependent on these resources.

Kenya's main stay is agriculture and majority of its people depend on it for their livelihood. It is therefore unfortunate that the nutrient layer of fertile topsoil on which agriculture thrives is being rapidly lost through soil erosion. Its increase in the recent years can be attributed to several factors, viz.: high rate of population growth and intensification of agricultural activities geared towards the production of enough food to feed the growing population and leaving some for export as well. The tendency in practice has been over-intensive exploitation of the soil, improper alteration of streams and river banks, unplanned settlements, overgrazing, deforestation among others.

Vegetation is the heart of life as it provides the bulk of food for human beings, animals, and is the source of energy, among many other uses. Trees are a crucial link in the hydrological cycle and in the regulation of water in the catchment areas. Thus the importance

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conservation of vegetation, for the subsistence of life cannot afford to be under-expressed. yet over the last few years the rate of destruction of vegetation has reached an alarming proportion, as rising population exert a heavy demand on vegetation products. These mainly include fuel wood, timber for construction, charcoal, and extraction of medicine among other uses. But noted Kenya is among the countries that have launched massive re-afforestation programmes. The government has greatly intensified awareness among land-users to take action in soil and water conservation plus afforestation programmes. But easier said than done, this has not reached all the corners of the country due to a number of factors such as accessibility, educational level, political, socio-cultural among others. Nevertheless, these exercises have had a very strong political backing where His Excellency the President has personally led and mobilized people in tree planting, building of gabions amongst others. To provide demonstration and training there needs to be a rapid strengthening of extension services. It is particularly important that extension services be interdisciplinary, multi-sectoral, and sensitive to the social and cultural characteristics of the areas of concern.

Apart from the many studies undertaken on the relationship (s) between population dynamics and natural resources utilization, there is need to undertake studies on how man's economic activities affect a specific resource in order to appreciate these interrelationships in a detailed and comprehensive way. This study aims at examining the effects of timber and wood-fuel extraction, local medicine extraction on forest cover of Mukogodo forest. The district has gazetted forests of about 52,233 hectares. Half of the hectarage in Rumuruti Division consists of planted forests. The rest are indigenous trees which are mainly bushes and scattered cedar trees. The Mukogodo forest falls in this category. The table below shows the gazetted forests in the district.

Table 1: Gazetted Forests in Laikipia District

Name of Forest	Area in Hectares	Percentage (%)
South Marmanet	5151	9.7
Ewaso Narok	2053	4.0
Lariak	3988	7.0
North Marmanet	6178	12.0
Rumuruti	6367	14.8
Ol Arabel	7724	12.1
Mukogodo	20872	40.4
Total	52233	100.0

Source: District Forest Extension Office, Nanyuki, 1998

Given the importance of forests as a source of fuel-wood, timber, medicine, as well as their crucial link in the hydrological cycle and regulation of water in catchment areas, the current study on environmental implications of human activities on forest resources is of great relevance. This is more crucial, putting into consideration that the area of study is a semi-arid zone that is prone to land degradation.

1.1 Statement of the Research Problem

Many environmental problems including destruction of tropical forests, desertification and reduction in biodiversity are most clearly evident in the third world countries and Kenya is not an exception. While rapid population growth is often considered an important factor in this environmental degradation, solid empirical evidence on its role is almost non-existent. Understanding the effects of population on the environment requires careful consideration of the full range of factors responsible for environmental deterioration. The nature of this

relationship is heavily determined by land use patterns and agricultural policies adopted by the government.

The government of Kenya gives the matter of environment very high priority in national planning in order to ensure that development is consistent with the enhancement of the environment for the well being of the present and future generations. However, no systematic attempts have been made to study the effects of human activities on the forest environment especially in the arid and semi-arid areas.

This study therefore investigates the role played by the local Masaai people's economic activities on Mukogodo forest as an ideal setting

The research questions formulated were,

- What are the possible effects of nomadic lifestyle on cover change?
- What are the cumulated effects over time of these nomadic activities on the forest cover change?

1.2 Objectives of the study

1.2.1 General Objectives

The main objective of this study was to examine the human impact on Mukogodo forest of Laikipia District. It was concerned with human activities that result into forest clearing and hence, depletion. It also aimed to offer policy recommendations that would guide forestry programmes and environmental programmes.

1.2.2 Specific Objectives

The specific objectives of the study were: -

(i) To analyze the role of household wood-fuel consumption on forest cover in Mukogodo.

(ii) To establish the extent of timber extraction on forest cover.

(iii) To analyze the impact of human settlement and farming activities in Mukogodo forest in East Laikipia if any.

(iv) To offer policy recommendations that would guide environmental programmes in the area or similar areas.

1.3 Research Hypotheses

The following hypotheses were formulated for the purposes of this research:

(i) H_O Household wood-fuel consumption does not significantly contribute to forest cover shrinkage in Mukogodo forest.

(ii) H_I Alternative

(iii) H_O There is no significant relationship between timber extraction and forest depletion in Mukogodo forest.

(iv) H_I Alternative.

(v) H_O Human Settlement activities do not significantly contribute to forest shrinkage.

(vi) H_I Alternative.

1.4 Outline of Chapters

Chapter One

In this chapter, a general introduction to the study together with the statement of the research problem is given. It gives a summary of the chapters as well.

Chapter Two

This chapter gives the justification of the study as well as a detailed review of the past works relevant to the study.

Chapter Three

This is an introductory chapter in which the background information to the study area is examined. It deals with both physical and socio-economic aspects, which are necessary for the current work.

Chapter Four

In this chapter, the research methodology is examined. It specifies the data requirements, the methods of data collection, processing, analysis and the presentation of the results.

Chapter Five

It analyses the aspect of population characteristics and its dynamics as it relates to the forest cover changes between 1966 and 1996 in the study area.

Chapter Six

Chapter five gives a summary of the research findings, conclusions and recommendations.

CHAPTER TWO

2.0 Literature Review

Studies have been carried out at national and international levels on the effects of man's activities as a cause for forest resource depletion. Literature relevant to such aspects in Kenya and elsewhere is enormous, but only a selective review has been done. Literature review serves as a guide to the study of the theoretical framework within which the current study lies. It also serves as a strategy to avoid duplication of past studies, identifying relevant aspects to the current study, and assists the researcher to at least know the details of previous studies and therefore be able to detect gaps to be filled and strong points that need to be reinforced. The research is therefore intended to make contributions to existing works.

2.0.1 Theoretical Bases of the Review

The population environment debates during the 1980s incorporated a new dimension, the concept of sustainable development (WCED 1987). The most important component of sustainable development is the protection of the environment. This is a critical question of the capability of the biological systems to accommodate the multitude of human activities. There is a great future uncertainty about the ability of the biosphere to accommodate mankind's present use of both flow and non-renewable resources. Besides other factors, the carrying capacity of the earth is already under stress because of expansion of human numbers. Therefore, WCED saw population growth and poverty as a major cause and effect of environmental problems.

In the view that Africa is progressively drying out (Kollmannsberger, 1966) the last reserves of forests should be strictly protected. Though the studies were carried out at global level, the current study agrees with Kollmannsberger and more-so because the area of study is a forest reserve in a semi-arid place where regeneration is almost nil and if any then it is quite a slow process.

Tuve, G. L. (1976), observes that environmental degradation as reflected in the depletion of resources involves the operation of several factors, jointly and individually. These factors according to him include, demographic factors, market factors, technological factors and public interventions. According to him rapid population change in association with such external factors as public interventions and commercialization induces structural changes in the village communities. Changes in occupational patterns, group dynamics and distribution of economic and political power at the local level foster disregard of conventions and social sanctions that previously helped to protect resources. With respect to market factors, the increased marketability and profitability of products lead to overexploitation. Public interventions including institutional reforms, welfare measures disrupt the traditional management systems; contribute to overexploitation, poor protection and degradation. The current study deals with a section of what Tuve observed because it looks at some aspects of demographic factors affecting forest cover.

The crux of population-environment link is in unrestricted human reproduction according to Erhlich, P. (1970), which he contends is the major cause of environmental deterioration. Given the high rate of population growth, non-renewable resources are being exploited at an alarming rate and therefore mankind is destroying the capability of the planetary biosphere to renew the supply of renewable resources.

According to Raymond, D. (1970), it is not the population growth rate but rather the misuse of the ecosystem on whose functioning man depends. On the other hand Philip, H. (1963) does not see overpopulation, in a numerical sense as an immediate danger, but to him the problem to be solved is the maldistribution of the present population. Population explosion, implosion, displosion and accelerated tempo of technological advancement are viewed as the

four perspectives of the problem. Although, the above are global generalizations, they highlight the conflicting opinion with regard to human environment.

Carole, L. J. (1993), observed that increasing numbers of people and animals as well as expansion of agriculture have placed stress on the forests. Deforestation has thus become a serious problem, because energy demands for wood and charcoal have increased and land has been cleared for agriculture and settlement. The decline in tree and bush cover has thus reduced soil productivity and promoted soil erosion. Carole adds that, although the increasing severity of environmental problems in the third world is now widely recognized, continuing population growth and the nature of development are widely considered responsible. Although the studies have been generalized on third world countries, Kenya is not an exception despite the fact that different countries in the third world are at different stages of socio-economic developments, different political settings as well as ecological settings. Nonetheless, the current study area is pastoral setting where the local Maasai people believe in large numbers of livestock and their main grazing area is always the forest because the surrounding is a dry land with virtually no pasture and water especially during very dry weather.

In studies spanning two decades in Meru District, Kenya, Bernard (1988) observed that increasing population density in fertile highland areas, road construction and Government policies promoting privatization led to deforestation and resulting soil erosion on the rich, volcanic soil slopes as well as decrease in fallow periods on nearby poor soil low-land areas resulting in soil degradation and desertification. The researcher appreciates the impact of increasing population on forests, although these two areas cannot be compared because of differences in climatic conditions, socio-cultural as well as economic setting. This is more so evident when one appreciates the fact that Laikipia is a semi-arid region.

Although there has been new settlement due to immigration from neighbouring Districts and eventual clearing of forest land for agriculture this has mainly happened in West Laikipia because the climate is not as hostile as in East Laikipia. Omoke, K (1998). East Laikipia is mainly a pastoral land where Maasai believe in keeping large herds of cattle. These are normally grazed in the forest and bushland hence exposing the bushland to erosion.

Covering over half the earth's surface, arid or semi-arid rangelands represent the major land resource in most developing countries. Characterized by low and uncertain levels of rainfall, high desiccating factors, and periodic drought these uncultivated lands can be grazed and browsed by both wild and domestic animals. In the developing countries of Africa, of which Kenya is not an exception, and more so East Laikipia in particular, these lands comprise over half the land area and support a large population dependent in one way or another, on grazing livestock. These lands also produce forage for wildlife and are an important source of critical fuel wood, which provides the energy source for around 80 percent of the African population. Therefore with human population increase the fuel wood energy source among other uses of rangelands will be threatened, (Talbot, 1986).

In an effort to study the causes of deforestation in North Eastern Thailand Panayotou (1989) found out that rising population density was the most important factor leading to forest depletion. This was followed closely by prices of fuel wood and then poverty. Basing on these studies, there is therefore need to carry out a research, though in an area of different ecological as well as socio-economic setting to unveil the contribution of different human activities on Mukogodo forest of East Laikipia.

Population impacts on the environment in the developing countries was partly an area of concern because it was generally believed that population and environment have an exceedingly strong link in the less developed countries compared to the developed countries.

The general arguement is that, much of the environmental stress in the developed countries is due to production and consumption patterns, while on the other hand population factors are the overall contributions to environmental degradation in the third world counties, (U.N. 1994).

The Amsterdam declaration on Better Life for Future Generations adopted during the International Forum on Population in the Twenty First Century (November 1989) acknowledged the fact that population resources and environment are inextricably linked, and a call for the need for a sustainable relationship between population resources and development have received global attention in Agenda 21 adopted by the United National Conference on Environment and Development in Rio de Janeiro 1992. It was noted that population variables are among the many forces that affect the environmental resource base on which sustainable development ultimately depends.

2.1 Empirical Review

The current section of the review brings to attention specific and relevant contribution by previous research on man-forest interactions. This forms the basis for the identification of gaps to be filled and strong contributions to be emphasized by the current researcher.

The livelihood of Kenyans depends essentially on renewable resources of which forestry ranks second to agriculture. Therefore, forests form one of the most important flow resources, which if the yield could be sustained, can be used indefinitely. However, given the high rate of population growth, coupled with the fact that 81 percent of its land comprises arid and semi-arid area (Obara, 1983) forest resources are increasingly being jeopardized and hence turning into "stock" resources.

Tiffen, et al, (1994) in their research based in Machakos District noted that increased human population hence settlements meant increased afforestation, and the movements of farming households into the drier ecological zones of Kenya has no deleterious effects on the environment of the semi-arid region. Given that wood fuel demands, land for cultivation among other forest related needs increase with rising population pressure, the assertions about Machakos may not hold for Mukogodo although the two areas almost share similar climatic conditions. This is so because these two areas, though in the same country are at different levels of socio-economic set-up. First the researcher found out that Mukogodo is an area geographically inhabited by Maasai (pastoralists) community whose mainstay is mainly livestock keeping, with no or very little farming going on in their farms. Their land in most cases is owned communally and they live in low-graded housing units well known as "Manyattas". This is an area mainly inhabited by locals with very little or no influence from other areas of the country. So no new ideas have been absorbed as opposed to Machakos which though a dry area, has had a lot of outside influence through exchange of ideas and economic practices. Quite a number of Non-Governmental Organizations (NGOs) have set their feet in Machakos bringing with them new ideas and monetary support. Therefore the researcher cannot compare the two areas.

Indigenous forests in Kenya cover a total hectarage of 1.2 million. It has been found by Lockwood, that these forests are declining by almost 5,000 hectares per annum. Therefore according to him, the rate will need only 248 years to have the forests completely cleared. On the other hand plantation forests cover up to 170,000 hectares. Of these, a larger proportion has already been cleared without replacement, and therefore forests are at large under severe pressure from illegal clearing for different human activities, Lockwood, (1995).

Increasing population and need for economic changes in Kenya have created strong pressure on natural resources as found out by Ayiemba, (1990). Approximately, 80 percent of timber

requirement by industries come from natural forests, while the rest were from forest plantations in the 1960s. However, the trend has reversed, where by timber requirements by the industry are supplied from plantations. 75 percent of the domestic energy needs of the rural people is from wood-fuel. This rural population accounts for at least 81 percent of the total population, Okidi (1989). Therefore, there is need to examine domestic energy requirements and its contribution to forest cover change in Mukogodo.

Some reductions in coverage of natural forests is due to excisions from forest reserves. Despite intentions to cease forest excisions especially from government reserves, there is continued degazettement. Excised forest reserves are significant in size and in terms of conservation of bio-diversity, and IUCN concluded that since 1960, Kenya has lost slightly over 15,000 hectarage of natural forests especially as a result of excisions IUCN, (1995).

Marshall, (1995) pointed out demand for timber as a major contribution to forest depletion in Kenya. She however appreciates the factors that lead to the mounting pressure to exploit the Kenyan forests. These, according to her include demand for agricultural land, grazing land as well as harvestable products. She contends that over population has either led to overall depletion or reduction in bio-diversity. Although Laikipia is generally a semi-arid land, Berger, (1984) observed that despite adverse climatic conditions, which cannot favour rain fed agriculture, small-scale agriculture is increasingly expanding from areas with about 700-800 mm. of rainfall per year to areas of less than 600 mm. This is therefore an indication of the changing economic activities and as such a need for more land for cultivation. The current research agrees with the findings of the above scholars.

According to Mpaka, (1984) 75 percent of the gazetted forests in Kenya were purposely meant to regulate ground water, safeguard the fertility of soil as well as maintaining the microclimate. But given the rural immigration into these areas and even settlement, these

regions have been placed into a strenuous situation with regard to the above purposes initially meant for them.

Noted 71 percent of energy in Kenya comes from wood. This is mainly in forms of firewood and charcoal. As population in the country rises to over 50 million by the year 2020, fuel-wood consumption will increase from 3 percent in 1995 to approximately 5 percent by the year 2020. Increasing population will automatically lead to reductions in forest cover with forest plantations reducing from 150,000 hectares in 1995 to 100,000 hectares by the year 2020, while indigenous forest cover will reduce from 1 300,000 hectares in 1995 to about 1180 hectares in the year 2020. Nevertheless it is not only fuel-wood that will cause the enormous depletion but other causes as well. The above estimations have been made by the central bureau of statistics the department of forestry.

Mung'ala (1979) in his estimation of the present and future demands for fuel-wood in Machakos District asserts that because wood-fuel, crop residues and dung as forms of non-commercial energy, are freely collected and consequently unrecorded, it is not straight forward to determine the fuel consumption in many developing countries. However, he adds that it is important for planning purposes to find out how much fuel is consumed, and that the fuel demand is not resulting in the removal of vegetation cover from watershed areas and fragile ecosystems. In his estimation of household wood-fuel demand, he estimated the volume/weight using a 50-kg spring balance, a three-metre nylon tape and sisal strap. He found a conversion factor through displacement water experiments, which he finally used to estimate the household wood quantity being harvested per given period of time. He arrived at a conversion factor of 0.028 m^3/kg.

In conclusion, the studies in the literature review above have a number of gaps that need to be filled, and these include: -

(i) No studies on human influences on forest cover have been carried out in the study area.

(ii) Most studies carried out are on macro level, and therefore need for micro-level studies.

(iii) Studies carried out previously have been on forest areas/forest reserves that are easily accessible and hence automatic human influence unlike the current area of study.

(iv) Most studies carried out previously on the human influence on forest cover have concentrated on forest plantations/reserves in areas that are well fed with rainfall, but the current study on the same is in a semi-arid region hence different ecological setting as well as economic activities.

(v) As far as the district of study is concerned, most studies carried out on the same have always been centered around mount Kenya region especially the western side of the district, therefore Mukogodo area has generally been neglected. This is possibly a result of inaccessibility, lack of much economic activities and that, the community is still largely traditional. From migration trends, most immigration were centered in western Laikipia where people from neighbouring districts settled and started crop farming activities because the climatic condition is not as hostile. It is fair to assert here that it is this hostile climatic condition that has down played migration as a population dynamism in the area of study.

2.2 Theoretical and Conceptual Framework

There is need to strike a balance between population dynamics and resource use. This has been a subject of considerable theoretical as well as philosophical concern over time. The population and development debate has addressed this issue of concern at large. The population - resource nexus was first envisaged by Chinese philosophers such as Confucius and later followed by Greek scholars such as Aristotle and Plato. The Chinese scholars advocated that "excessive growth of population reduced output per worker, depressed the

levels of living of the masses". This works introduced the concept of optimum population in relation to agricultural output. Their arguement was based on the fact that there exists an optimum level of population, that is, carrying capacity, which is not any particular number. This model of population versus resource use model contends that if the resource such as land or forest's carrying capacity is exceeded by growth of population then the resource base finally collapses. But according to this model, no systematic investigations were carried out to find the truth and the assumptions that were used were vague and generally philosophical.

According to Malthus theory on the relationship between population and resource in his treatise: "The principle of population in 1798, he vested his argument on a number of suppositions viz.:

a) Man's capacity to increase his means of subsistence was much less than his capacity to multiply.
b) Populations tended towards a limit after which natural checks came into operation this he referred to as the natural safety - valve mechanism, which he hypothesized.

He postulated that man could increase his subsistence in an arithmetic progression whereas man's numbers could increase in a geometrical progression. Though rather vague, the principle brought to light the presence of the population - resource imbalance which needs to be addressed.

In the Malthusian theory, the borne of contention is that population, production and resources are deliberately related especially at the level of subsistence. Malthus theory shoots a hot debate whereby he sees the potentiality of population growth but no potential for resources, especially the supply of food. Considering his reasoning and argument, Malthus saw the supply of food as being inelastic and hence this inelasticity according to him is the main

factor governing population growth rate. According to Malthus, population growth was determined generally by agricultural productivity.

Consequently Malthus theory has the following weaknesses: -

(i) It does not appreciate the existence of the substitution of agricultural production factors; that is, resources can also increase through technological innovations.

(ii) And that pressure of population can help generate more resources because of increased demand hence channels from innovations. Nevertheless there exists a limit to resource availability which if exceeded by growth in population can be deleterious.

Despite its weakness the theory has highly contributed to the present understanding of the population resource nexus. However, the contention that population growth in purely a function of subsistence is not a reality.

Neo-Malthusian school revitalizes the old ideology where population growth is regarded as a variable dependent on agricultural output. This is entirely based on the fact that increase in population leads to land destruction and for people to avoid starving they move to other land elsewhere, which is in turn destroyed. However, this theory is rather dilute when it tends to neglect the evidence available of increasing populations, which have in turn through new and improved methods of production managed to conserve their environment for sustainability. This research does not accept the view that the food potential is incapable of increase, because resource use and management are key elements in the sustainability of any resource.

In her Model of Land Use Boserup E, (1965), considers the effects of changes in population on agricultural production and not the causes of these population changes. He contends that population growth, as an independent variable is a major determining factor in agricultural developments. She postulates that population explosion is as a result of medical inventions and other factors rather than improved conditions of food production. She argues that as

population grows in relation to land, there is tendency to use land more extensively and intensively by increasing labour per unit of land and reducing the fallow time.

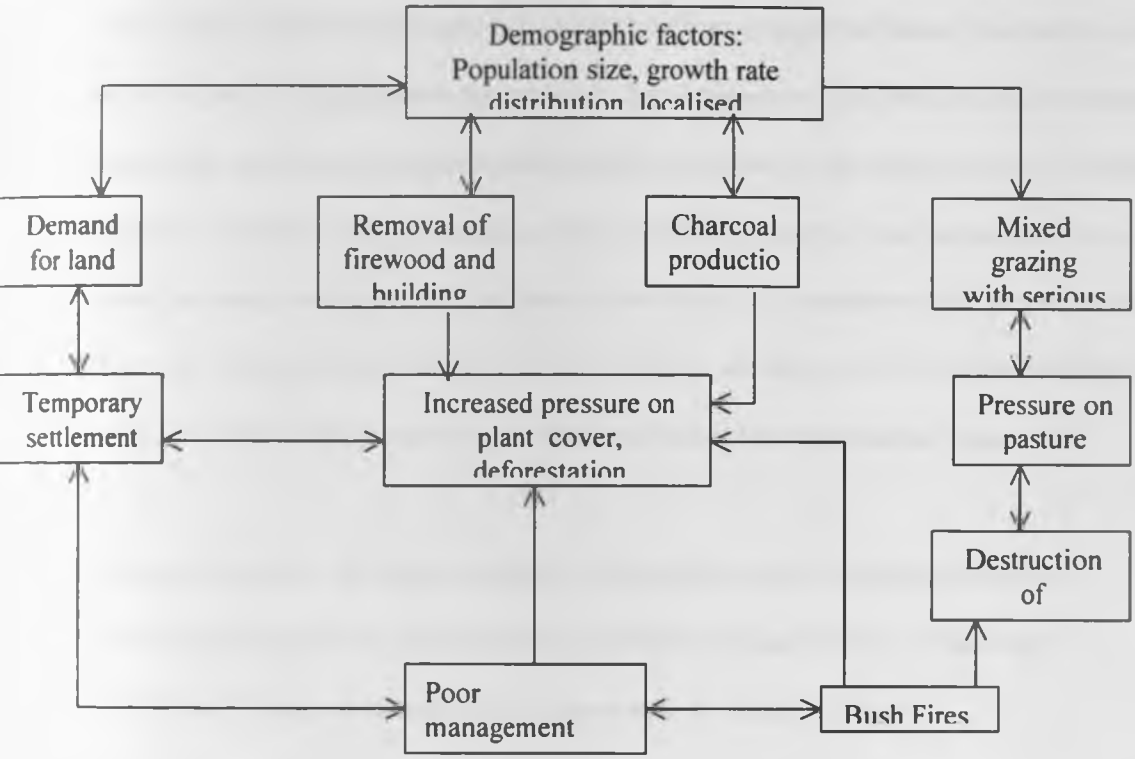
The depletion of forest resource involves operation of several factors, jointly and individually. They can be grouped under: -

1. Demographic factors
2. Market factors
3. Technological factors
4. Public interventions

Demographic factors influence forest resource utilization directly by raising demand for land and indirectly by leading to privatization. On the other hand, rapid population change in association with such external factors as public interventions and commercialization induces structural changes in the village communities. Changes in occupational patterns, group dynamics and destruction of economic and political power at the local level foster disregard of conventions and social sanctions that previously helped to protect resources.

With respect to market factors, the increased marketability and profitability of products lead to overexploitation. Public interventions including institutional reforms, welfare measures disrupt the traditional management systems, contribute to overexploitation, poor protection and degradation.

Fig. 1: Conceptual Framework (Model) for Population characteristics and Forest Resource Use



Source: Researcher 2001

The Conceptual Framework of the above has been designed to specifically deal with demographic factors believed to cause changes in the needs of the population and how they affect the forest cover in the area of study. These demographic factors are population size, growth rate and immigration (mainly by the pastorolists who come to graze their livestock during dry seasons).

The increase in each of the factors give rise in demand for woodfuel, timber for the construction and fencing of the manyattas, charcoal production as well as for grazing due to large heads of livestock kept by the maasai pastoralists. From the foregoing discussion the only economic need/activity in the area of study is the livestock rearing. But Socio-political

needs should not be ignored since they are known to operate in any area irrespective of the level of its economic development.

Under normal cases there is bound to be either positive or negative impact when such needs have to be met or fulfilled from the available forest resources. The level of forest resources management (government policies practicability) is known to govern this, since it ensures sustainable utilization of this resource. But considering the fact that Mukogodo forest is situated in a semi-arid area, physical factors also come into operation. This makes it rather difficult to effect the sustainability in use. During periods/years of extreme shortage of rainfall the ability of the forest to re-establish itself after clearing is almost impossible.

In summary therefore, the conceptual model analyses how these population needs are satisfied from the available forest resources and their resultant impacts. A thorough discussion of the same conclusions and recommendations then followed.

2.3 Justification of the Study

The entire study is based on the influence of human activities on forest resources in Mukogodo area of Laikipia District. The study was intended also to come up with findings that can assist future researchers, resource use planners and policy makers in identifying areas of conflict between human beings and forests, what is drawn from forests, its implications and also develop and execute comprehensive resource use policies in order to achieve sustainability.

Given the fact that Laikipia District has undergone changes in land ownership and land use dynamics since the beginning of the twentieth century as a result of the take over by colonialists of what was a pastoral land and the subsequent change of use into large-scale ranching, acquisition of the ranches by the landless and eventual subdivision and migration of

people from the neighbouring agriculturally high potential areas into this marginal land in search of land for settlement and cultivation, and finally the introduction of small-holder farming systems, especially in West Laikipia, these land use practices are not in line with the prevailing agro-climatic conditions and have thus triggered serious environmental degradation processes. Therefore forest reserves in the district are thus facing extinction due to this activities. No study on the influence of human activities on Mukogodo forest has been done. It is of importance because the pastoral communities living near the forest have different economic activities as compared to West Laikipia where crop farming among the immigrants is highly practiced.

The need to conserve forests for sustainable development in Kenya and elsewhere in the world stems from the multiplicity of forest uses. For years, forests throughout the country have served as sources of timber, fuel wood, medicine, food, fruits, resin, latex, fodder, fibres among others. Natural forests in Kenya are essential as water catchment areas and for soil conservation because the trees cover the soil hence it cannot be prone to wind as well as water erosion. Consequently, destruction of forests has several adverse effects, which do vary in intensity from one locality to the other. When forests on hillsides are destroyed there tends to be a general increase in the rate of soil erosion. Since a greater percentage of population in third world countries is rural based and poverty is rampant, fuel wood from forests supplies much of household energy needs. Faster rates of evapo-transpiration are normally experience in deforested areas hence causing desiccation of soil and eventual changes in climate. Forests are well known homes of millions of species whose disappearance leads to loss of genetic pool available to mankind. Just to say the least forests are aesthetically more appealing than what normally replaces them after they have been cleared.

2.4 Scope of the Study

The current study undertaken in Mukogodo area of East Laikipia was so to speak, meant to examine human activities leading to forest cover change as a result of utilization by the pastoral Maasai community. In essence, the study examines socio-economic activities of the people and how this activity affects the forest. Such activities include animal grazing, household wood fuel use, timber for construction, medicine extraction as well as honey harvesting. Other needs outside the above are not covered.

2.5 Limitations of the Study

The limitations encountered by the researcher in the field were numerous, some of which are stated below. First, the researcher found out that data on forestry and changes that may have occurred over-time was missing from the relevant ministries and departments. This was because, no such records had been kept for Mukogodo forest, probably due to its location in a semi-arid area as opposed to other forests, which are usually found in high agricultural potential areas where crop farming competes with forestry.

The other one was difficulty in transport and communication in the field. No public means of transport was available in the study area and also the study covered a very wide area, thus walking on foot could not do much.. Communication was hampered by the fact that literacy level in the area is still very low hence the use of vernacular.

The occurrence of land clashes especially during the overview survey also posed a problem to the study. There was also the element of suspicion and lack of co-operation on the part of some of the respondents. They claimed they could not be sure of the intentions of the research. Cultural barriers did not allow maasai women to freely talk to strangers. Of significance also was the effort by the researcher to translate the questions to a language

which could be easily understood by the local people as well as the tendency to expound on some of the questions in a bid to render them clear to some of the respondent tended to have a bearing on the interviews and forms group discussions.

2.6.1 Solutions to the Study Limitations

The unavailability of data that could have helped in the assessment of past situation in and around the forest concerning forest cover change was solved mainly by using a combination of maps, aerial photographs and satellite imageries of the study area. This was done for a period of 30 years divided into decades. Contributions by respondents also aided to some extent.

The researcher had to hire private means of transport each time she had to go round. This made this research work to be extremely expensive and moreso because the researcher relied on her own funding. Concerning the difficulty in communication, two people who understood both the national languages and Maasai language were incorporated in the team of field assistants. They were useful to the study especially during the focus group discussions where most of the participants were illiterate.

The problem of land clashes had no immediate solution apart from just waiting for it to cool down before embarking on the work. Fortunately, the clashes did not last for very long, thus its effect or impact on the research was not much.

Suspicion and unwillingness to participate on the part of some respondents was carefully avoided, though not fully, by involving the area chief who in turn gave one person familiar to the people to take the field term round as he tries to explain to the people the aims and objectives of the study. The researcher also ensured that a good rapport existed between the interviewer and the interviewee before proceeding to interview and discuss.

2.6.2 Operational Definitions and Concepts

For purposes of understanding the present study a number of terms have been coined or adopted for use. An operational definition according to Harvey D. (1969) is any idea of specifying meaning and it involves the description of complex inter-relationships between different terms in such a way as to ensure consistency of use. An operational concept is a general idea or notion underlying a given term.

2.6.3 Operational Definitions

Impact:

The term in this research refers to the effect of human induced action on the forest ecosystem.

Household:

This refers to a person(s) normally living together under one roof or same compound.

Manyatta:

Housing unit(s) built and used by the local Maasai people. Normally made of poles, cow-dung and some grass.

Population:

This refers to the total number of people in a given geographical area. In statistics the term is also used to denote the aggregate of units to which the research or interview is to be administered.

Forest:

This refers to large areas of land thickly covered with trees. This term includes both closed canopy as well as glade areas.

Timber:

It is used in the context of the study to refer to wood extracted from Mukogodo forest and used in constructing houses.

2.6.4 Operational Concepts

Land cover:

This describes the "vegetational and artificial construction covering the land surface" (Anderson et al. 1976). Concepts covering land cover and land use activities are closely related and in many cases have been used interchangeably.

Forest Cover Change:

Refers tot he depletion (loss) or gain (re-growth) of forest cover as observed over a specified time frame.

Resource:

It refers to something or anything that can be used for the benefit of man either socially, economically or politically depending on the present or future technology. Elements are classified as resources depending on: the knowledge and technical skills to allow its extraction and utilization; and a demand for the materials or services produced. It is the human ability and need which create resource value, not mere physical presence. Forests are thus classified under critical zone resources, which become non-renewable once the regenerative capacity is exceeded.

Natural Resources:

This term is used to mean that human beings use resources provided by nature and they attach some values to these resources.

Sustainable Development:

Here the concept is used to refer to the type of developments that meets the needs of the present without compromising the ability of the future generations to meet their own needs. This is adopted from Brundtland Report (World Commission on Environment and Development, our Common Future 1987).

Sustainable Resource Use:

The concept refers to the present use of the forest resources for economic, social and ecological satisfaction without necessarily jeopardizing its ability to regenerate. Like any other renewable resource, the forest resource is in a state of dynamic equilibrium between renewability and utilization. If the equilibrium is upset, then degradation occurs.

CHAPTER 3

3.0 THE STUDY AREA: LAIKIPIA DISTRICT WITH REFERENCE TO MUKOGODO

3.1 Background to the Study Area

This chapter presents the background information of Laikipia district in general and Mukogodo area in particular. The information contained here relates to the physical, economic and demographic characteristics as they influence the dynamics of population and forest cover in the area of study.

3.2 Laikipia District: Location and Size

Laikipia District has an area of 9329.3 square kilometers. It is situated on the leeward side of Mount Kenya (Map 1) and is found in a semi-arid, high altitude plateau (1600-2200 metres above sea level). It is one of the 20 districts constituting Rift Valley province. It lies between longitudes 36°14' and 37°27' east and latitudes 0°20' south and 0°55' north, and occupies an area approximately 5.07 percent of the total area of the province and about 1.6 percent of Kenya as a whole. The district boarders the agricultural districts of Nyeri and Nyandarua of Central province in the West and South respectively, Central Meru and Isiolo districts to the east and the predominantly pastoralist districts of Samburu and Baringo in the North and West respectively.

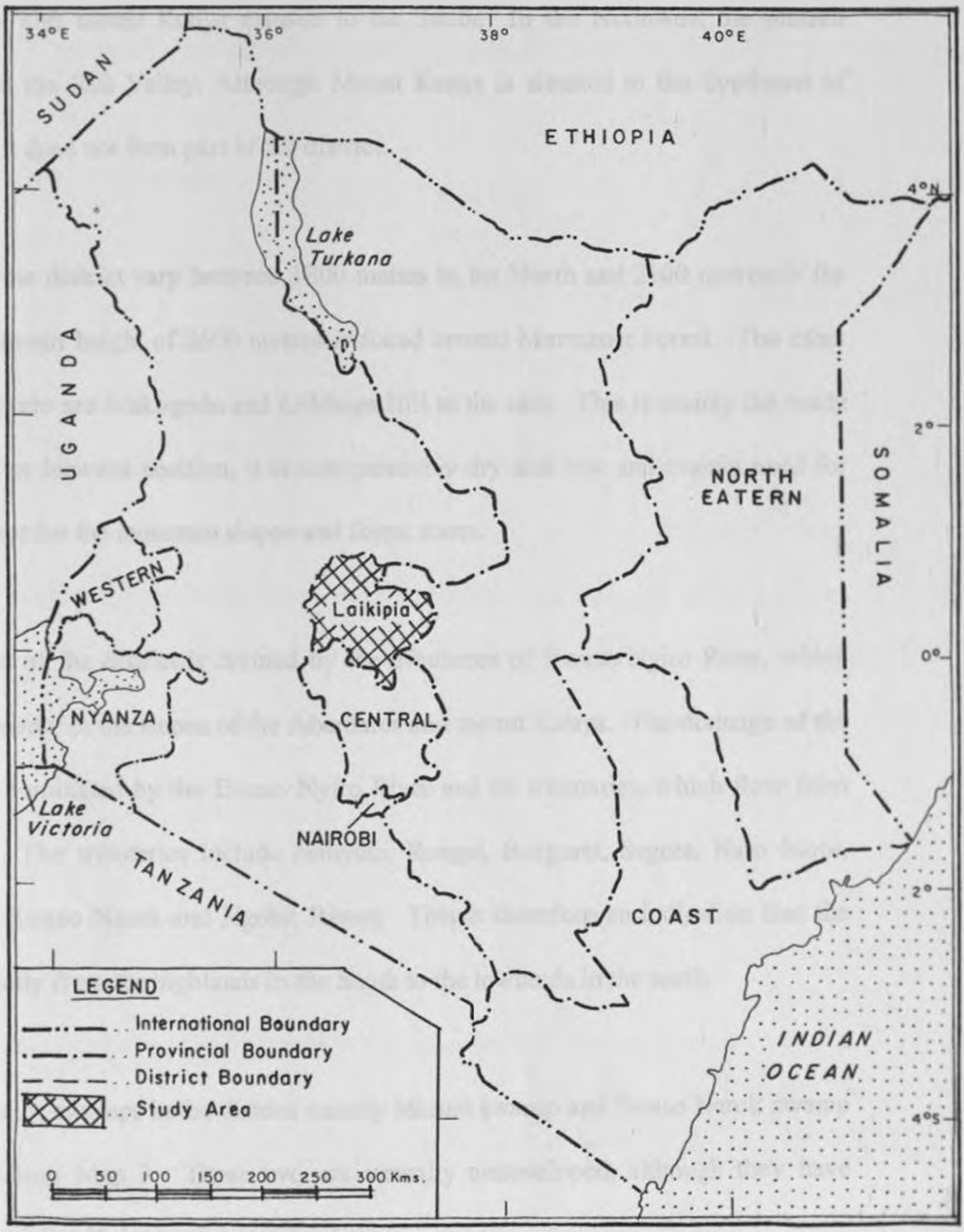
The area of the district by division is shown in the table below:

Table 2: Administrative Divisions of Laikipia District

Division	Area in square kilometres		
Lamuria	1116		
Central	2355		
		Rumuruti	2919
Mukogodo	1129		
		Nyahururu	167.3
Ng'arua	1643		
Total	9,329.3		

Source: Survey of Kenya (Public Map Office) 1998

From the data Rumuruti is the largest division covering 31 percent of the total area, followed by central covering 25 percent. The smallest division is Nyahururu which covers about 2 percent, Lamuria 12 percent, Ng'arua 18 percent while Mukogodo which is the area of interest of the current study 12 percent as shown in Map 7. Mukogodo is bordered by the Samburu, which is generally a pastoral community, this unveils the picture of temporal immigration of pastoralists from Samburu in search of water and pasture especially during the dry season. The only source of these is Mukogodo forest. This introduces the idea of conflict most of the time because of differences in social setting of these two communities.



MAP I KENYA: LOCATION OF LAIKIPIA DISTRICT. Source: Survey of Kenya

3.3. Physiography of the study area in relation to Economic activities

The district consists mainly of a level plateau bounded by the Rift Valley to the West and the Aberdare Ranges and mount Kenya massifs to the South. In the Northwest the plateau descends towards the Rift Valley. Although Mount Kenya is situated to the Southeast of Laikipia district, it does not form part of the district.

The altitudes of the district vary between 1800 metres in the North and 2100 metres in the south. The maximum height of 2600 metres is found around Marmanet Forest. The other areas of high altitude are Mukogodo and Loldaiga Hill to the east. This is mainly the study area and due to its leeward position, it is comparatively dry and low and mainly used for pasture land except for the mountain slopes and forest zones.

The level plateau of the district is drained by the tributaries of Ewaso Nyiro River, which have their catchments in the slopes of the Aberdares and mount Kenya. The drainage of the entire district is dominated by the Ewaso Nyiro River and its tributaries, which flow from South to North. The tributaries include Nanyuki, Rongai, Burguret, Segera, Naro Moru, Engare, Moyak, Ewaso Narok and Ngobit Rivers. This is therefore an indication that the district slopes gently from the highlands in the South to the lowlands in the north.

There are two major swamps in the district namely Marura swamp and Ewaso Narok swamp as can be seen from Map 3. These two are virtually undeveloped, although they have agricultural potentiality if reclamation can be done.

Topography plays an important role in determining economic activities including human settlement. The south western part of the district has the highest potential for forestry and

mixed farming due to its high altitude, especially around Maramanet area. It is also the most densely populated settled area. The eastern part is suitable for grazing and is the main area of interest of the current study. The rivers also determine human settlement, as they are sources of water, both for human and livestock consumption and possible irrigation activities. The flat nature of some of the areas renders roads impassable during the rainy season.

3.3.1 The Geology of the Area

The rock structure of an area is an important variable in that it influences the characteristic of the soils found in a particular area. This in effect, has a bearing on the agricultural activities suited for an area and therefore among other considerations determines production levels. The district is generally underlain by metamorphic rocks of the pre-Cambrian age and forms part of the extensive African Basement Complex extending south to Mozambique and next to West Africa. Outcrops of these rocks forming the Mukogodo and Loldaiga hills mainly of gneisses, migmatites and granites characterize the north eastern part of the district, which is the area of interest in the current study. The Western parts of the district are build up of extensive flows of phonolite lavas originating from the Nyandarua ranges and the edge of the rift Valley escarpment. These include the Nyahururu and Rumuruti phonolites. These soils support a wide variety of crops such as wheat, barley, maize, beans and potatoes.

The southern and eastern parts of the district have lavas of basaltic composition especially to the north of Nanyuki and Timau, and other volcanic materials originating from Mount Kenya. The latter cover most of the central parts of the district.

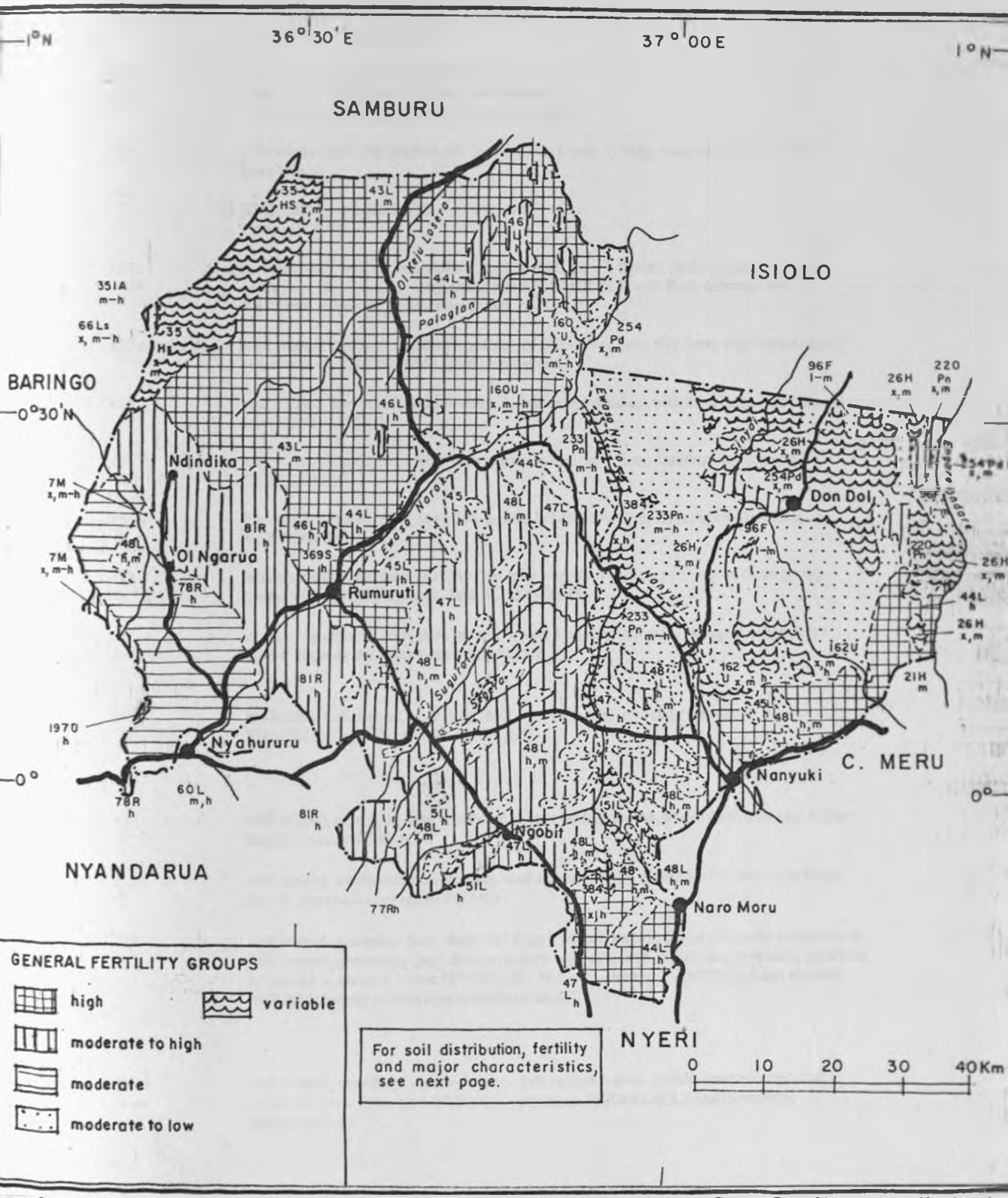
3.3.2 The Soils of the area

The north eastern part of the district is dominated by soils developed on uplands such as cambisols and luvisols. The hills and minor scarps in the eastern apart of the district are

covered by soils developed on basic igneous rocks such as serpentines, basalts, and nepheline phonolites, and those developed on undifferentiated basalt system rocks predominantly gneisses. These soils are also of moderate to high fertility and could sustain crop agriculture in the area of interest only that given the fact that the region lies in the leeward side it is in the rain shadow region hence rainfall is a major hindering factor to crop farming. It therefore leaves the area for nomadic herding (See map 2 and table 3).

The western, southern and some parts of the eastern region of the district are characterized by some volcanic footridges where soils developed on tertiary basic igneous rocks such as nitosols, cambisols, acrisols, and those developed on ashes and other pyroclastic rocks from recent volcanoes are prevalent. These soils have moderate to high fertility.

On the plateau all over the district, soils developed on tertiary igneous rock such as vertisols, phaeozerus and planisols are prevalent. The soils in these areas are imperfectly drained, deep and black to grey in colour. On the mountains moderate to high fertility soils, largely developed on olivine basalt and ashes of major older volcanoes, and those developed on undifferentiated basement system rocks are common. Variably fertile soils on swamps occur along the Ewaso Narok river. These soils are developed on in fill from undifferentiated basement system rocks and are of generally low fertility.



ap 2 Laikipia District: Soil types

Source: Farm Management Handbook of Kenya Vol. II

7 M x,m-h	well drained, shallow to moderately deep, dark reddish brown to dark brown, rocky, and bouldery, clay loam to clay; in places with humid topsoil.
2IH x,m	well drained shallow dark reddish brown friable rocky and stony clay loam (nito-chromic CAMBISOLS, lithic phase, with Rock outcrops)
26H x,m	somewhat excessively drained, shallow, reddish brown, friable, rocky or stony. Sandy clay loam (eutric REGOSOLS, with Rock Outcrops and calcic CAMBISOLS)
35Hs - x, m	predominantly well drained shallow, dark reddish brown, friable, rocky or stony, strongly calcereous, clay loam; in many places saline (LITHOSOLS with Rock outcrops and XEROSOLS, bouldery and saline phase).
43L - m	well drained, shallow to moderately deep, reddish brown, firm clay loam, with humic topsoil (chromo-luvic PHAEOZEMS, partly lithic phase).
44L - h	well drained, moderately deep-to-deep, dark brown, firm clay, with thick humid topsoil ortho-luvic PHAEOZEMS)
45L - h	imperfectly drained, deep, very dark grayish brown, very firm, cracking clay (chromic VERTISOLS)
46L - h	imperfectly drained, deep, very dark gravish brown, very firm, cracking clay (chromic VERTISOLS)
47L - h	imperfectly drained, deep, black to dark gray, very firm slightly to strongly cracking clay (pellic VERTISOLS and verto-luvic PHAEOZEMS).
48L - h,m	imperfectly drained, deep, dark grayish brown, firm clay (hardpan), abruptly underlying a topsoil of sandy clay loam (eutric PLANOSOLS).
51L - h	moderately well drained, very deep, dark grayish brown, firm clay (verto-luvic PHAEOZEMS;) with eutric PLANOSOLS)
77R - h	well drained, extremely deep, dusky red to dark reddish brown, friable clay; with acid humic topsoil (humic NITOSOL)
81R h	well drained, moderately deep-to-deep, dark reddish brown, friable to firm clay, with humic topsoil (chromo-luvic PHAEOXEMS).
78R h	well drained, extremely deep, dusky red to dark reddish brown, friable clay, with inclusions of well drained, moderately deep dark red to dark reddish brown, friable clay over rock, pisoferric or petroferric material (eutric NITOSOLS: - With nito-chromic CAMBISOLS and chromic ACRISOLS,partly pisoferric or petrorferric phase)
96F – l-m	well drained, very deep, yellowish red to dark reddish brown, friable, coarse loamy sand to sandy clay loam (chromic LUVISOLS; with rhodic FERRALSOLS and luvic/ferric ARENOSOLS).
160U – x,m-h	well drained shallow to moderately deep, strong brown to brown, firm, gravelly to stony, sandy clay to clay loam, over soft rock (orthic LUVISOLS, partly paralithic phase)

162U x, m -h	complex of well drained, shallow to deep, red to dark red, friable to firm, sandy clay loam to sandy clay, in places rocky (chromic and ferralo – chromic LUVISOLS, with chromic CAMBISOLS and Rock Outercrops)
197U - h	well drained, deep to very deep, dark reddish brown to dark red, firm clay; with inclusion of imperfectly drained, moderately deep, dark reddish brown clay (nito-ferric/chromic LUVISOLS; with glaic LUVISOLS, partly lithic or pisoferric phase)
220Pn - x,m -h	well drained, shallow very dark reddish brown, slightly calcareous, stony and bouldery, clay (chromic CAMBISOLS, bouldery and lithic phase)
233Pn - m -h	well drained, moderately deep to deep, dark red to strong brown, friable to firm, sandy clay loam to clay ferralo – chromic/orthic LUVISOLS).
254Pd - x, m	complex of well drained, shallow to moderately deep, dark red to yellowish brown, non to moderately calcareous, stony sandy clay loam over petrocalcic material or quartz gravel (calcic CAMBISOLS, lithic or petrocalcic phase; with chromic LUVISOLS, petric phase)

Table 3: Major Soils and Agro-ecological Zones

Soils	Description Limitations	Agro ecological Zone	Potential	
Soils on mountains excessively	Reddish brown, Sandy, clay Loam	UH 2, LH 2	Wheat, maize, Potatoes	Somewhat drained
Soils on hills And minor poor scarps	Reddish clay Excessively loam with rock out-crops	LH 5, UH 3	Sheep,	Cattle shallow, work ability
Soils on step Poor faulted scarps of R/Valley	Rocky stony loam workability	LH4	Cattle, Sheep	Hallow,
Soils on Plateaus & high plains	Reddish brown	LH 5	Ranching	Hardpan
Soils on drainage uplands	Clay loam, Greyish, brown clay	LH 3	Zone	Poor
Soils on dissected Erosion plains	Dark brown clay	LH 5	Wheat	Cracking clay
Dark brown clay loam, sandy clay loam to sandy clay	UM 6	Ranching zone	Poor moisture retention, Workability poor	
Stormy sandy loam with quartz gravel		Ranching zone		

Source: District Agriculture Office, Nanyuki, 1996

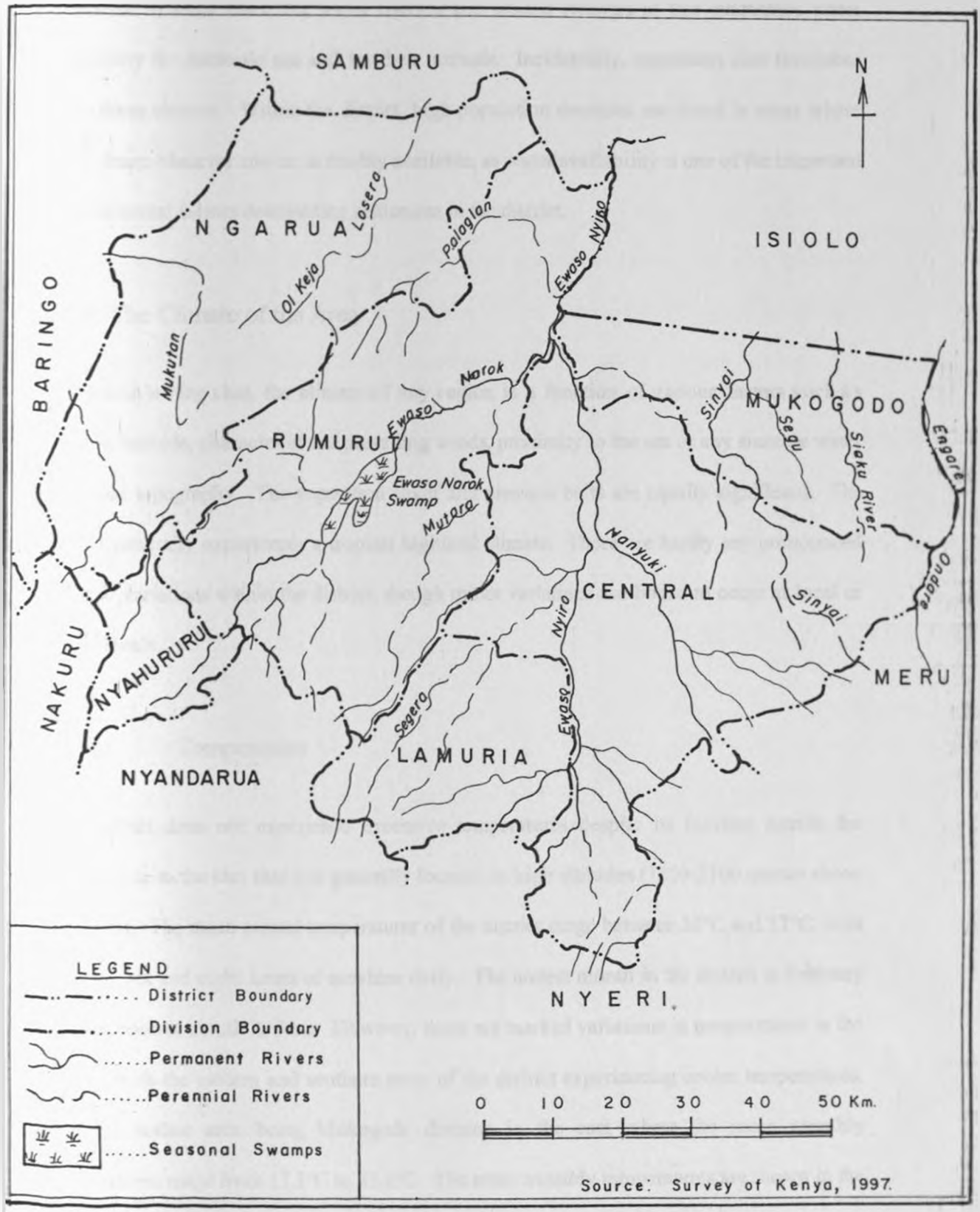
It is this variation in the nature of soils in the district and its related fertility differentials among other factors, that account for variations in human activities such as farming and settlement. Fertile soils in the western part of the district and presence of high levels of

rainfall coupled with socio-economic influences brought in from neighbouring districts during the process of immigration, support the extensive farming activities in the area. The soils in the eastern part of the district only support ranching activities. This is where the study area is located.

3.3.3 The Drainage system of the Area

It is suffice to note that, most of the rivers in the district form part of the Ewaso Ngiro river system which rises on the higher parts of Mount Kenya (over 2,000 metres above sea level) and the Aberdares and flows in a northerly direction across the Laikipia plateau and onto the Lorian swamp in Somalia as shown in Map 3. Rivers such as Ol Arabel, which rises from the Maramanet forest (2,600 metres above sea level) and Mukutan, which rises from the Ndindika area (2,000 metres above sea level) move north westwards to empty their waters in lake Baringo.

Most of rivers in the district are perennial in nature. But owing to high water abstractions during the dry seasons for the purpose of irrigation in West Laikipia and high evaporation and water percolation into the soil in the east and northern parts of the district (due to aridity), some rivers such as Rongai, Kongoni, Sirimon, Aiyam and Mutara sometimes dry up both in their lower courses and upstream. The palagina and Ol Keju Losera rivers flow northwards only during the rainy season. The drainage system in the district is illustrated in the Map 3.



Map 3 Laikipia District: Drainage System.

The drainage network is such an important aspect as it plays a big role in the distribution of both the population and socio-economic activities in the district. It tends to attract human settlement to areas bordering water courses and around swamps as this guarantees water availability for domestic use and for their animals. Incidentally, vegetation also flourishes along these courses. Within the district, high population densities are found in areas where water, from whatever source, is readily available, as water availability is one of the important environmental factors determining settlement in the district.

3.3.4 The Climate of the Area

It is worth noting that, the climate of any region is a function of various factors such as altitude, latitude, character of the prevailing winds, proximity to the sea or any sizeable water body and topography. The vegetation cover and pressure belts are equally significant. The district generally experiences a tropical highland climate. There are hardly any pronounced climatic variations within the district, though minor variations are bound to occur at local or micro-levels.

3.3.4.1. Temperature

The district does not experience excessive temperatures despite its location astride the equator due to the fact that it is generally located on high altitudes (1800-2100 metres above sea level). The mean annual temperatures of the district range between 20°C and 37°C, with between six and eight hours of sunshine daily. The hottest month in the district is February and the coolest month in June. However, there are marked variations in temperatures in the district with the eastern and southern parts of the district experiencing cooler temperatures, and the hottest area being Mukogodo division in the east where the mean monthly temperatures range from 17.1°C to 23.2°C. The mean monthly temperatures are shown in the table below:

The mean monthly temperatures tend to vary from area to area depending on the area's location in relation to Mount Kenya. For instance, areas on the slopes of Mount Kenya tend to experience cool temperatures throughout the year as compared to other areas in the district.

It is important to observe here that the variations in temperatures in the district determine the distribution of both the agricultural activities and the human settlement in the district. For instance, the people in West Laikipia practice some small-scale farming and keep livestock on large scale both because of tradition as well as climatic conditions. The figures in the table represent mean monthly temperatures for six stations (°C).

Table 4: Mean Monthly Temperatures (^{0}C)

Months/ Stations	Matanya	Kalalu	Siringa	Ngenia	Mukogodo	Rumuruti
January	16.6	15.8	18.5	14.9	18.1	18.0
February	17.9	17.1	19.6	16.2	19.6	19.3
March	18.1	17.1	19.4	16.5	20.0	19.4
April	18.1	17.2	19.0	16.2	19.8	19.7
May	18.3	16.8	18.4	15.7	19.9	19.2
June	17.8	16.4	17.9	15.1	19.6	18.1
July	16.6	15.5	16.5	14.3	18.2	17.6
August	16.7	15.7	16.7	14.3	18.2	17.7
September	17.3	15.9	17.8	14.7	20.0	17.7
October	17.7	16.5	18.6	15.4	20.0	20.0
November	17.0	15.7	17.5	14.7	19.3	19.2
December	17.1	15.7	18.4	14.8	17.7	18.4

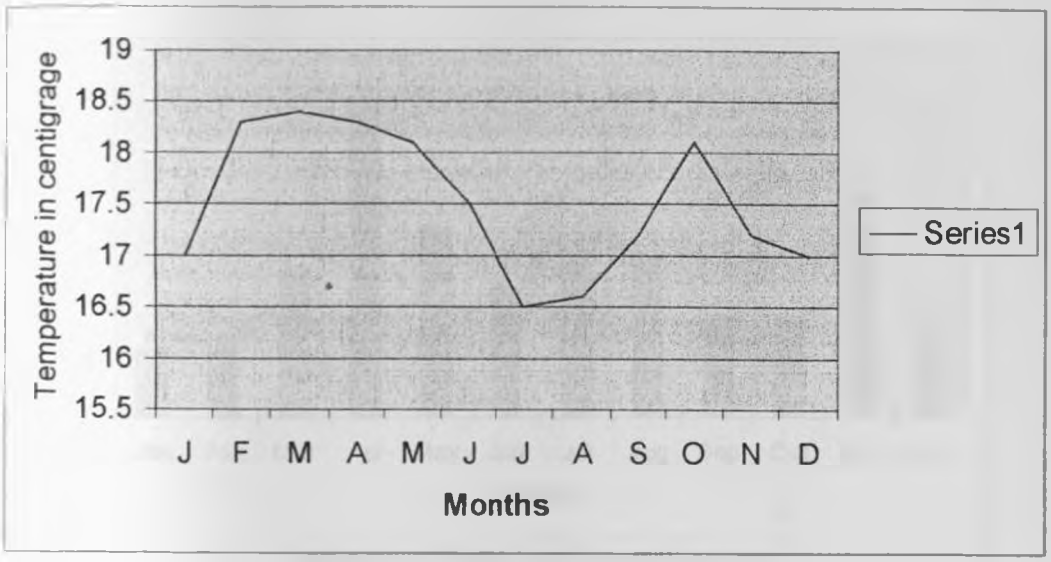
Source: Laikipia Research Programme, 1992

From the table above the researcher calculated the approximate average temperatures for the six stations as follow: (to the nearest one decimal place):

Table 5: Mean monthly temperatures (six stations)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
17.0	18.3	18.4	18.3	18.1	17.5	16.5	16.6	17.2	18.1	17.2	17.0

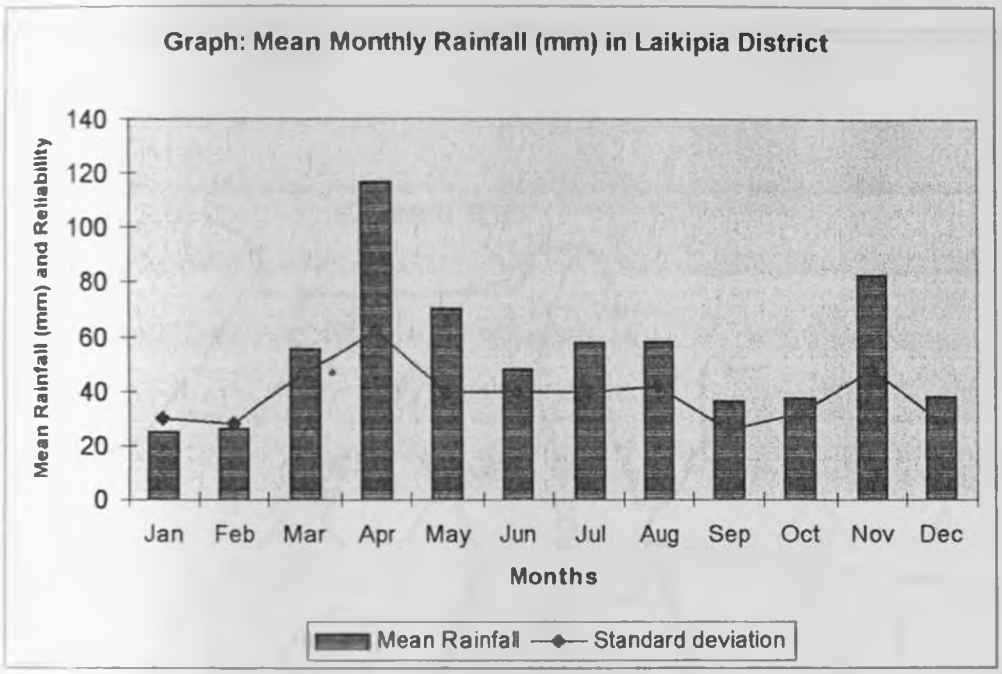
Geographically it can be represented as follows (Graph 1).



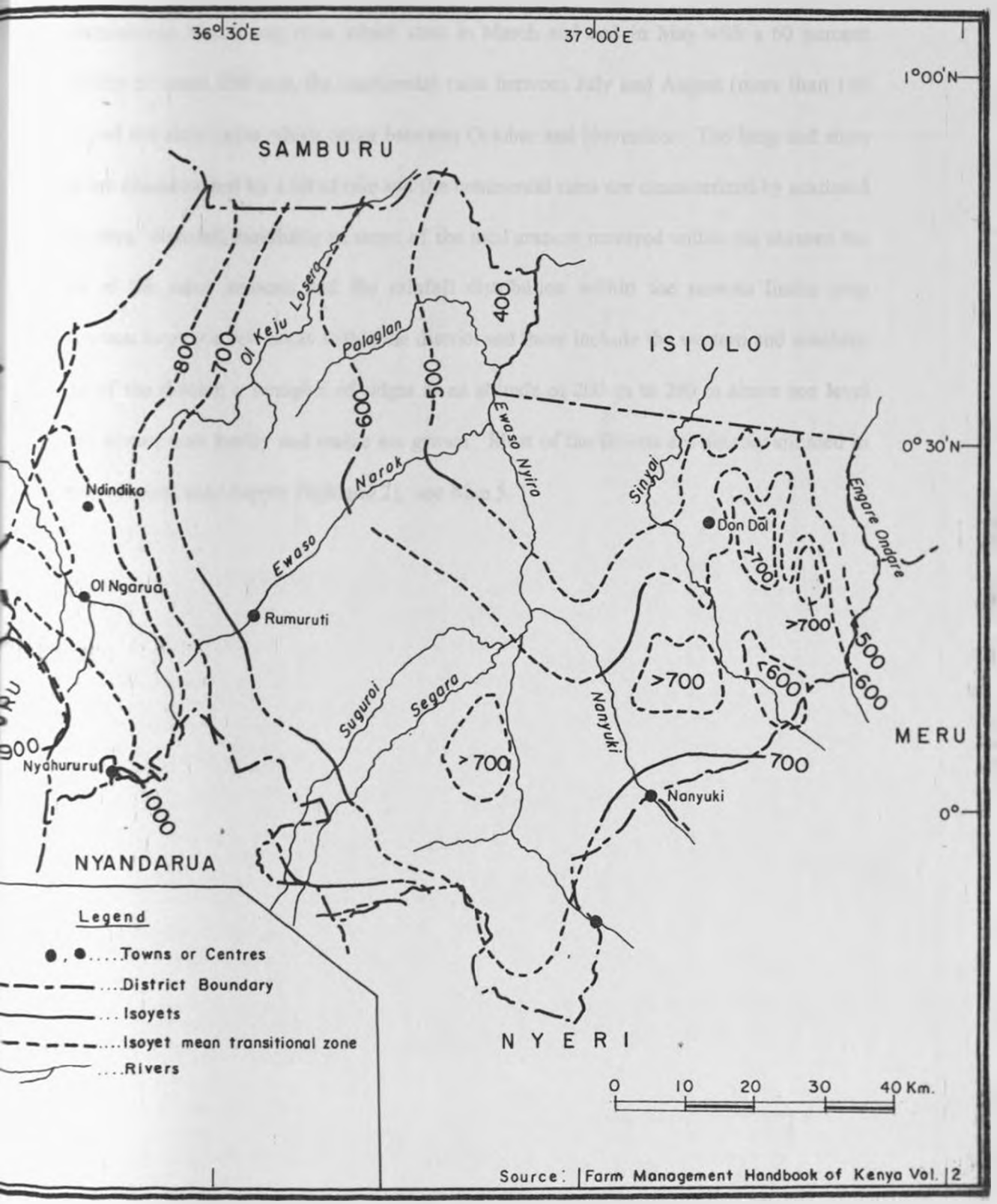
3.3.4.2 Rainfall

Laikipia district is generally semi-arid. The amount of rainfall received throughout the year as well as its reliability are significant considerations of the economic activities in the area. The long term average annual rainfall (in mm) is fairly high and ranges between 600 in the central plateau and 900 to the west of the district on the eastern ridges of the Rift Valley, but it is too unreliable and too scattered during the year. The long-term mean monthly rainfall variations calculated on the basis of mean monthly rainfall (mm) records from 12 weather stations in Laikipia District are presented in the graph below. These stations are fairly distributed in the district, and therefore the figures obtained are fairly representative of the rainfall situation in the district.

These are 25.2, 26.1, 55.4, 116.8, 70.2, 48.1, 58.0, 58.1, 36.3, 37.7, 82.4, 37.9 respectively for the months of January to December in ascending order.



It is noted that the month of April is the wettest month with over 62.2 percent reliability of rainfall. This is contrasted with the months of January and February that tend to be the driest. The annual mean rainfall is 673.4 mm. This potrays situation of semi-aridity. The rainfall pattern is biomodal with the long rains occurring between March and May and short rains from October to December. This seasonal distribution is a function of the influences of the northeast and south trade winds and westerly winds in the middle troposphere in July and August However, this pattern does not apply to the high mountain areas such as Mount Kenya and the Nyandarua Range as these are areas of high rainfall in other periods of the year owing to the influence of the trade winds (see Map 4).



Laikipia District: Mean Annual Rainfall.

The annual rainfall totals in the district seem favourable, but for purposes of crop production, rainfall distribution across the year is more important. Three rainfall seasons are easily distinguishable, viz.: Long rains which start in March and end in May with a 60 percent reliability of about 100 mm, the continental rains between July and August (more than 120 mm) and the short rains which occur between October and November. The long and short rains are characterized by a lot of rain and the continental rains are characterized by scattered rainy days. Rainfall variability in terms of the total amount received within the seasons the onset of the rainy seasons and the rainfall distribution within the seasons limits crop production to only a few areas within the district and these include the western and southern edges of the district; a complex of ridges at an altitude of 200 m to 260 m above sea level where wheat, malt barley and maize are grown. Most of the forests are notably situated in agro-ecological zone (upper Highland 2), see Map 5.

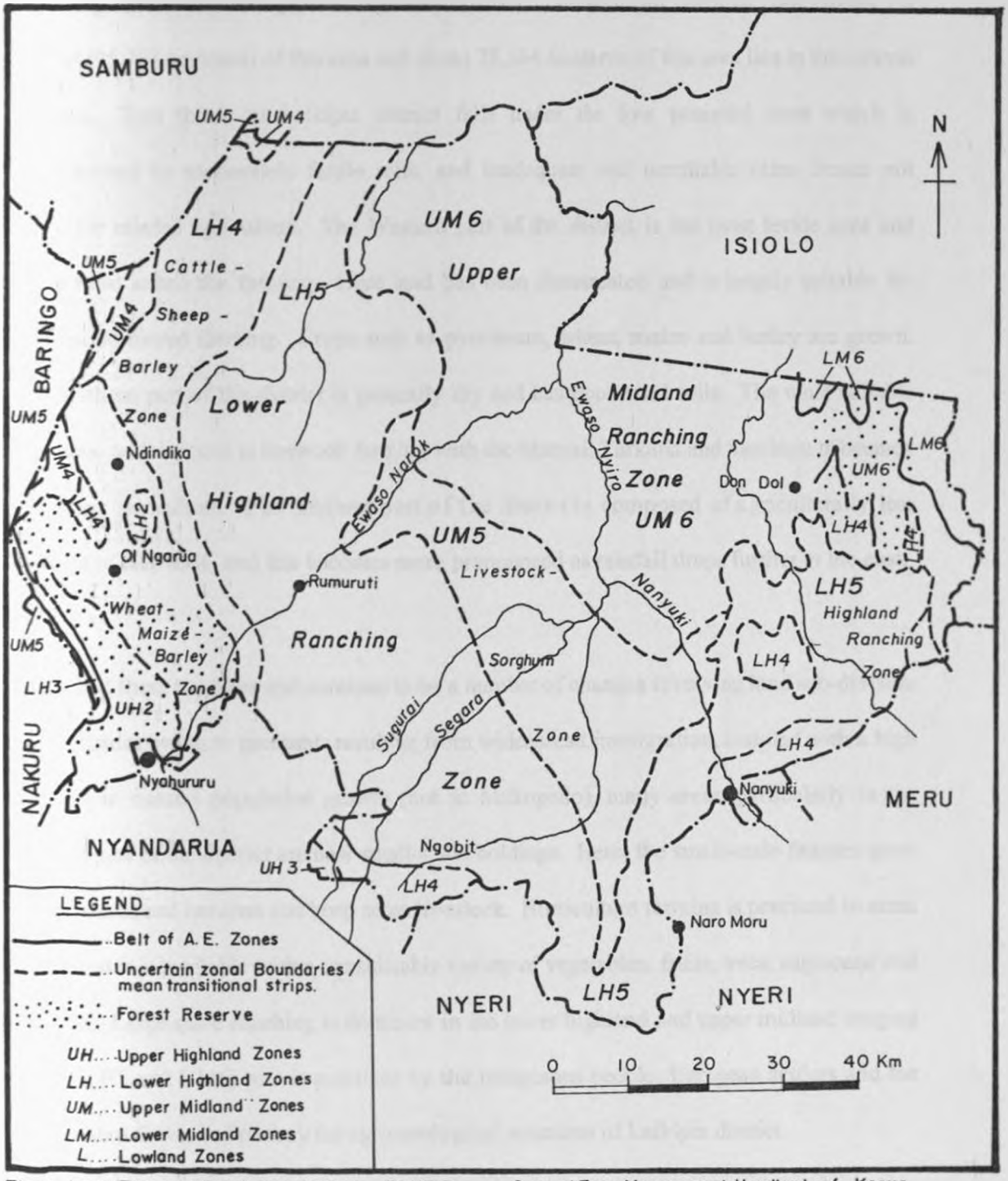


FIG.5 LAIKIPIA : AGRO-ECOLOGICAL ZONES Source : Farm Management Handbook of Kenya

3.3.5 Agro-Ecological Zones

These are the zones showing potential land-use, based on the natural or environmental factors. Laikipia district is divided into three main agro-ecological zones, viz.: high, medium and low potential lands. Zones 1 & 2 occupy 1.7 percent of the entire district area and this covers Rumuruti and some parts of Ng'arua divisions. The medium potential zone covers 9.8 percent (95,208 hectares) of this area and about 78,164 hectares of this area lies in the central division. Two thirds of Laikipia district falls under the low potential zone which is characterized by moderately fertile soils, and inadequate and unreliable rains, hence not suited for rainfed agriculture. The Western part of the district is the most fertile area and hence most suited for farming. Here land has been demarcated and is largely suitable for small-scale mixed farming. Crops such as pyrethrum, wheat, maize and barley are grown. The northern part of the district is generally dry and has poor sand soils. The most suitable economic activity here is livestock farming with the Maasai, Turkana and Samburu tribesmen practicing nomadism. The southern part of the district is composed of agriculturally less productive clay soils, and this becomes more pronounced as rainfall drops further to the east.

Given that there has been and continue to be a number of changes involving land sub-division in the district owing to pressures resulting from widespread immigration, coupled with a high increase in natural population growth (not in Mukogodo), many areas, particularly in the western part of the district are now small-scale holdings. Here, the small-scale farmers grow maize, beans and bananas and keep some livestock. Horticulture farming is practiced in areas where water is available with a considerable variety of vegetables, fruits, trees, sugarcane and bananas. Large scale ranching is dominant in the lower highland and upper midland ranging zones (LH5 and UM6) and is practiced by the indigenous people, European settlers and the GOK. Map 5 overleaf portray the agro-ecological zonations of Laikipia district.

3.3.6 Vegetation

The vegetation of the district varies from sub-humid forests through the semi-arid bush lands the wetlands to the arid shrubby grasslands. The main vegetation types in the district can be categorized into forests (both indigenous and plantation forests), acacia bush land (1000m-1800m above sea level), shrubby grassland (dominated by the themeda triadra which is ideal for ranching), wetlands, (along some rivers traversing the Laikipia plains dominated by the reed (cypress) and papyrus e.g. Ewaso-Narok and Pesi swamps, and the cropland complex; which accounts for about 8 percent of the district area and 10 percent of Ng'arua and Rumuruti divisions characterized by crops such as maize, wheat, potatoes, beans and agro-forestry tress.

The distribution of vegetation types in the district is a function of several factors, viz.: altitude, soils, rainfall types and the extent of human occupation and utilization which affects both the distribution and the diversity of vegetation. Notably forest excision and bush clearing for cultivation, excavating, illegal charcoaling, and increasing pressure on vegetation for fuel wood and construction wood continues to pose a serious threat to the ecological balance. It has been established, especially in West Laikipia that, at the periphery of the agricultural landscape, the clearing of woody vegetation for timber, charcoal, and firewood has increased in the course of recent settlement. The situation precipitates a wood fuel and timber crisis in the next 5 to 10 years, if the vegetation is not balanced with tree planting.

When all the components of the natural environment are considered, it is most appropriate to assert that human activities affect vegetation more than anything else. Changes brought about by human in plant cover lead to modifications in soils, influence climates, affect geomorphic processes, and change the quality and quantity of water sources.

In Laikipia district, areas with flourishing vegetation are areas of high rainfall and have good potential for farming. This has led to a conflict between the need for human settlement,

farming, and the existence of these vegetation areas, leading to serious depletion and degradation. Apart from the fact that some human needs such as wood, food, and medicine are obtained from such areas, these areas also serve as grazing grounds for animals, consequently they tend to attract both human and animal concentrations.

3.3.7 Demographic characteristics

The demographic characteristics of the district are diverse depending on factors such as the migration trends, agro-ecological zonations, and urban influence, among others. Given that these parameters vary in magnitude, both innate and acquired population characteristics such as population size, density distribution, structure and income, have significant variations some of these variations are portrayed in the table below: -

Table 6: 1999 Population Distribution in Laikipia District

Adm. Area	Sq. km	Male	Female	Total	Sex Ratio	Density
Central	2385	40039	37439	77478	1.07	32
Lamuria	1106.6	19585	18932	38517	1.03	35
Mukogodo	968.6	6432	6744	13176	0.95	14
Rumuruti	2716.5	39446	39484	78930	0.99	29
Ng'arua	1804.6	37601	39073	76674	0.96	42
Nyahururu	247.6	18595	18817	37412	0.99	151
Laikipia	9225.1	161698	160489	322187	1.01	35
Rift Valley	182539	3498989	3488047	6987036	1.00	38
Kenya	581677.2	14205589	14481018	28686607	0.98	39

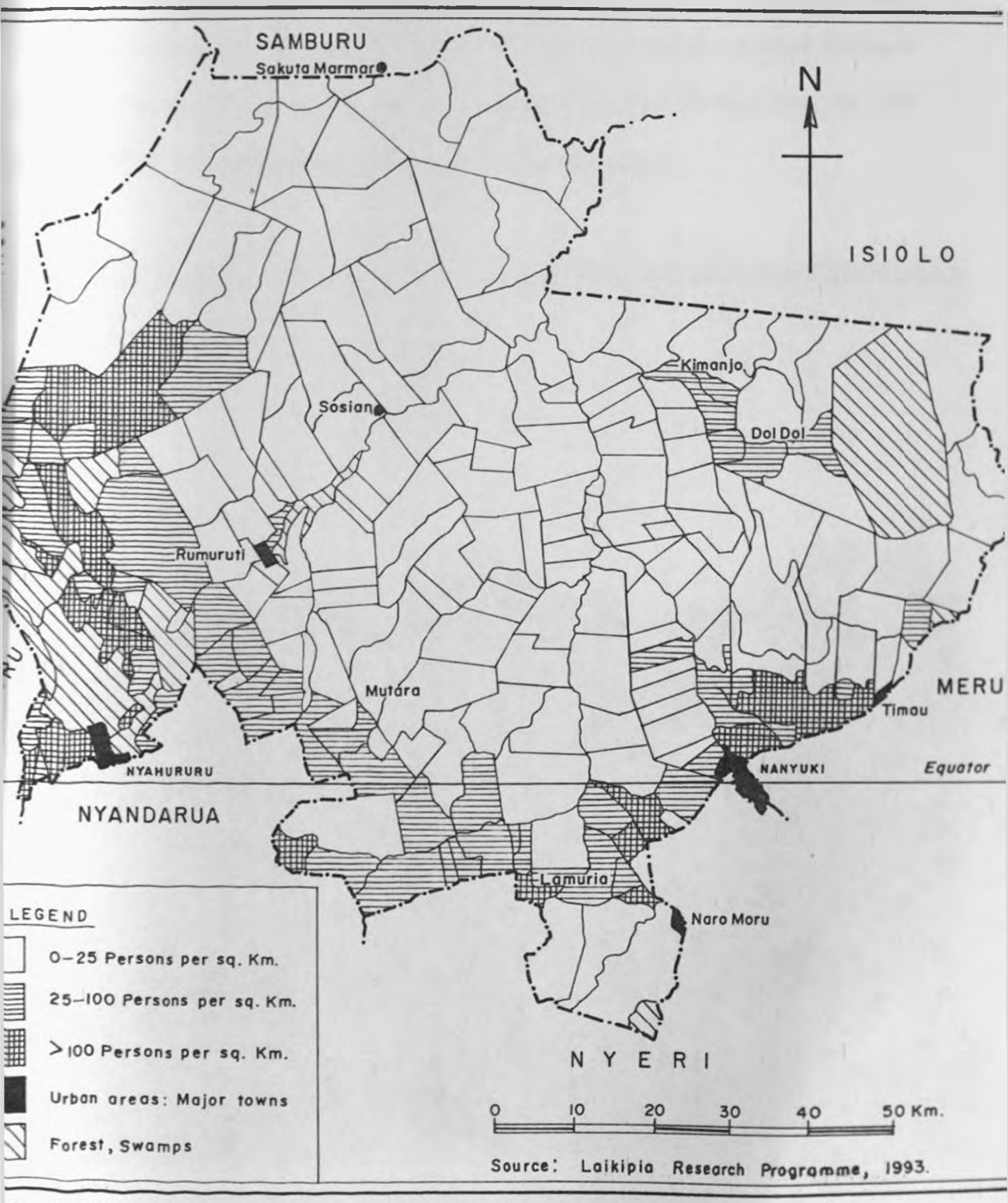
Source: CBS Population Census, 1999 (These density figures are approximated to the nearest whole numbers)

Based on the 1989 sex ratios and distribution for Laikipia District and its constituent divisions above (table 6), it is evident that there are more males than females in the district.

This situation could be explained by the fact that wherever in-migration has taken place, more males tend to migrate and settle as compared to women. The variations in sex ratios observed in the divisions are attributed to the local variations. For example, Lamuria and Central divisions have highest ratios owing to the fact that some of their parts are still

influenced by in-migration and that a bigger portion of Central division is still under large-scale production as well major urban centres that attract more men to work. Ng'arua division has the second lowest (after Mukogodo) sex ratio in the district because the area has relatively old and stabilized settlements with relatively no new settlements taking place.

The spatial population distribution and density differentials in the district portray an existence of distinct population clusters, which are separated by broad areas of sparse population. This situation is, among other factors, also accounted for by the immigration differentials. It is also a reflection of the varying physical and biological environmental constraints in the district. The distribution of population in the district is well illustrated in the dominant land use and population density map shown on Map 6. Despite the general trend of the number of males being higher than females, it is slightly different in Mukogodo division because the area is still somehow not affected by in-migration of people to come and settle. From the research carried out in the study area, more than 90 percent of the people interviewed are the native Maasai and Samburu pastoralists. The sex ratio in this region happens to be the lowest amongst all the divisions within the district hence the presence of more females than males.



6 Laikipia District: Population Density and Distribution.

3.4 The Study Area: Mukogodo Forest

Mukogodo Forest is situated in Mukogodo Division of East Laikipia. It covers an area of 20,872 hectares while Mukogodo Division as a whole covers 1129 sq. km with a population of 13176 persons (as per 1999 population census). It is the least densely populated division in the district (approx. 12 persons per sq. km). It witnessed a small increase from the 1989 figure of 10,916, which had a density of approx. 10 persons per sq. km.

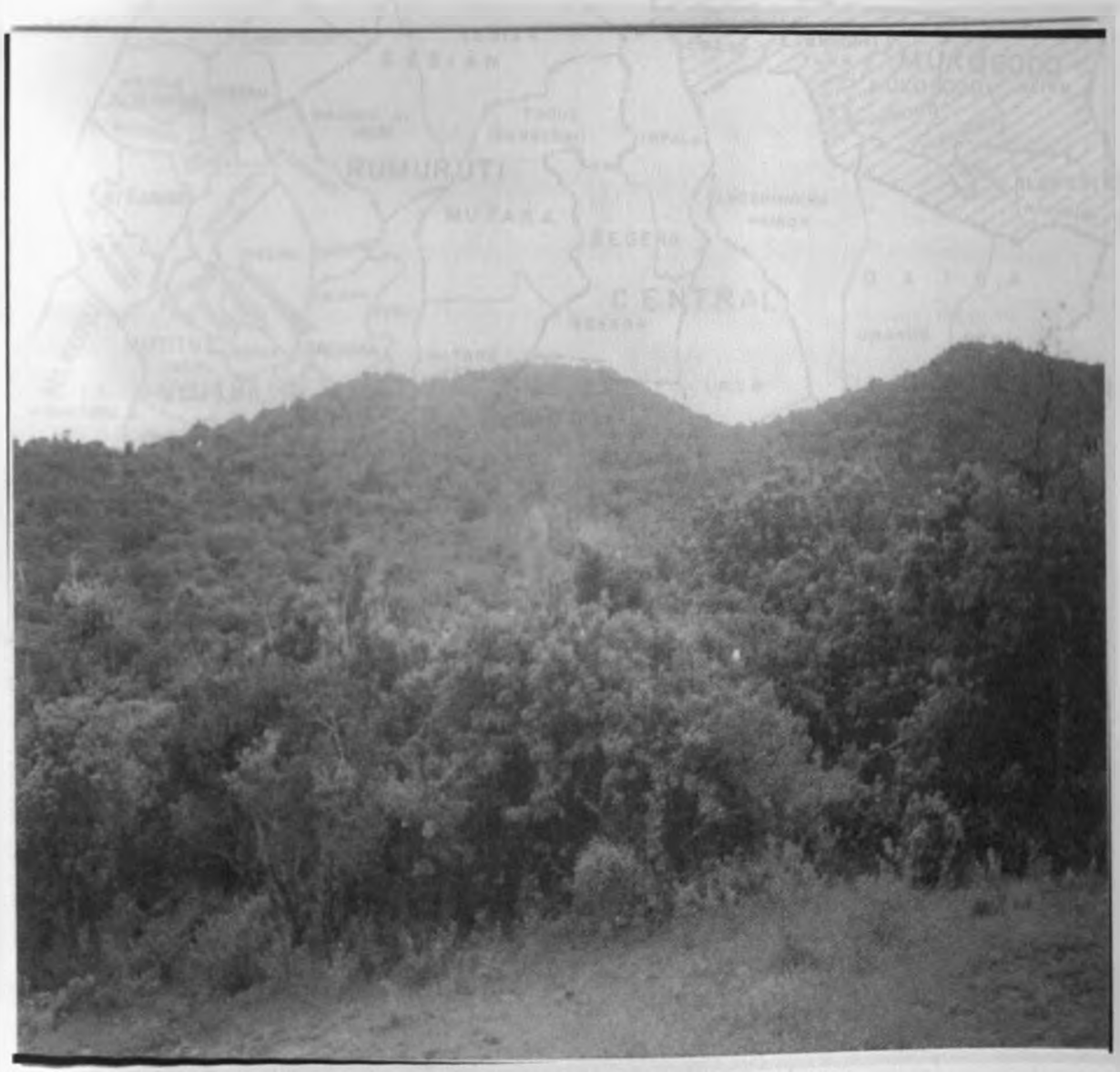


Plate 1:Part of Mukogodo Forest (Notice the indigenous nature)

Map 7 Laikipia District: Location of Mukogodo Division.

This low population density is as a result of dry climatic conditions with low rainfall totals, which are very unreliable (Map 4). Temperatures are very high during the day and very low at night. It thus, has high diurnal ranges. Because of this climatic condition in the area, the division has very minimal economic activities. The community is solely dependent on livestock keeping and at times establishing their number becomes difficult due to their nomadic way of life.

3.4.1 Justification for the choice of the Study Area

While it is a fact that the Government of Kenya is keen on environmental issues, much attention has been given to areas of high agricultural potential to the neglect of arid and semi arid areas. This is because, it is in such areas where there is conflict between the needs and requirements of the population on one hand and the need to conserve the existing natural resources for sustainability on the other. For instance, people tend to have encroachment into the forests for settlement and cultivation in these agriculturally suitable areas. This high economic base favours such rush for settlement. Arid and semi-arid lands have low population resulting from their low economic base. People tend to shy away from low economic potential areas despite land availability. Because of this attitude, the government and the researchers alike have all along ignored the cardinal point that; arid and semi-arid lands also need to be planned for, in-order to have control of the resources for renewable sustainability.

In-order to remove this a normally, the researcher chose Mukogodo Forest in Mukogodo Division which lies in a semi-arid area to be her study area. The study aimed at coming up with findings and recommendations that would serve as eye opener to the government planners and future researchers to enable them dig more into the improvement of the

economic basses of such areas. Secondly, Mukogodo Forest is unique in the sense that, it is a huge natural forest standing at the center of a semi-arid land. To this effect, it serves as the life-stream to the flora and fauna in the forest. It provides a complete ecosystem to both of the two groups. And given that the temperatures in the forest are cooler than in the surrounding and that the forest has some flowing rivers while the surrounding is dry, the researcher wanted to know how the nomadic community has interacted with the forest for her economic well-being.

CHAPTER FOUR

4.0 METHODOLOGY

4.1 Introduction

This chapter discusses the methodology used in this study. It introduces the nature and scope of data required, their sources, methods of collection, techniques used in the processing, analysis as well as in the presentation of the resulting information.

4.2 Experimental Design

This is a methodological outline in research which seeks to answer questions on aspects such as the population sample, the data sought for, methods of collecting this information; and hence how to process, analyze, interpret and result presentation (Moser, C.A 1968). A well planned research design should therefore take into consideration aspects such as the purpose of the research, the degree of accuracy desired in the results, the cost, time and labour among other practical considerations so as to at least strike a balance amongst all or most of the above factors.

In this study, the following subsections outline how the study was carried out in a bid to ensure that the stipulated objectives of this research were attained.

4.2.1 Reconnaissance Survey

The researcher felt it necessary to have a preliminary survey of the area. This task, conducted during the first two weeks of December 1999 in East Laikipia helped to bring into light some good understanding of the subject mater of the present research, the population it was to cover, its spatial variability, and the possible reaction(s) to some of the questions from the respondent. During this reconnaissance, the questionnaire adequacy pre-test was done and

helped to provide guidance on aspects such as the adequacy of the sampling frame, population distribution, probable response and non-response rates for the questions, the suitability of the methods of data collection, and the general organizational aspects in the field.

4.2.2 Population and Sample Frame

4.2.2.1 Sampling frame/population

A population is taken as part of the universe relevant to a specific problem in question. It is any finite or infinite collection of individual objects (Kendal et al 1957) and consists of a number of units of inquiry. A geographical population is therefore a collection of objects with some geographical characteristics in common.

The target population in the study area constituted all households (Manyattas), heads located 15km or less from the forest, forest officers, local administrators (chiefs), in East Laikipia. These populations constituted the basic sample frame from which the required samples were drawn. For the case of the manyattas, the researcher liased with the local administration who assisted in counting and listing all the households located approximately 15 kilometers or less from the forest. This exercise found a total of 521 manyattas / households.

Only the households which border the forest reserve of Mukogodo were considered in the sample frame based on the simple assumption that the nearer a given manyatta is to the forest, the more likely it is to utilize the forest reserve more. From the total number of houses, a sample of 10% (52) of the households were selected using the procedure explained below.

4.2.2.2 Sample Selection

The selection of the required household/manyatta was done by random sampling procedure. The principle of randomization, argues Hosking et al, (1986), that, it helps to "average out" the effects of extraneous factors that may be present in the sample frame. Simple random sampling was done during the household counting. The houses were assigned a number from 1 to 521. From this, a household listing was done. The 50 households were then selected from this list using a random table generated by SPSS. Other target groups namely the forest officer(s) and local administration (chief) were all sampled because they were only five i.e. 2 forest officers and 3 chiefs.

Nevertheless, it is important to note that there is no procedure which goes without problems that could threaten to compromise quality of the results and in the present case, the randomness of the required sample. These, among others included cases of abandoned households or manyattas especially during the very dry weather like between December and February. This was mainly because the Maasai pastoralists had travelled with their animals to graze in the forest (Mukogodo) because this is the only rescue when the plains are dry and without both pasture and water. Looking at the rainfall distribution patterns, one finds out that Mukogodo as a forest has higher rainfall (approximately 700 mm) as opposed to the plains (approximately 400-mm). This therefore renders the forest to be green when the plains are so dry. Even most of the rivers especially seasonal rivers have their sources in Mukogodo forest therefore, they serve as a source of water during the dry season. There were also cases of absence of respondent(s) by reason(s) of sickness, death(s), ceremonies and festivities and any other un-coperativeness. In the case of absence of the respondent, the next Manyatta would be selected. This was justified by the fact that all Manyattas in the study area had an equal chance of being included in the required sample. Due to this problem therefore, only 50

and not 52 houses were interviewed at the administration of the questionnaire attached at the appendix 1.

4.3 DATA TYPES AND SOURCES

Given the importance of the data quality, its relevance and availability in any meaningful research undertaking, the nature of data required for this study was carefully considered. This is justified by the fact that the conclusions arrived at, at the end of the research work and the related recommendations largely are dependent on the analysis of the data collected.

In order to fulfill the requirement of the study; data was required on three main aspects;

1. Population dynamics over three decades especially growth rate, size and density and population projections for Laikipia district.
2. Forest cover changes since over three decades, i. e. 1966 to 1976 to 1986 and 1996.
3. Forest resource utilization in aspects related to timber and non-timber products.

Each of these aspects required a different kind of data set and a methodology of data collection. Some of the data was available from secondary sources while others had to be collected from primary sources.

In order to test the validity of the hypothesized relationships, a substantial methodological framework was needed for data collection.

4.3.1 Primary Data

This is mainly raw data (i.e. data on household population characteristics, woodfuel consumption, and migration history). This data was obtained from the field among other sources. The sources of primary data for this study included; the use of questionnaires, focus group discussions, direct map measurements (distances in kilometers) as well as direct observations by the interviewer.

Direct map measurements and interpretation of maps, aerial photographs and satellite imagery (SPOT imagery) were used to get information on aspects such as forest cover change in Mukogodo over designated years. Both formal and informal questionnaires were used to suit particular groups of interest.

4.3.1.1 Formal Interviews

Under this technique, questionnaires were used to get relevant data from the randomly selected households and forest officers. For the households, only mature household members, irrespective of their gender and status were interviewed, though in most cases only males as heads of households were free to respond as opposed to females who could in most cases shy off because of culture, education status and exposure.

The questionnaires were administered by the researcher as face to face interviews in a bid to ensure the following: -

a) High response rates from the respondents.

b) Explanation for clarity of questions and relevant answers, and

c) Probing and cross-checking.

Questions were both open and closed ended. This was done in order to allow appropriate flexibility in the responses of the interviewed, and also to restrict the interviewees to relevant issues.

4.3.1.2 Informal Interviews

These were conducted as free, open and often casual interviews with the respondents after the formal interviews, and also with special key informants in a bid to supplement and probe

some information prior given. Nevertheless, these informal interviews were often dictated by the degree of responsiveness of the various respondents interviewed, and the astute judgment or evaluation of these responses by the researcher.

4.3.1.3 Observation

Observation simply means the use of eyes to accurately watch and take note of phenomena as it is or occurs in nature. The researcher uses this option to ascertain the existence of what he observes, and to discuss with the respondents what, why and how things are done, besides checking what one is told against what he sees.

Both direct observation (of what is actually seen affecting the forest e.g. the cutting of wood, grazing, the burning of forest with fires started to scare away bees in the process of honey harvesting among others) and indirect observation (inferences of implications of what is actually observed) were used by the interviewer so as to get a first hand and authentic picture of the research problem. Measurement, extraction and interpretation of maps were also done in order to get the required data.

4.3.2 Secondary Data

Secondary data was extracted from previously published and unpublished material sources such as; books (literature review), annual reports, topographic sheets, magazines, study reports, journals, theses and general library publications and occasional papers.

4.3.2.1 Secondary Data Sources

The following include secondary sources from which data was obtained: -

a) **Population Census Reports** - These reports provide information relating to population dynamics in the whole country and the district of study in particular.

Census reports for the years 1969, 1979,1989 and 1999 were particularly very useful in this study.

b) **Development Plans**

This data source provided useful information relating to resource availability and planning aspects at national and district levels in particular. Development plans for the following plan periods were very useful to the researcher: 1984/1986, 1994/1996, 1996/1998, 1997-2001.

c) **Statistical Abstracts** - These are normally published yearly and therefore provided information relating to various aspects of the economy. They were therefore useful to the researcher in providing data on various economic aspects especially on annual basis.

d) **Other Published and Unpublished Materials** - These include Research Programmes such as the Laikipia Research Programme with its numerous publications and reports. They provided a lot of background data on Laikipia as a district and Mukogodo forest and its environs, and also constituted a basis for comparison with the information on particular aspects collected during the current research.

4.4 DATA PROCESSING, ANALYSIS AND PRESENTATION

In order to process, analyze and present the data collected from the field, a number of relevant statistical tools were used: Given the kind of data collected from the field, it necessitated the use of a microcomputer especially in data processing. Data coding and entry was carefully done as to allow for specific analyses of the data using among others the statistical package for social scientists (SPSS).

The analyzed data (information) was presented in different ways depending on suitability such as tables, charts, graphs, diagrams and maps. Each of these data presentation tools has its own unique advantages and therefore enriched the output of this research. An initial summary of the data obtained from the field using these tools was very useful in the preliminary investigations and hence conclusions of this study.

It is important to note that the kind of technique used in analyzing data depends, in part, on the nature of the data available for analyzing and the assumptions underlying each technique. Both quantitative and descriptive methods were used in analyzing and presenting the raw data collected from the field.

4.4.1 Qualitative Analysis

Most of the data collected from the field is summarized, processed, and compiled in the form of tables, diagrams, graphs and maps. They have been used purposely as summary statistical tools because they give a quicker visual impression of the various aspects treated in this study.

The use of summary statistical tools is very important because of a number of reasons. These include: -

a) Acting as good visual aids given their ability to present data in simple and readily comprehensive forms.
b) Are more fascinating impressive and therefore attractive.
c) The ability to synthesize and synchronize information in a few words.
d) Are used for analytical purposes as they help unveil trends between variables for comparison purposes.

It is however noted that, the use of figures such as graphs and charts only helps to represent in diagrammatic forms the items of data where no continuity exists between the individual items. (Ferguson et. A. 1981). On the other hand in the case of bar charts, the length of each bar is proportional to the value the bar represents, pie charts use a circle to represent the given mass of data.

4.4.2 Quantitative Analysis

For purposes of this study, a diversity of inferential statistics has been employed to compute as well as test the validity of the hypothesized relationships

In the case of descriptive statistics, which include means, frequencies, and percentages have been used. This has been done in order to help in comparing between sets of raw data, facilitate easy assimilation of data, and present the data in a summarized form for quick and easy comprehension.

In quantitative analysis, both inferential and non-inferential statistical tools haven been used. Summary statistics have been used as measures of aggregation and dispersal in the data distribution. Inferential statistics have been used to test the research hypotheses and to assist in generalization of the research findings. The basic statistical tools used widely for data analyses are simple linear and multiple regression models, and correlation.

4.4.2.1 Simple Linear Regression Analysis

This was used in the analysis to investigate the linear relationship between two variables of interest namely: aspects of population dynamics and population characteristics versus the spatial variations in forest cover in the study area. It has also been used to examine the variations in the household woodfuel consumption and other wood uses as they relate to forest cover changes in Mukogodo. Simple linear regression analysis is used to examine

linear relationship between a dependant and independent variable. The dependent variable in the current study is forest cover changes, while each of the forest uses is an independent variable.

The simple linear regression model is expressed as:

$$Y = \beta_0 + \beta_1 X_i + e_i$$

Where,

Y = Dependent variable

X = Predictor value (independent variable)

β_0 = Y intercept or constant

β_1 = Gradient/Slope term

e_i = the error term (residual)

Using observed data, and least squares technique the best estimate of the regression model is given as: -

$$Y = b_0 + b_1 x_i + e_i$$

Where,

Y = the estimate of the dependent variable

x_i = the independent variable

b_0, b_1 are estimates of the parameters of the statistical model (b_o+b_1)

In the current research, therefore, it is assumed that no linear relationship exists between:

a. Household wood fuel consumption and forest cover change.

b. Timber for construction and forest cover change.

4.4.2.2 Simple Linear correlation

It is used to express the degree of the relationship between variables, that is, it seeks to determine how well the linear equation explains the relationship between the components of population dynamics and forest cover in the study area.

The correlation measure is given by the Pearson correlation coefficient (r) as: -

$$r = \frac{\sum x_i y_i}{\sqrt{(\sum x_i^2)(\sum y_i^2)}}$$

$$= \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{[\sum (X_i - \bar{X})^2][\sum (Y_i - \bar{Y})^2]}}$$

The least squares estimates are a function of the sample data. The data changes from sample to sample and for this the least squares estimates also change from sample to sample. There is therefore the need to have some measure of "reliability" or precision of the estimates $\hat{\beta}_0$ and $\hat{\beta}_1$. The appropriate measure is the coefficient of determination, r^2, and is computed using the formula:

$$r^2 = \frac{\sum (\hat{Y} - \bar{Y})^2}{\sum (Y_i - \bar{Y})^2}$$

The coefficient of determination, r^2, is a measure of the proportion or percentage of the total variation in Y explained by the regression model. The r^2 has two basic properties:

- It is a non-negative quantity
- Its limits are $0 \leq r^2 \leq 1$. An r^2 of 1 means a perfect fit, whereas an r^2 of zero means no relationship between the dependent variable and the independent variable(s).

4.4.2.3 Fisher's Test statistics (F-test)

Fisher's Test statistics (F-test)

This is given by: -

$$F = \frac{MSREG}{MSRES}$$

where,

MSREG is the mean sum of squares due to regression and MSRES is the mean sum of squares due to residuals

This is therefore used to determine whether there exists any significant relationship between variables examined in this study.

At $\propto$ =0.05 level of statistical significance, the calculated F value was compared with the tabulated critical F value at given degrees of freedom. Thus, if

1. Calculated F was equal or greater than the critical F value, the null hypothesis was rejected and the alternative adopted.
2. Calculated F was equal or less than F critical, there was not enough evidence to reject the null hypothesis.

Other statistical methods used in analyzing data relating to population include: -

4.5 Population and Demographic Analysis techniques

4.5.1 Population Growth Rates

It was done using the arithmetic growth rate method which gives both effects of rates of natural increase and net migration on the population of a given area and is given by the formula: -

$$R = \frac{2/n(P_n - P_0)}{(P_n + P_0)} \times 100$$

Where

R is growth rate

P_n - population at a later census count

P_o - population at an earlier census count and

n is intercensal period

4.5.2 Population Doubling Rate

This is the number of years the population takes to double itself if it continues to grow at the same rate. Doubling time method is given as:

$$DT = {}^{70}/_{GR}$$

where,

DT is the doubling time

GR is the growth rate of the population

70 is a constant

Changes in Population Distribution

This is used to show how population distribution has changed spatially between the periods.

It is given by: $1C = \frac{P1}{P2}$

In which:

1C = index of spatial change

P1 = population of last census

P2 = population of an earlier census

NB: These are not considered parse, but along side other regional indices such as rainfall, weather patterns etc., to show the patterns of change.

Population Density

Was treated as the number of persons per square kilometer of land, whether it is under forest or water. What is considered is administrative units or boundaries. The population data was got mainly from national census reports and also from statistics office Nanyuki as well as from Laikipia Research Programme.

4.6 Vegetation Cover and Use Analysis methods

4.6.1 Measurement of weight of wood-fuel

In order to look at forest resource utilization in the study area, there was need for measurement of weight of wood-fuel. This approximation was done using a spring balance to weigh samples of wood-fuel head-loads. Wood was tied in bundles by use of ropes and weighed then a conversion factor of 1.4 m^3 = 1 tone(Earl D.E, 1975) was used to give the researcher the possible volumes of wood fuel used monthly or yearly.

4.6.2 Analysis of Data Relating to Forest Cover charges

Data relating to change in forest cover in Mukogodo over the selected years (1966, 1976, 1986, 1996) was compiled from three main sources, viz: Aerial photographs (scale 1:30,000), SPOT imagery (scale 1:100,000) and topographic maps of Laikipia District (scale 1:50,000). This integrated approach was applied because no single source was capable to provide the data required to meet the needs of the present study. Aerial photographs were used for 1966 and 1976 while imageries were used for 1986 and 1996.

From the aerial photographs, the areal extent (coverage) of the forest at designated periods in time was transferred according to change detection onto a tracing paper. The same was done for the imageries both spot and landsat. Finally, final maps were drawn conventionally which were then scanned and screen digitized. Data analysis and presentation thus occurred at this

stage. This process allows for overlays of maps of different years in order to detect any changes in the forest cover (see maps 9-13). The use of aerial photographs in this study is of prime importance because this tool has been used in the past to monitor and create inventories of both forests and rangelands. It has been used by foresters for many years to measure the area and conditions of forests and to estimate the volumes of timber forests contain. Aerial photographs can provide data on tree height and canopy cover, soils vegetation community types and land use patterns. Up to the early 1980's , aerial photography was the only technique used to give information on spatial data in the study area due to its high resolution. It is still in use despite the introduction of remotely sensed data (satellite imagery) which tends to have favours over the aerial photographs due to the costs involved. But still in many cases aerial photographs are used since the skills used are bigger than in imageries hence more clarity.

Although the resultant maps are provisional, they serve well for the purpose they were intended for due to their capability to show changes in forest cover. Although a recent tool, the use of SPOT and LANDSAT data is advantageous owing to a number of reasons. These include: -

1. Enabling us to monitor changes in land use/land cover over many years. Landsat is well known for its use in the study of land use systems. When used for a research such as this it allows for easy detection in changes of the forest cover.
2. Its multi-spectral capability and relatively high resolution (10-30 metres) are suitable for observing even subsistence agriculture, which is based on small parcels.
3. Normally there are at small scales and so one sheet is enough for most researches unless it has very large area coverage.

Notably, the assessment of the forest cover changes, and the subsequent production of maps has greatly benefited from the Geographic Information Systems (GIS) technology map 13. This has a number of advantages over the traditional hand drawn maps, which include excellent data storage and display tools. It can produce a variety of formats such as maps, tables and statistical graphics. It has overlay techniques and this allows for cover changes for different periods to be detected, both on the screen and when printed in different colours or tint screens.

CHAPTER FIVE

5.0 POPULATION CHARACTERISTICS AND RELATED FOREST RESOURCES UTILIZATION IN EAST LAIKIPIA

5.1 Introduction

Human settlement is influenced by the availability of natural resources namely land, water, minerals, extra. Areas with rich soils and water attract more settlement than poor soils with poor drainage system. These factors may affect population distribution of any magnitude. People move in search of the resources available in the attracting areas.

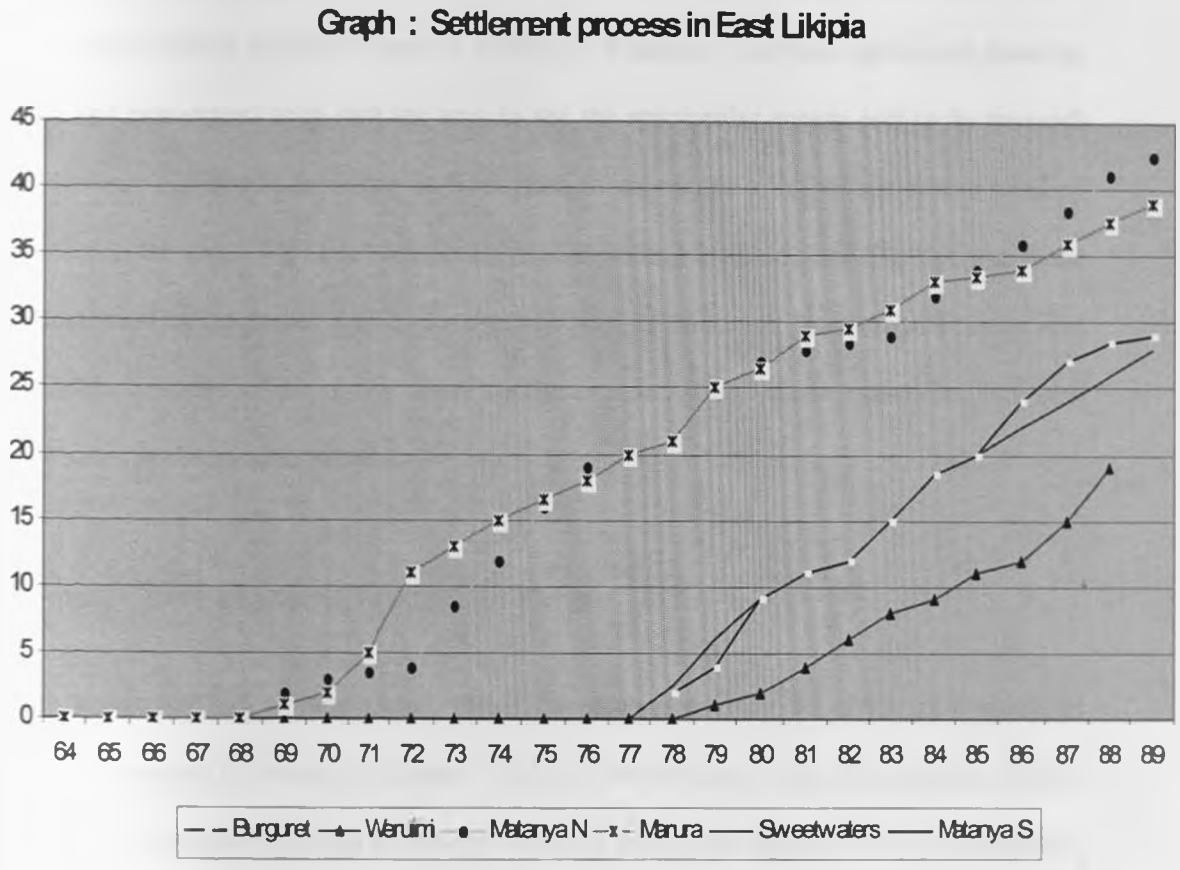
It is actually not easy to measure the magnitude of migration. This is due to the fact that it is both physical and social in nature and not just a mere biological event. The high population increase in developing countries coupled with large number of people migrating to rapidly growing cities and towns as well as to some rural areas that attract settlement are salient forces of population redistribution. Gould et al, (1975) noted that Africa's population are highly mobile and that the typology of their movements is rather complex. This is due to the nature of pull and push forces that are in place. These forces see migrations from rural to urban; rural to rural and urban to rural.

Before the settling of the white settlers in the white highlands established for them in various parts of the country including West Laikipia, the district served mainly as grazing ground for the Maasai pastoralists while the highlands to the west of the district were mainly being cultivated by the neighbouring Kikuyus. When the whites moved into occupy the white highlands, the Africans were removed into African reserves. It should be noted that even the grazing grounds for the Maasai pastoralists were also affected by creating huge ranches for the whites. The Africans were thus, faced with land shortage.

But shortly after the attainment of independence, the Kenya Government created settlement schemes in the areas that were occupied by the white settlers and encouraged the formation of private land buying companies to facilitate returning the land back to Kenyans. Most of the settlement process occurred in the medium to high agricultural zones of the district (zones II and III) – West Laikipia. But this process increased with time into drier zones of the district (Kohler, 1987).

The trend of population movement has seen a lot of population increase especially in West Laikipia mainly due to its high agricultural potential and job opportunities in the farms (Oucho, 1979 and Ayiemba 1990). The assessment of the settlement process in Laikipia District revealed that settlement process in Laikipia has been very rapid and fast to reach its peak and thereafter slows down while that of East Laikipia has been very slow (Graph) then picks up with time (Omoke 1998). This may be explained in terms of the variations in the natural resource potentials across the district to support the increasing population. People rushed in to settle in the West which had required resources but not in East Laikipia that lacked these resources.

Graph 3: Settlement Process in East Likipia



Source: Wisemann, LRP, 1996

Wiesman, (1997), asserts that a given settlement density plays a very important role as a "pull" factor in the process of population in-migration in the district given that high densities across the district tend to attract more people as this reflects high natural resource potentials and the availability of security. He however notes that this work only up to certain threshold. Above a population of between 50 – 70 percent in the semi-humid areas, the rate of settlement slowly levels off.

Apart from manyattas, there are scattered permanent settlements within reach of the Mukogodo Forest. Dol Dol serves as the trading centre and it accommodates chief's office among offering other services. The research carried out revealed that most of the businesses are being managed by the Kikuyus although a few cases were noticed of Merus and

Kalenjins. So, the few who are there from neighbouring districts did not come as a result of availability of land as such or due to pressure of land in their original areas but to offer services to the mainly pastoral Maasai in exchange of money. They also get money from the tourists and researchers who visit the area to see the spectacular scenes and to do research respectively. The government has at least tried to encourage a rather permanent kind of settlement in the area. We have such primary schools like Mukogodo and Dol Dol just in the neighbourhood of the forest, which have permanent buildings. A few boreholes were also dug for the purpose of supplying water to the population and their livestock. No land cultivation was observed in the area.

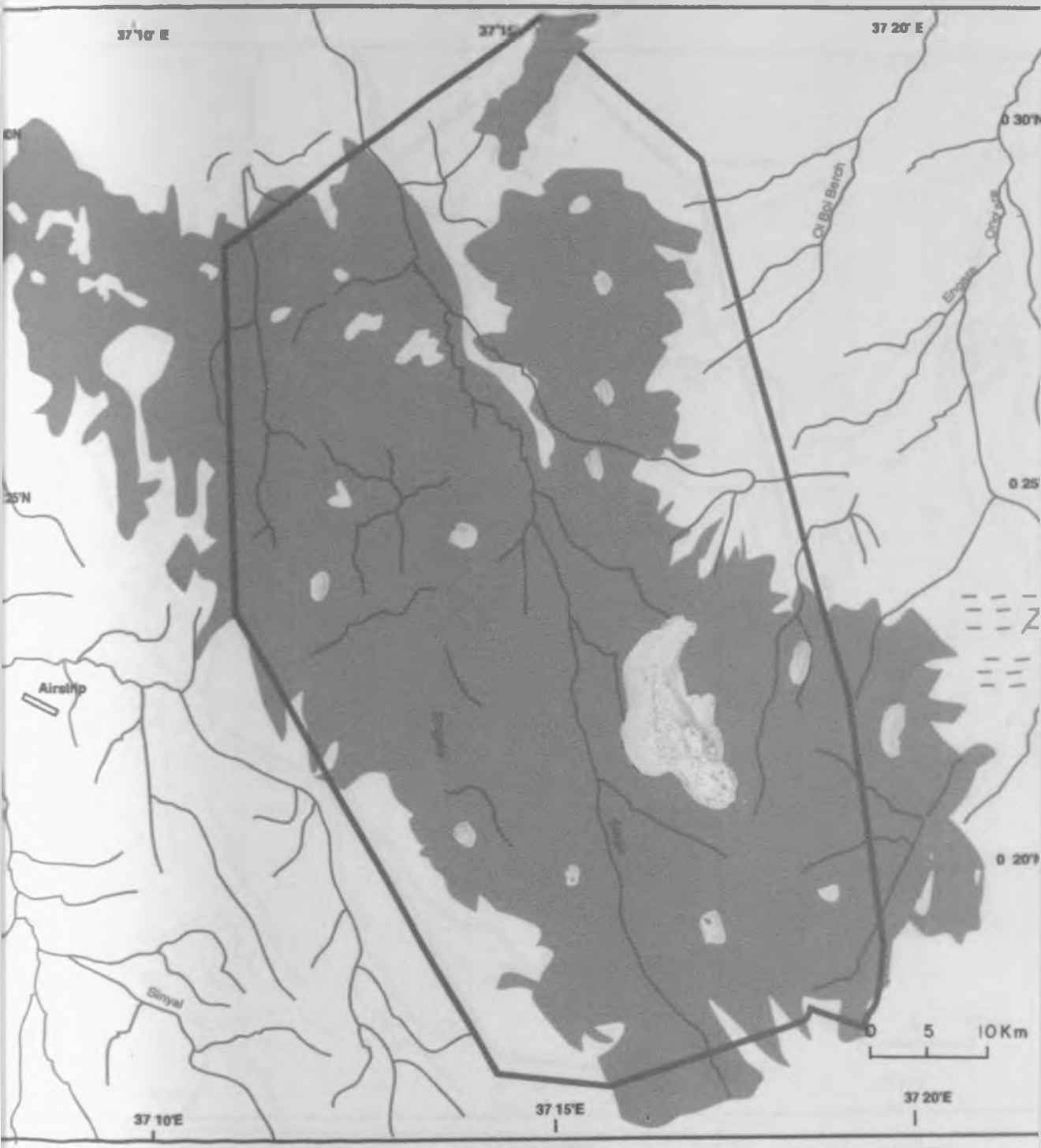
5.2 Forest Cover change in Mukogodo Forest

As the researcher has already stated, forest cover changes may be either as a result of physical factors and or biological factors. To detect the changes, aerial photographs, satellite imageries and topographic maps of the area of study were used together with questionnaires and observations. It became apparent that the forest boundaries have never changed. This could be attributed to the fact that, the area being semi-arid, no cultivation of land has been done. Not even settlement that could interfere with the boundaries. In other words, there is no encroachment into the forest in the absence of serious human settlement and cultivation.

What has changed over time is the forest cover. While forest cover changes in West Laikipia have been as a result of human settlement and land cultivation as well as afforestation, the changes in Mukogodo forest have come mainly as a result of environmental or physical factors. The region has low rainfall totals which are very unreliable and has been decreasing in amounts over the years. This has caused some trees/bushes to dry up without replacement during years of prolonged droughts while new ones sprout up during years of improved rainfall. This has resulted in the opening/sealing up of pockets in the forest and or depletion

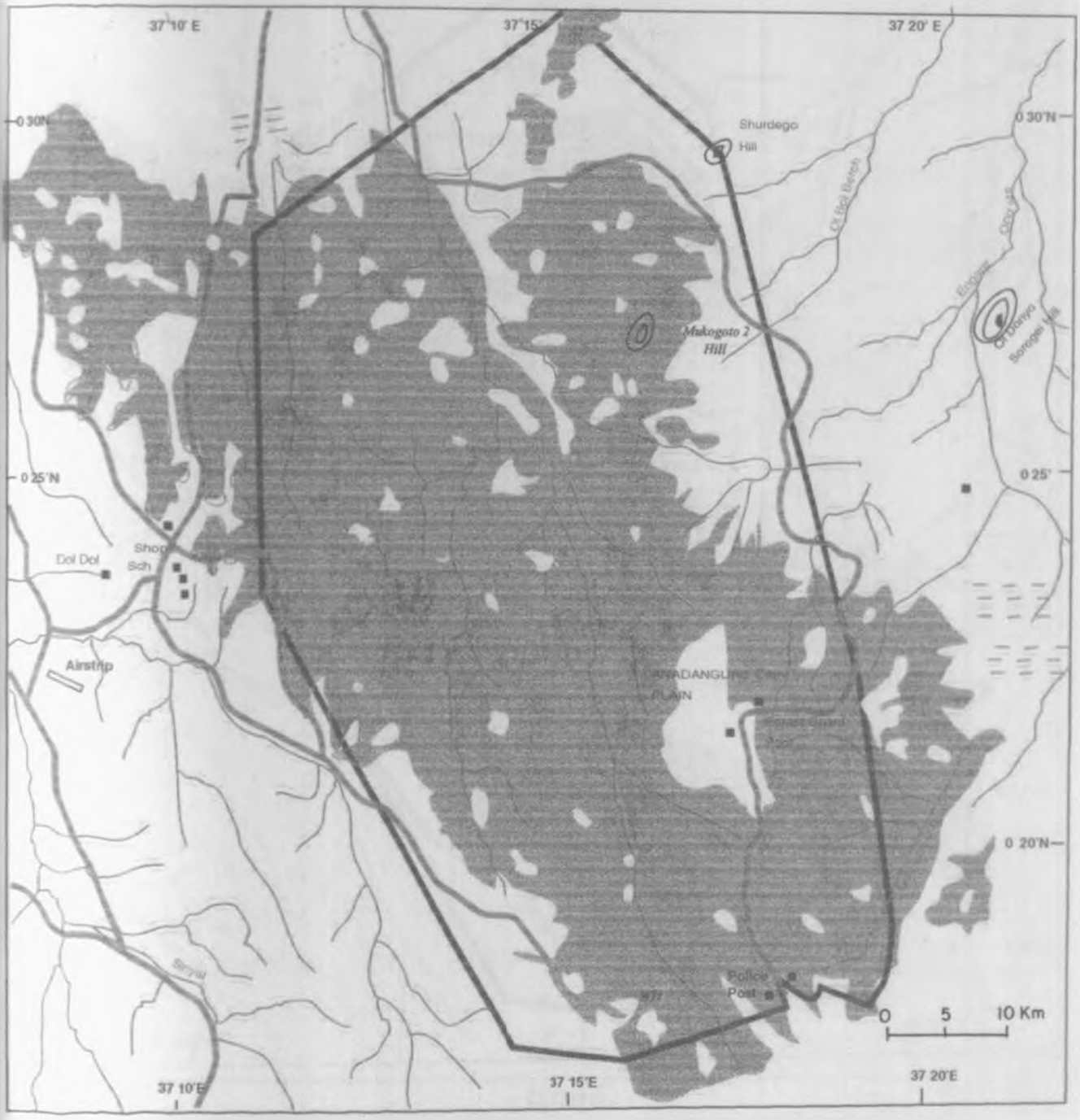
at the edge as can be observed from the Maps 8-11 where they are overlaid under GIS environment. Map 12 gives the forest cover change between 1966 and 1996 (an overlay map).

The other factor influencing forest depletion is the biological, which involved both human activities as well as the effect of other animals on the forest cover. From the interviews conducted in the field and the observations made by the researcher, the study established that poles and tree branches used in the construction and fencing of the manyattas come from the forest. Firewood, herbs and honey are all collected from the same forest. Charcoal burning, although not very rampant, has also been noticed to be going on here and there. All these were established to have had negative effect on the forest cover as can be seen in the analysis (Correlation and Regression) results in the next chapter and in appendix 3.



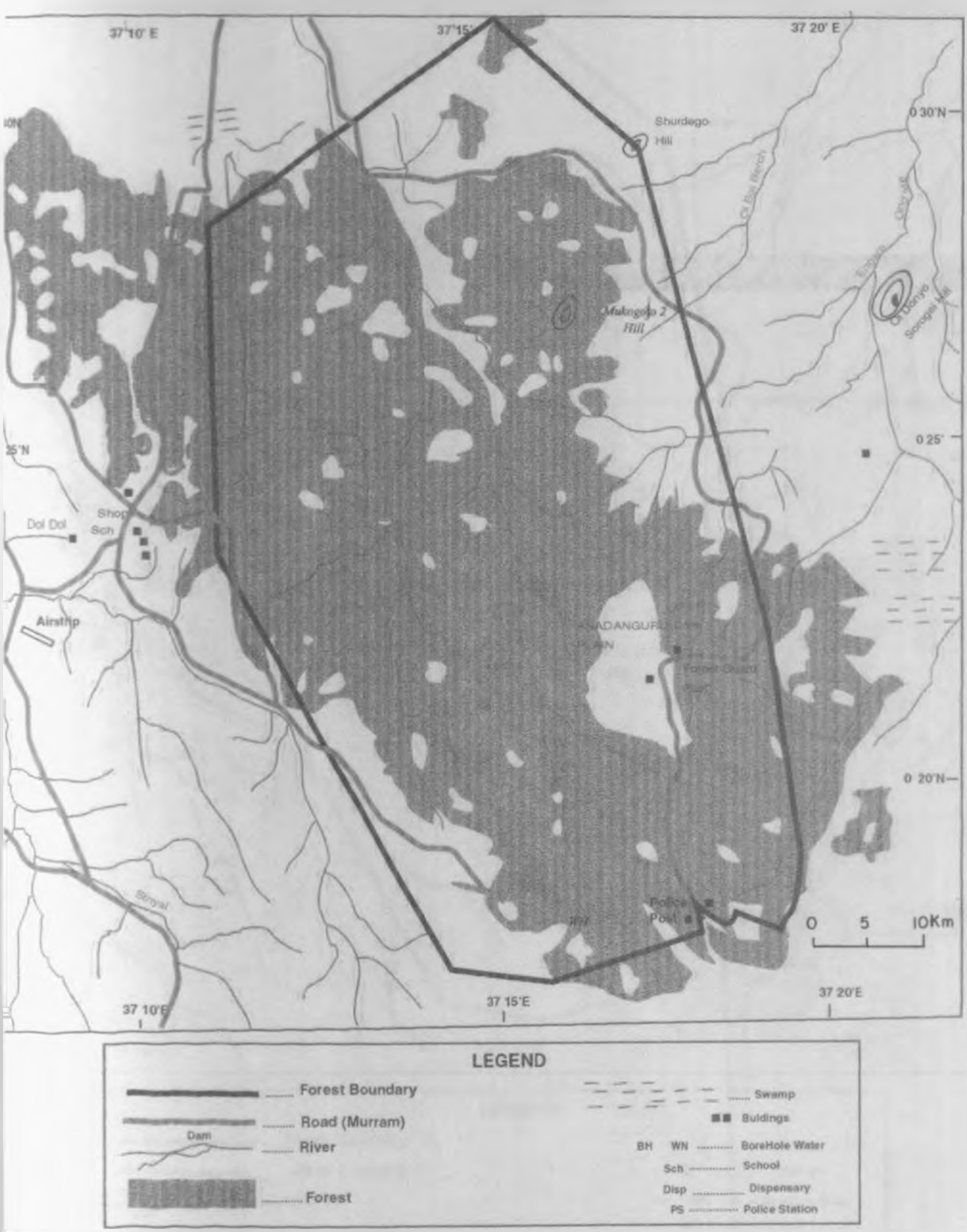
MAP 8 Mukogodo Forest Cover in 1966

SOURCE: Compiled from aerial Photographs 1966 &1976, Satellite Imageries 1986 & 1995



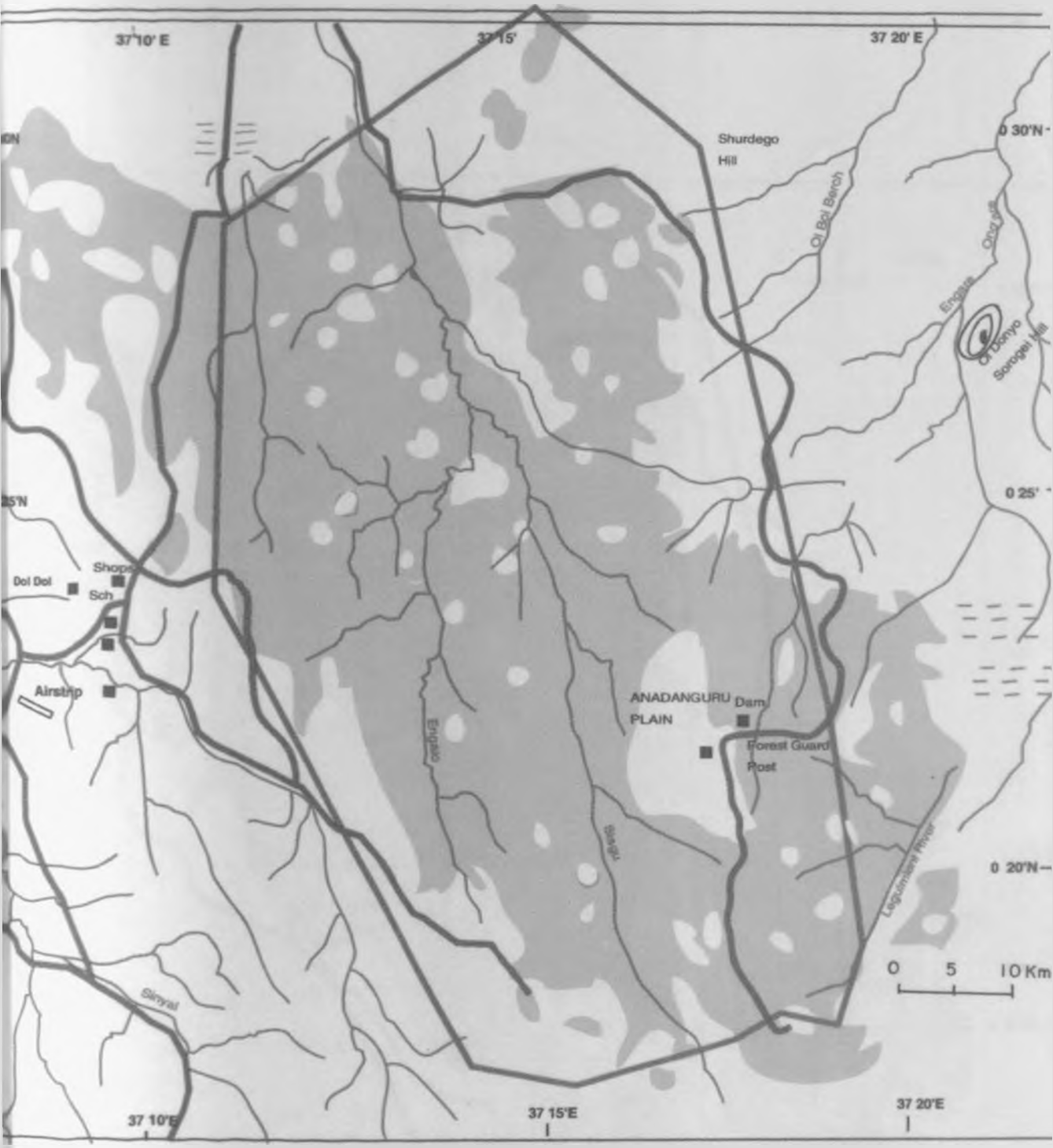
MAP 9 Mukogodo Forest Cover in 1976

SOURCE: Compiled from aerial Photographs 1966 & 1976 , Satellite imageries 1986 and 1996



MAP 10 Mukogodo Forest Cover in 1986

SOURCE: Compiled from aerial Photographs 1966 & 1976 , Satellite imageries 1986 and 1996

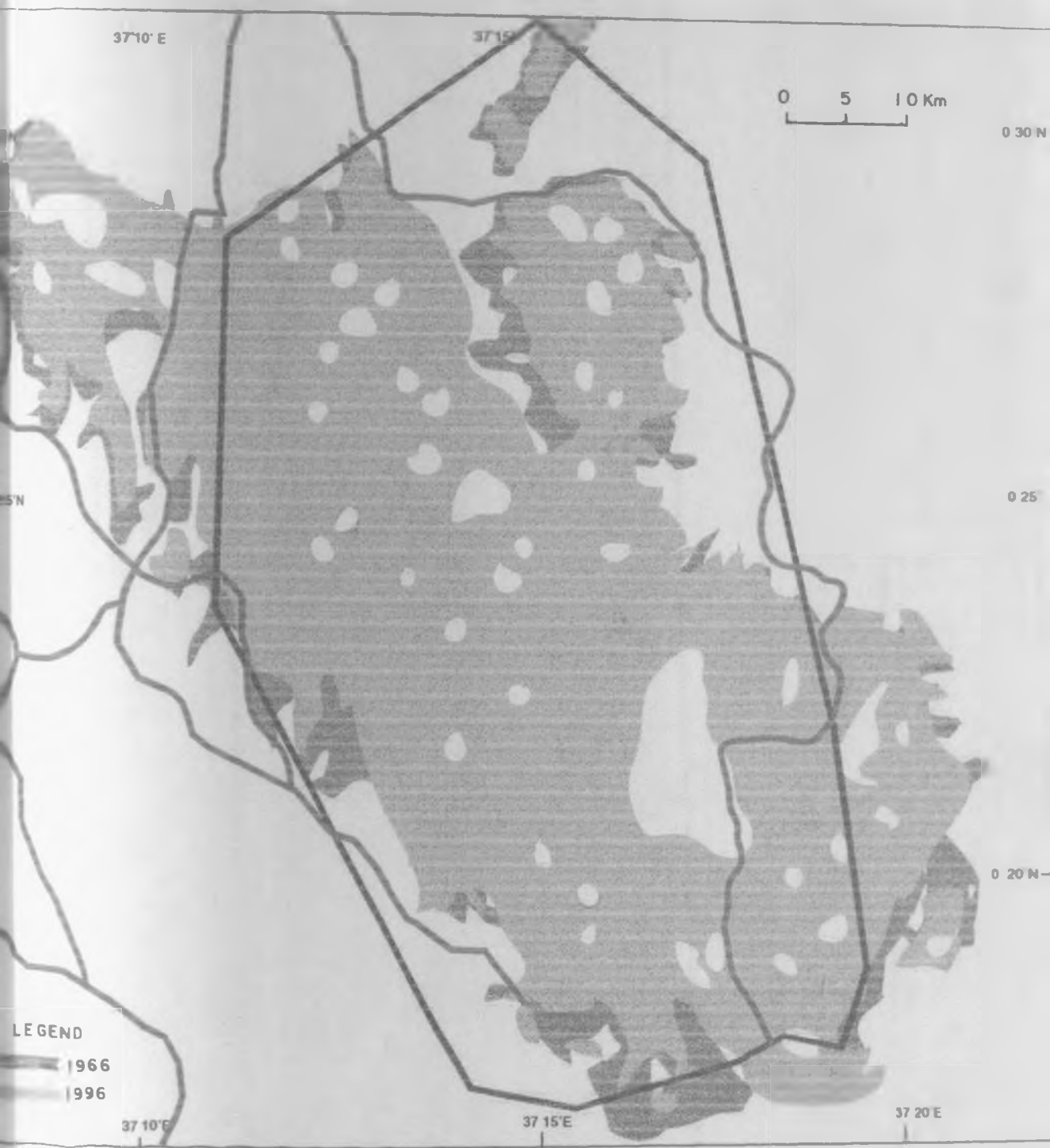


LEGEND

- ....Forest Boundary
- ..... Road (Murram)
- Dam ..... River
- ..... Forest
- ..... Swamp
- ..... Buildings
- BH WH ..... BoreHole Water
- Sch ..... School
- Disp ..... Dispensary
- PS ..... Police Station

AP 1.1 Mukogodo Forest Cover in 1996

SOURCE: Compiled from aerial photographs, 1966 & 1976
Satellite imageries 1986 and 1996



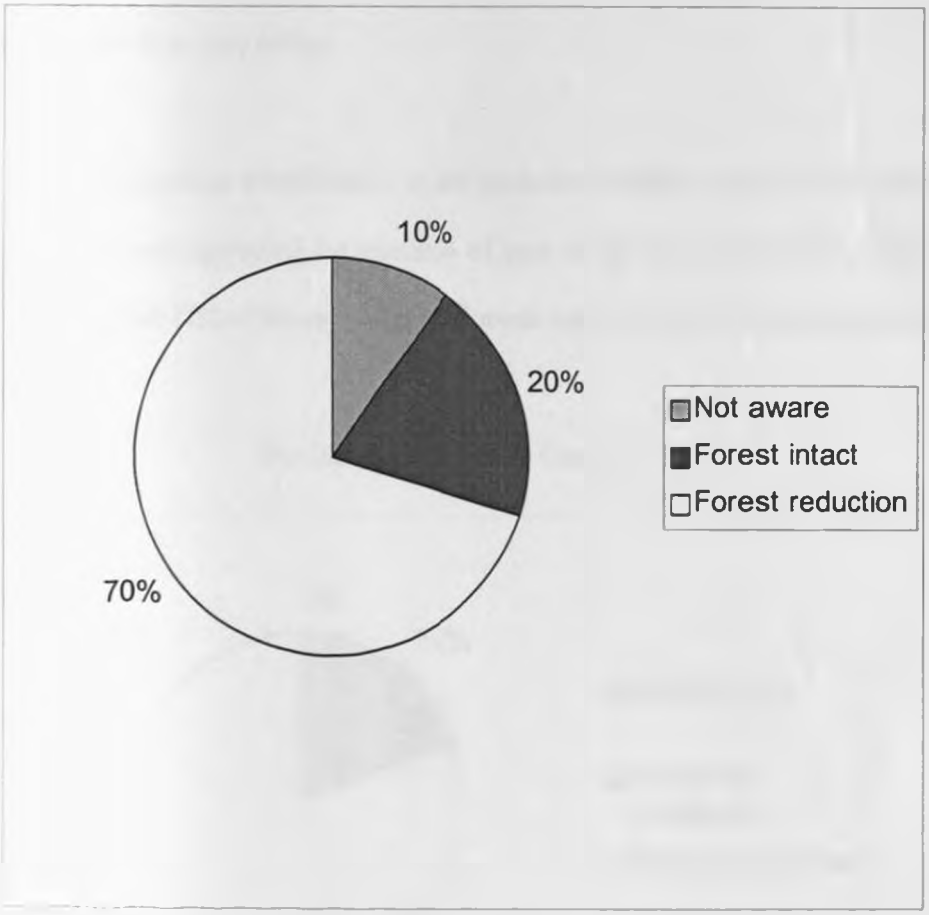
12 Mukogodo Forest Cover Change 1966-1996

SOURCE compiled from aerial Photographs 1966 & 1976, Satellite imageries 1986 & 1996

5.3 Awareness of any forest depletion and the need to conserve the forest.

Based on the responses from the focus group discussions, it is justified to conclude that the population is aware of the forest cover reduction. They attributed this to both the harsh physical environment and the human activities in the forest. They responded as shown in the pie chart below: -

Pie Chart 1: Awareness of Forest Reduction

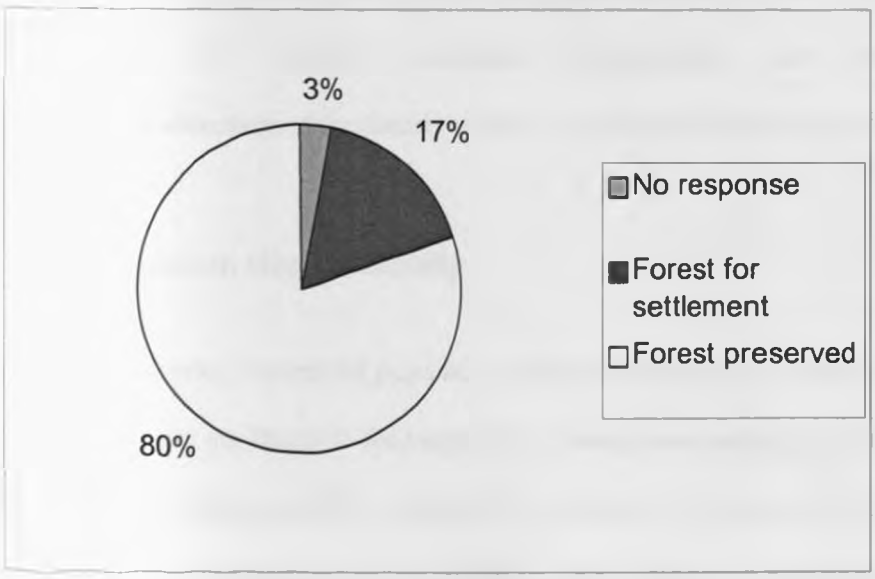


The researcher came to this conclusion by the fact that 70% of the respondent is aware of the forest cover having been reduced while just 10% is not bothered of what goes on in the forest.

Concerning the need to conserve the forest, almost over 80 percent of the local community is for the idea. They sited various benefits they derive from the forest as the reasons for the idea. As it has become apparent in various parts of this world, they are: - extraction of timber; firewood; herbs; honey; as well as serving as grazing ground and watering point for their livestock among others.

As has already been mentioned, a small pocket of Dorobos reside in this forest and for long, they have been appealing for excision of part of the forest for them to settle. So it is not surprising that 17% of those interviewed were not for the idea of conservation of the forest.

Pie Chart 2: Need to Conserve Forest-



The rapidly increasing population in Kenya, coupled with economic growth puts a lot of strain on the available natural resources as the demand for products also increases. These changes have a bearing on the land-use dynamics in the district and this in effect leads to environmental problems. Land-use changes, which result in the removal of forest cover, are noted to be the principal cause of the increased soil erosion in the country. In Kenya, although the exploitation of the planted forests for economic use is becoming increasingly dominant, the use of indigenous forests has a substantial economic value.

This chapter focuses on analyses relating to household population characteristic (viz.: population distribution, density, age, sex characteristics, education levels), and the related population needs and/or activities as reflected in the forest resource utilization.

5.4 Household Population Characteristics

In this section, both innate and acquired characteristics are examined as they are presumed to relate to the forest resource use over the designated period in time. Based on the changes observed in the selected household characteristics and how they affect consumption/utilization of the forest resource, a number of observations are drawn.

5.4.1 Population size and density

In Laikipia district, household population characteristics such as size, composition, growth rates and density are linked to the variations in the agro-ecological potentialities, security and subsistence, off-farm activities, migration trends and the human/wildlife conflicts. These parameters are area-specific and interlinked. The changes in population size and density particularly in east Laikipia (Mukogodo) and Laikipia district in general are presented in the table below.

Table 7: Population size, density and growth rates for Mukogodo and Laikipia District in general

		1969			1979			1989		
Adm Area	Sq. km	Pop	Pop. Dens	Gr. Rate	Pop	Pop Dens	Gr. Rate	Pop	Pop Dens	Gr. Rate
Mukogodo	1,129				11,585	10		10,916	10	
Rumuruti	2,919				48,279	17		63,941	22	2.8
Ng'arua	1,643				34,868	21		65,908	40	6.2
W. Laikipia	4,562				83,147	18		129,849	28	4.39
Laikipia District	9,162	66,506	7		134,534	13	7.3	218,957	24	4.65
Rift Valley		2,210,289	12		3,240,402	19	3.77	4,981,613	27	4.2
Kenya	582,846	10,942,705	19		15,327,061	26	3.3	21443,636	37	3.3

Source: CBS: Population Census 1969, 1979, 1989

Compared to the 1989 population census report there is a general increase in the population densities of the divisions. It is clear that the population density of Mukogodo division has increased from 10 to 12 persons per square kilometre. Laikipia as a district has increased from 24 persons per square kilometer to 35 persons per square kilometer. It is not easier to compare on a smaller scale because more administrative areas have been created as per the 1999 population census as compared to the earlier census. But there is a generally upward trend in population density in all administrative areas and

Table 8: Population Size, Density and Growth Rates

Administrative Area	Sq. km	Population	Population density
Mukogodo	1129	13,176	12
Central	2355	77,478	32
Lamuria	1116	38,517	35
Ng'arua	1643	76674	47
Nyahururu	167.3	37,412	254
Rumuruti	2919	78,930	27
Laikipia	9329.3	322,187	35

Source: CBS Population Census: 1999

Mukogodo is not an exception. Increased population densities mean increased intensification of human activities such as animal raring and grazing, construction of housing units hence increased interference with forest cover in the area of study.

From the above table, it is noted that Mukogodo, based on the 1979 population census results had a total population of approximately 11,585, 1989 it was 10,916 while in 1999 census it had 13,176 people and a population density of 12 persons per square kilometre. Following the 1999 population census, the total population for Mukogodo division was estimated to be 13,176 with a male population of 6,432 and a female population of 6,744. This gives a ratio of 51.2 to 48.8 in favour of females.

5.4.2 Population distribution

As already noted, the population distribution pattern in the district depends, almost entirely, on factors such as agro-ecological potentials, in-migration flows, security and off-farm activities, among others. However, the spatial changes in the population distribution between

1979 and 1989 in the area (see table below) shows that, in comparison with other areas Ng'arua division has the highest index of spatial change as opposed to Mukogodo division which happens to have the lowest (0.942). The difference is so much because of contrasting climatic conditions in the two areas, which hence affects economic activities in these two areas. In addition, the study area Mukogodo, has both historical significance as a "Native Reserve' where population movements in and out were highly restricted for many decades. Mukogodo division offers unique ecological conditions, as it is inhabited by a pastoral community whose "cattle-complex culture" has traditionally been portrayed to have serious implications on the forest resources hence the environment generally. Laikipia as a district has generally the highest index of spatial change as calculated from the population of the two censuses.

Table 9: Index of Spatial Change (i.c.) for Mukogodo and Laikipia in General

Administrative Area	Population 1979	Population 1989	Index of Spatial Change (IC)
Mukogodo	11,585	10,916	0.942
Rumuruti	48,279	63,941	1.324
Ng'arua	34,868	65,908	1.890
West Laikipia	83,149	129,849	1.561
Laikipia District	134,534	218,957	1.627

Source: CBS 1979, 1989 Researcher 2001

The index of spatial change I.C is calculated as P1/P2 where P1 is the population of last census and P2 population of earlier census. It show the general pattern of change in Population distribution between two periods.

It is generally not easy to make comparisons of spatial indices of change calculated from the population census of 1999 and 1989 because of the changes in administrative areas, which in this case happen to be the divisions. More divisions have been curved out of the old divisions hence interfering with areal extent of these areas hence the total count. The area of study (Mukogodo) shows an increase in the index of spatial change hence the resultant increased human interference with Mukogodo forest especially through animal herding and Manyatta construction.

Table 10: IC for the Intercensal Period 1989 to 1999

Administrative Area (Division)	Population 1989	Population 1999	Index of Spatial Change (IC)
Mukogodo	10,916	13,176	1.207
Rumuruti	63,941	78,930	1.234
Ng'arua	65,908	76,674	1.163
Central	78,192	77,478	0.991
Lamurai	-	38,517	-
Ol moran	-	11,129	-
Nyahururu	-	37,412	-
Laikipia	218,967	322,187	1.471

Source: CBS 1989, 1999 Researcher 2001

5.4.3 Population Age-Sex Structure

Age and sex are important characteristics as they influence aspects of population dynamics namely mortality, fertility as well as migration in the district. It is realized that the percentage of population comprising children under 15 years of age and persons over 60 years of age, i.e. the dependent population is 53 percent, while the remaining proportion makes up the productive population. In this population, the ratio of males to females is 50.1 to 49.1 per cent in favour of males. This is as per the 1989 population census. This largely dependent population puts serious strain on the available resources in the district. And given the meagre economic resources in the area, this high dependency has acted as a barrier to any meaningful economic growth in the area. The level of awareness at all levels is still very low. This is likely to have had a lot of negative impact on the Mukogodo forest which they really depend on in so many ways.

Table 11: Population Age -Sex Structure, 1989

Age Group	Male	Female	Total
0-4	19,151	18,354	37,505
5	18,483	18,107	36,590
10	16,314	15,502	31,816
15	12,177	11,267	23,444
20	9,280	9,615	18,895
25	8,187	8,149	16,336
30	5,559	5,148	10,707
35	4,340	4,309	8,649
40	3,774	3,638	7,412
45	3,077	3,133	6,210
50	2,448	2,284	4,732
55	1,765	1,565	3,330
60	1,566	1,570	3,136
65	1,212	1,113	2,325
70	949	836	1,785
75	744	6,111	1,355
80+	984	972	1,956
Age NS	122	90	212
Total	**110,132**	**106,263**	**216,395**

N/B NS - Not Stated

Source: CBS: Population Census 1989

Total females below age 15 is 51,963

Total females over 60 years of age is 5102

Total females of age below 15 and above 60 is 57,065

Total males below age 15 is 53,948

Total males over age 60 is 5,455

Total males of age 15 and above 60 years of age is 59,403

5.4.4 Household Education levels

The need to consider household education levels was necessary because variability in educational attainment has a bearing on the decisions affecting household organization, perception as well as resource utilization. Because the research employed so much of focused group discussions, majority of those present during the discussions were the ones who were interviewed. This was so because it was easier to find them along the forests

grazing their livestock as well as women gathering fire wood. It was also easier to get them this way because Maasai herdsmen normally move in big groups for security purposes, especially when attacked by cattle raiders and even wild animals of which elephants, leopards and hyenas are quite common in Mukogodo forest. The table below shows the educational levels of those interviewed.

Table 12: Males' educational levels

Educational Level	Code	Frequency	Percent	Cumulative %
No formal education	0	19	59.4	59.4
Pre-primary	1	0	0	59.4
Primary	2	9	28.1	87.5
Secondary	3	0	0	87.5
Post-Secondary	4	0	0	87.4
Other	5	4	12.5	100
Total	-	**32**	**100**	-

Source: Fieldwork data, 2001

Out of the 50 people interviewed 32 were males while 18 were females. Of the males educational level 59.4 percent had not formal education, 28.1 percent primary education and about 12.5 percent claimed to have had informal education.

Table 13: Laikipia District Population By Sex, Age Group And School Attendance

Male Age Group	At School	Left	Never Attended	Not Stated	Total
6-9	9,036	181	3,035	1,960	14,212
10-14	14,210	619	1,192	293	16,314
15-19	7,969	3,138	899	171	12,177
20-24	1,413	6,524	758	585	9,280
25-29	200	6,529	850	608	8,187
30-34	85	4,199	859	416	5,559
35-39	68	3,302	816	154	4,340
40-44	61	2,748	841	124	3,774
45-49	34	1,987	975	81	3,077
50-54	31	1,453	914	50	2,448
55-59	14	931	785	35	1,765
60+	56	1,860	3,455	84	5,455
Age NS	5	30	28	59	122
Total	**33,182**	**33,501**	**15,407**	**4,620**	**86,710**

Source: CBS, Population Census 1999

From the above table the total males who have never attended school is 15,407, which is about 17.8% of the total male population, which is quite a representative figure/percentage. It is normally assumed that the more people get educated, the more informed they get about issues such as conservation of their environment. But on the other hand, the more educated communities get, the more technological know-how they get exposed to hence the risk of resources getting over-exploited for the benefit of man-kind. The Maasai community in question is somehow still quite traditional in their approach to things hence communal

ownership of property as well as conservation. Hence activities such as timber harvesting on commercial scale is non-existent in Mukogodo forest.

Table 14: Laikipia District Population By Sex, Age Group And School Attendance

Female Age Group	At School	Left School	Never Attended	Not Stated	Total
6-9	8,996	205	2,965	1,754	13,920
10-14	13,371	542	1,365	224	15,502
15-19	6,555	3,425	1,140	147	11,267
20-24	806	7,310	1,342	157	9,615
25-29	208	6,182	1,664	95	8,149
30-34	105	3,387	1,610	46	5,148
35-39	72	2,502	1,686	49	4,309
40-44	40	1,606	1,947	45	3,638
45-49	25	1,079	1,984	45	3,133
50-54	13	570	1,674	27	2,284
55-59	12	308	1,224	21	1,565
60+	31	548	4,393	130	5,102
Age NS	4	15	36	35	90
Total	**30,238**	**27,679**	**23,030**	**2,775**	**83,722**

Source: CBS, Population Census 1989

The total number of females who have never attended school according to the 1989 census is 23,030 which is approximately 27.5% of the total population in the district. It shows that the illiteracy level in the district is generally quite high and particularly in the study area. According to the 1999 population census the total number of males in the district who have

never attended school is 19,251 which is about 14.5% of the total male population while that of females is 29,132 and is approximately 21.7 of the total female population. There is still therefore a higher percentage of females who are illiterate as compared to males in the district generally, as it is common in other areas of the country, but the general area of study portrays a very high level of illiteracy amongst women as shown from the data collected in the field by the researcher.

Table 15: Females' Educational levels

Educational level	Code	Frequency	Percent	Cumulative %
No formal education	0	8	44.4	44.4
Pre primary	1	0	0	44.4
Primary	2	3	16.7	61.1
Secondary	3	0	0	61.1
Post Secondary	4	0	0	61.1
Other	5	2	11.1	72.2
Missing	8	5	27.8	100.0
Total	-	**18**	-	0

Source: Field work data 2001

It is noted that the percentage of females with no formal education is equally large in both cases. This can be attributed to the fact that Maasai people are largely traditional in nature and have not yet given greater attention to formal education as an important aspect. Only 16.7 percent have attained primary education. The column for missing which accounts for about 27.8 percent is for women who were unwilling to respond due to mainly suspicion and the traditional approach of women of being reserved especially among the traditional Maasai. In this case it has proved a bit contrary as compared to other cases of study where educational level has been found to create awareness among locals on how to utilize and conserve forest resources around them in order to sustainably meet their resources needs. Working on the

understanding that males are more often than not the household decision-makers as opposed to females, decisions affecting household wood-fuel consumption are bound to be dictated by this anomaly. This is so because firewood is normally collected by women and the frequency of collection depends on availability to some extent but it is the kind of food being cooked which determines the rate at which it is consumed.

5.5 Forest Resources Related Population Needs/Activities

5.5.1 Household Energy Utilization

In Mukogodo area of East Laikipia, like in any other part of Kenya and the developing world in general fuel wood constitutes the single main source of energy particularly for cooking and warming purposes. Firewood alone accounts for about 96 percent of household energy needs, the other about 44 percent use both charcoal, fuel wood and partly kerosene. This is mainly found in Dol Dol, which is a shopping centre. Otherwise of the rural population especially those staying near and around the forest none of those interviewed uses an alternative source of energy. The population in the study is mainly rural-based. However household wood-fuel consumption varies significantly with household size because this in turn determines amount of food to be cooked. Another factor determining wood-fuel consumption is the proximity to the resources. This is so because those staying a bit far from the source rarely come to collect the firewood and also carry smaller loads because of the long distance they have to travel.

(i) Yearly household wood-fuel consumption (m^3) and household size.

Here the hypothesis "Household woodfuel consumption does not significantly contribute to forest cover shrinkage in Mukogodo forest is tested". From the calculations done from the data obtained from the fieldwork, it is found out that the mean monthly wood fuel consumption is 0.16576 m^3 whereas the mean yearly wood fuel consumption is 1.98912

cubic metres. Using this data, the relationship between these two variables shows that there exits a weak correlation (r0.281) with a positive slope, meaning that as household size increases, there occurs a corresponding increase in yearly wood fuel consumption at household level. r^2=0.079 which means that only about 7.9 percent of variation in wood-fuel consumption is explained by changes in household size. The computed F statistic in this case is 4.115 while the significant F is 0.048 at one and two degrees of freedom in the numerator and denominator respectively. Therefore the computed F - value is greater than the critical F -value. Therefore it means that the slope of regression is different from zero and therefore is significant. Therefore in conclusion, the regression accounts for a significant amount of variation on the sample data. Notably, firewood is the main source of energy for almost all households in Mukogodo and consequently acts as a cause of deforestation in the study area.

Plate 2:Children collecting firewood in the forest

Plate 3:Firewood harvesting from the forest dry wood.

(ii)Charcoal consumption

Apart from firewood, charcoal is another alternative source of energy especially for cooking purposes. However from the field data quite a small percentage of people in the study area use charcoal for cooking. Those who use charcoal for cooking were mainly from Dol Dol shopping centre. This accounted for a very small percentage of the sample interviewed. Of the 50 people interviewed only about 6 use charcoal as an alternative source of energy. This accounts for about 12% of the total sample. Otherwise the rest about 88% use mainly fire wood alone. This is so because firewood is easily and readily available. It is also cheaper in terms of cost in relation to charcoal. However, charcoal quantification is a little bit difficult, as it is not frequently used as well as produced by these mostly pastoral Maasai households. Although there is relatively little charcoal production in the gazetted indigenous forests in the country, almost no illegal charcoaling is rampant in the area of study. Anyway, fuel consumption in the study area contributes very insignificantly to forest cover change in Mukogodo forest. This may be attributed to the fact that the local Maasai, being pastoralists, mainly feed on raw blood and milk for their diet. They mainly cook and roast meat. Therefore this one alone does not consume a lot of fuel. This is unlike in Western Laikipia where settlement has taken place due to favourable conditions to agriculture. People have moved in from neighbouring districts and have carried in their behavioural modes of life. Mukogodo area has realized very little or no in-migration from neighbouring districts to Laikipia so their culture is still intact.

5.5.2 Fencing and construction needs

The hypothesis "There is no significant relationship between timber extraction and forest depletion in Mukogodo forest" is tested. The materials used in construction of Manyatta housing units in the study area include poles, branches of trees, cow dung and soil. From the interviews carried out by the researcher, no one grows trees in his/her homestead. So the poles and tree branches for construction are got from Mukogodo forest. Data on the

approximate number of poles used in the construction of houses is shown in the appendix 3. An examination of the relationship between household size and the approximate number of poles used in the construction of Manyattas shows that there exists an average correlation (r0.529) with a coefficient of determination r^2 (0.280) explaining only 28 percent of the number of poles used for house construction in the study area. In other words 72 percent of the variation in number of poles used is due to other considerations other than household size. These factors may include easy access and availability of the materials, personal considerations such as financial, cultural aspects, among others.

Most Maasai homesteads are not fenced. They simply lie in the open. This may be attributed to a number of factors such as lack of interest to see the need, cultural factors, and social factors such as lack of land demarcation thus free movement. The few that are termed fenced are done so by use of tree branches got from the forest. The researcher did not witness any serious fencing as by barbed wire or sawn timber.

Plate 4:Manyatta-Constructed with timber from the forest.

Plate 5:Cow shed-also constructed with timber from the forest.

OLAP Cubes

Case Processing Summary				
Cases		Mean monthly woodfuel consumption by volume (cubic metres) * Total household size * Educational level	Mean yearly woodfuel consumption by volume (cubic metres) * Total household size * Educational level	Approximate number of poles used in wall construction of manyatta * Total household size * Educational level
Included	N	45	45	45
	Percent	90.0%	90.0%	90.0%
Excluded	N	5	5	5
	Percent	10.0%	10.0%	10.0%
Total	N	50	50	50
	Percent	100.0%	100.0%	100.0%

Frequencies

Statistics						
		Mean monthly woodfuel consumption by volume (cubic metres)	Mean yearly woodfuel consumption by volume (cubic metres)	Total household size	Approximate number of poles used in wall construction of manyatta	Educational level
N	Valid	50	50	50	50	45
	Missing	0	0	0	0	5
Mean		.16576	1.98912	8.84	17.62	1.20
Mode		.112	1.344	9	12	0
Std. Deviation		8.5387E-02	1.02464	2.99	4.72	1.74
Variance		7.2909E-03	1.04989	8.91	22.24	3.03
Skewness		.610	.610	-.069	-.189	1.304
Std. Error of Skewness		.337	.337	.337	.337	.354
Kurtosis		-.747	-.747	-.425	-.408	.513
Std. Error of Kurtosis		.662	.662	.662	.662	.695
Range		.280	3.360	12	21	5
Minimum		.056	.672	3	6	0
Maximum		.336	4.032	15	27	5

Frequency Table

Mean monthly woodfuel consumption by volume (cubic metres)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.056	7	14.0	14.0	14.0
	.112	19	38.0	38.0	52.0
	.168	7	14.0	14.0	66.0
	.224	7	14.0	14.0	80.0
	.280	6	12.0	12.0	92.0
	.336	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

Mean yearly woodfuel consumption by volume (cubic metres)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.672	7	14.0	14.0	14.0
	1.344	19	38.0	38.0	52.0
	2.016	7	14.0	14.0	66.0
	2.688	7	14.0	14.0	80.0
	3.360	6	12.0	12.0	92.0
	4.032	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

Total household size					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	3	6.0	6.0	6.0
	4	1	2.0	2.0	8.0
	5	4	8.0	8.0	16.0
	6	2	4.0	4.0	20.0
	7	5	10.0	10.0	30.0
	8	7	14.0	14.0	44.0
	9	8	16.0	16.0	60.0
	10	7	14.0	14.0	74.0
	11	3	6.0	6.0	80.0
	12	3	6.0	6.0	86.0
	13	4	8.0	8.0	94.0
	14	2	4.0	4.0	98.0
	15	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

Approximate number of poles used in wall construction of manyatta					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	6	1	2.0	2.0	2.0
	8	1	2.0	2.0	4.0
	12	9	18.0	18.0	22.0
	14	3	6.0	6.0	28.0
	15	1	2.0	2.0	30.0
	16	5	10.0	10.0	40.0
	17	4	8.0	8.0	48.0
	18	4	8.0	8.0	56.0
	19	3	6.0	6.0	62.0
	20	5	10.0	10.0	72.0
	21	4	8.0	8.0	80.0
	23	4	8.0	8.0	88.0
	24	4	8.0	8.0	96.0
	26	1	2.0	2.0	98.0
	27	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

Educational level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No formal education	27	54.0	60.0	60.0
	Primary	12	24.0	26.7	86.7
	Other	6	12.0	13.3	100.0
	Total	45	90.0	100.0	
Missing	Missing	5	10.0		
Total		50	100.0		

Regression

Variables Entered/Removed (b)			
Model	Variables Entered	Variables Removed	Method
1	Total household size (a)	.	Enter
a All requested variables entered.			
b Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)			

Model Summary (b)									
					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.281(a)	.079	.060	8.2795E-02	.079	4.115	1	48	.048
a Predictors: (Constant), Total household size									
b Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)									

ANOVA (b)						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.821E-02	1	2.821E-02	4.115	.048(a)
	Residual	.329	48	6.855E-03		
	Total	.357	49			
a Predictors: (Constant), Total household size						
b Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)						

Coefficients (a)								
		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
Model		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	9.471E-02	.037		2.565	.014	.020	.169
	Total household size	8.037E-03	.004	.281	2.029	.048	.000	.016
a Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)								

Residuals Statistics (a)					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.11882	.21527	.16576	2.3995E-02	50
Residual	-.11908	.16895	-6.60583E-17	8.1946E-02	50
Std. Predicted Value	-1.956	2.063	.000	1.000	50
Std. Residual	-1.438	2.041	.000	.990	50
a Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)					

Regression

Variables Entered/Removed(b)			
Model	Variables Entered	Variables Removed	Method
1	Total household size(a)	.	Enter
a All requested variables entered.			
b Dependent Variable: Mean yearly woodfuel consumption by volume (cubic metres)			

Model Summary (b)									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.281(a)	.079	.060	.99354	.079	4.115	1	48	.048
a Predictors: (Constant), Total household size									
b Dependent Variable: Mean yearly woodfuel consumption by volume (cubic metres)									

ANOVA(b)						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.063	1	4.063	4.115	.048(a)
	Residual	47.382	48	.987		
	Total	51.444	49			
a Predictors: (Constant), Total household size						
b Dependent Variable: Mean yearly woodfuel consumption by volume (cubic metres)						

Coefficients (a)								
		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
Model		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.137	.443		2.565	.014	.246	2.028
	Total household size	9.645E-02	.048	.281	2.029	.048	.001	.192
a Dependent Variable: Mean yearly woodfuel consumption by volume (cubic metres)								

Residuals Statistics (a)					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.42586	2.58324	1.98912	.28794	50
Residual	-1.42900	2.02745	1.6476E-15	.98335	50
Std. Predicted Value	-1.956	2.063	.000	1.000	50
Std. Residual	-1.438	2.041	.000	.990	50
a Dependent Variable: Mean yearly woodfuel consumption byvolume (cubic metres)					

Regression

Variables Entered/Removed (b)			
Model	Variables Entered	Variables Removed	Method
1	Total household size (a)	.	Enter
a All requested variables entered.			
b Dependent Variable: Approximate number of poles used in wall construction of manyatta			

Model Summary (b)									
					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.529(a)	.280	.265	4.04	.280	18.654	1	48	.000
a Predictors: (Constant), Total household size									
b Dependent Variable: Approximate number of poles used in wall construction of manyatta									

ANOVA (b)						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	304.991	1	304.991	18.654	.000(a)
	Residual	784.789	48	16.350		
	Total	1089.780	49			
a Predictors: (Constant), Total household size						
b Dependent Variable: Approximate number of poles used in wall construction of manyatta						

Coefficients (a)								
		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
Model		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	10.233	1.803		5.674	.000	6.606	13.859
	Total household size	.836	.193	.529	4.319	.000	.447	1.225
a Dependent Variable: Approximate number of poles used in wall construction of manyatta								

Residuals Statistics (a)					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	12.74	22.77	17.62	2.49	50
Residual	-10.92	8.25	-1.63E-15	4.00	50
Std. Predicted Value	-1.956	2.063	.000	1.000	50
Std. Residual	-2.700	2.039	.000	.990	50
a Dependent Variable: Approximate number of poles used in wall construction of manyatta					

Regression

Descriptive Statistics			
	Mean	Std. Deviation	N
Mean monthly woodfuel consumption by volume (cubic metres)	.16302	8.5948E-02	45
Total household size	8.91	2.86	45
Educational level	1.20	1.74	45

Correlations				
		Mean monthly woodfuel consumption by volume (cubic metres)	Total household size	Educational level
Pearson Correlation	Mean monthly woodfuel consumption by volume (cubic metres)	1.000	.262	-.010
	Total household size	.262	1.000	-.106
	Educational level	-.010	-.106	1.000
Sig. (1-tailed)	Mean monthly woodfuel consumption by volume (cubic metres)	.	.041	.473
	Total household size	.041	.	.244
	Educational level	.473	.244	.
N	Mean monthly woodfuel consumption by volume (cubic metres)	45	45	45
	Total household size	45	45	45
	Educational level	45	45	45

Variables Entered/Removed (b)			
Model	Variables Entered	Variables Removed	Method
1	Educational level, Total household size(a)	.	Enter
a All requested variables entered.			
b Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)			

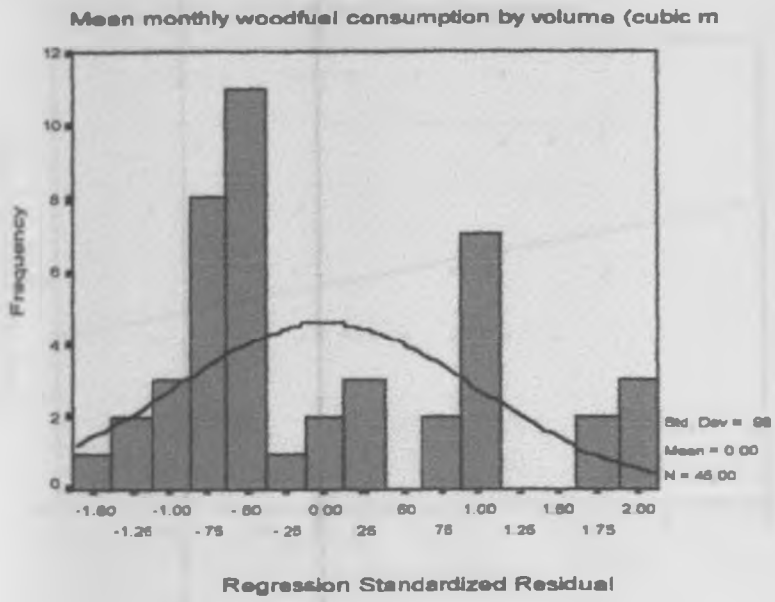
Model Summary (b)									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.263(a)	.069	.025	8.4876E-02	.069	1.559	2	42	.222
a Predictors: (Constant), Educational level, Total household size									
b Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)									

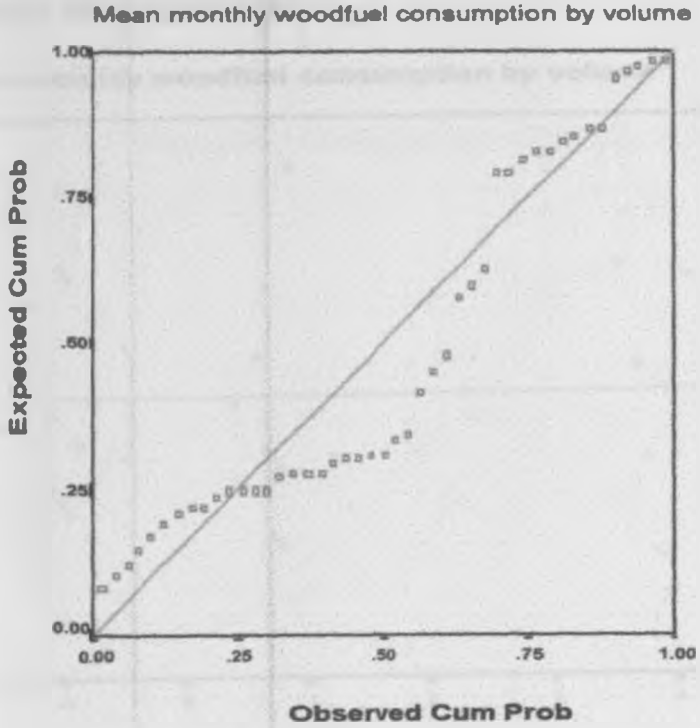
ANOVA (b)						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.247E-02	2	1.123E-02	1.559	.222(a)
	Residual	.303	42	7.204E-03		
	Total	.325	44			
a Predictors: (Constant), Educational level, Total household size						
b Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)						

Coefficients (a)						
		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	9.119E-02	.044		2.080	.044
	Total household size	7.943E-03	.005	.264	1.765	.085
	Educational level	8.789E-04	.007	.018	.119	.906
a Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)						

Residuals Statistics (a)					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.11678	.21209	.16302	2.2597E-02	45
Residual	-.11901	.17333	-7.70988E-17	8.2924E-02	45
Std. Predicted Value	-2.047	2.171	.000	1.000	45
Std. Residual	-1.402	2.042	.000	.977	45
a Dependent Variable: Mean monthly woodfuel consumption by volume (cubic metres)					

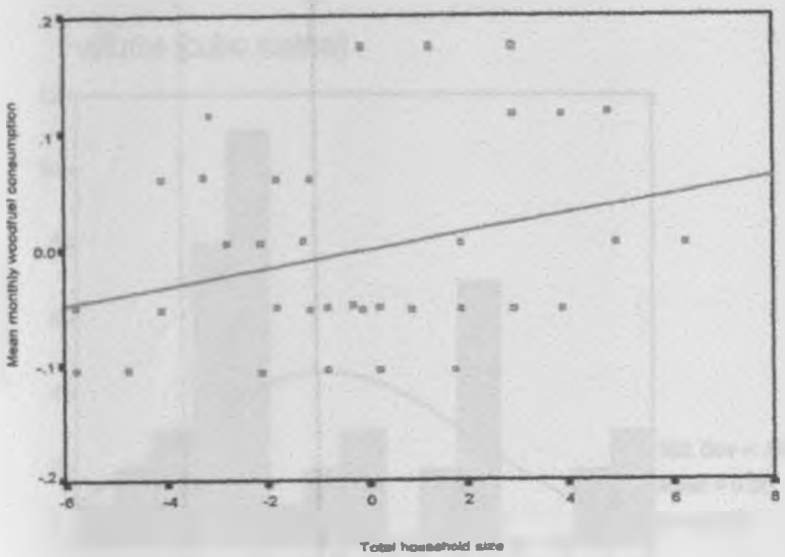
Histogram


Mean monthly woodfuel consumption by volume (cubic m
Frequency
Std. Dev = .98
Mean = 0.00
N = 45.00
-1.50
-1.00
-.50
0.00
.50
1.00
1.50
2.00
-1.25
-.75
-.25
.25
.75
1.25
1.75
Regression Standardized Residual


Mean monthly woodfuel consumption by volume
Expected Cum Prob
Observed Cum Prob
0.00
.25
.50
.75
1.00

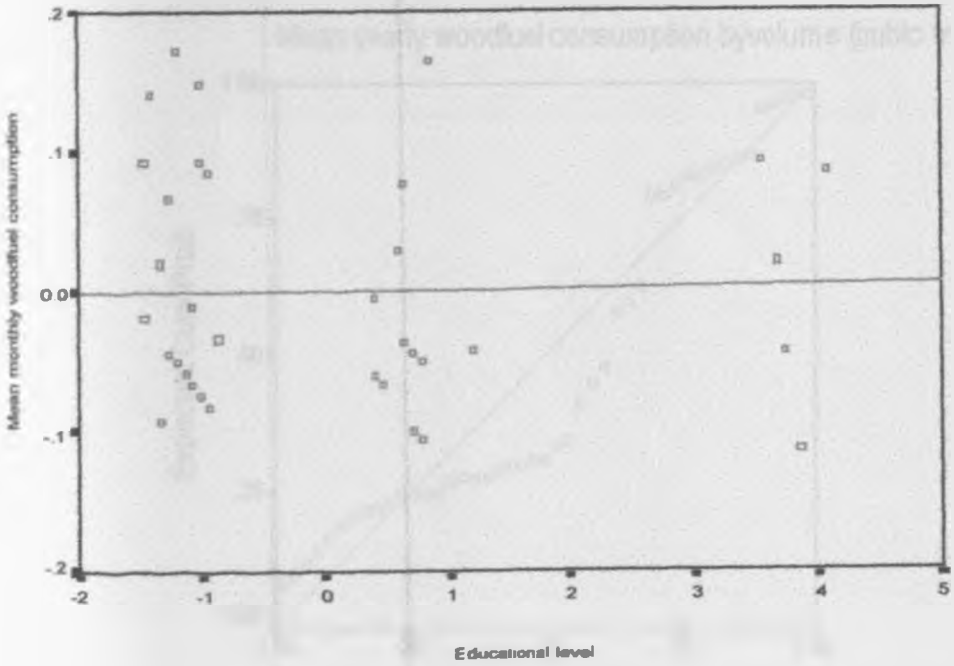
Partial Regression Plot

Mean monthly woodfuel consumption by volume

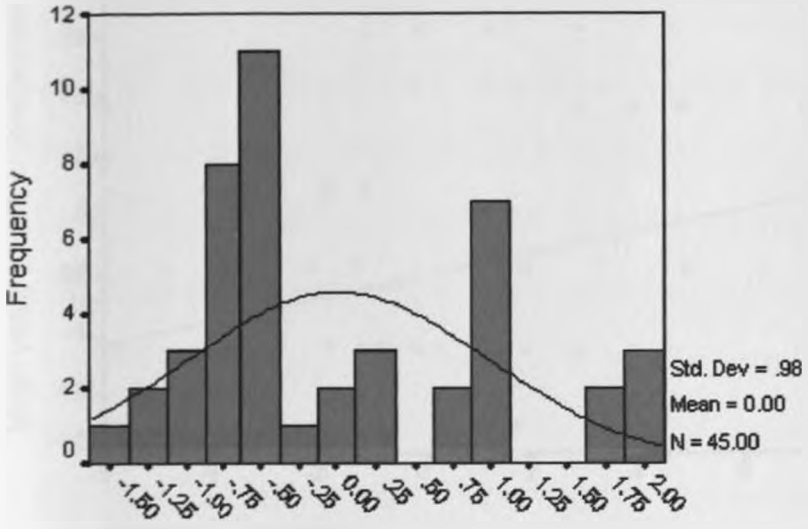


Partial Regression Plot

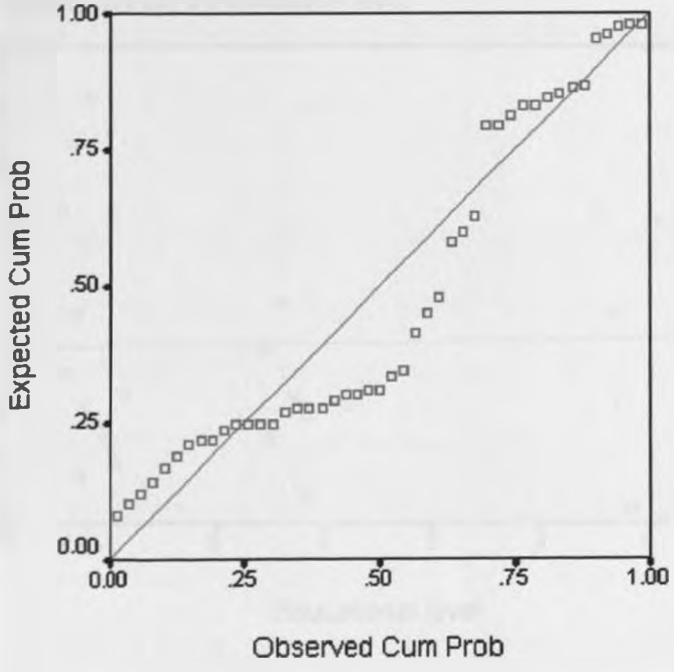
Mean monthly woodfuel consumption by volume



Mean yearly woodfuel consumption by volume (cubic metres)

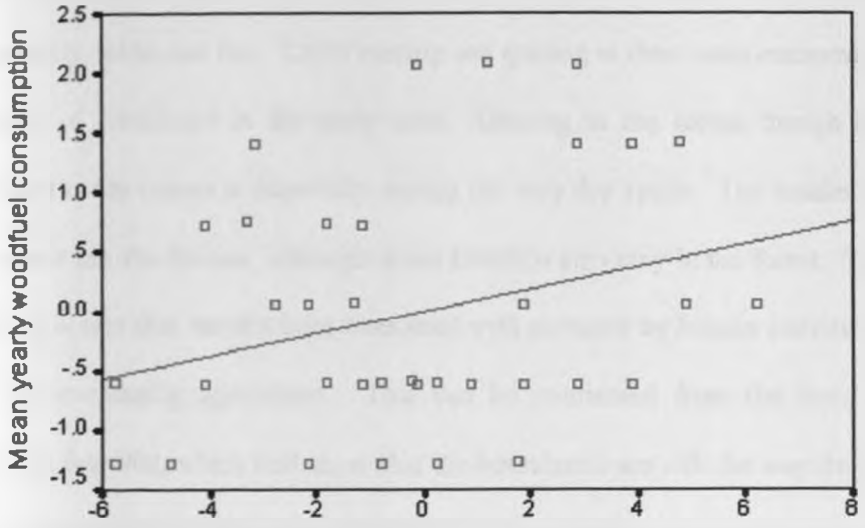


Mean yearly woodfuel consumption byvolume (cubic m



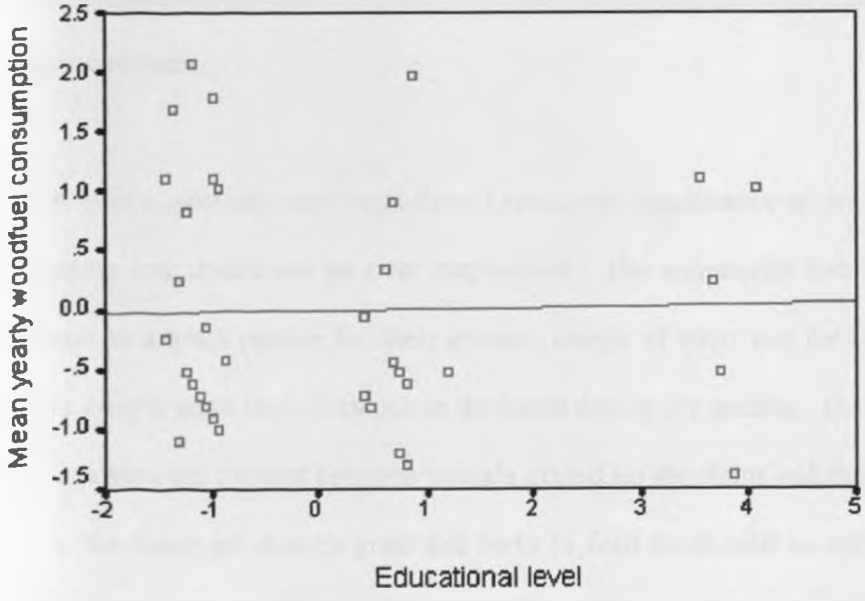
Mean yearly woodfuel consumption by volume

(cubic metres) by household size



Mean yearly woodfuel consumption by volume

(cubic metres) by education level



5.5.3 Animal grazing

It is noted that over 90 percent of the households keep livestock in large numbers. They keep animals such as cattle, sheep and goats. The wealth of a Maasai is gauged on the number of animals especially cattle one has. Cattle rearing and grazing is their main economic activity and the source of livelihood in the study area. Grazing in the forest, though an illegal practice in most cases comes in especially during the very dry spells. The residents around Mukogodo forest are the Maasai, although some Dorobos also stay in the forest. To say the least, the forest is one that has not been interfered with so much by human activities such as settlement and eventually agriculture. This can be confirmed from the latest satellite imageries of the late 90s, which still show that the boundaries are still the way they were in the 60s. At certain points the boundary is inside the forest while at some places it is out in the open (shrubs). The researcher established that the forest cover change has more to do with the physical than human factors. But non-interference with the forest has not been simply because of low population pressure and harsh climatic conditions but more so on the discipline of the residents and adherence to rules and instructions from the local leaders such as chiefs and their assistants.

Mukogodo Forest is in a quite dry area (semi-desert) and so the significance of the forest to the area is enormous and should not be over emphasized. The community has all a long preserved the forest as a green pasture for their animals, source of water and for medicinal value. The native people graze their livestock in the forest during dry periods. During very dry spells, there is a very big contrast between animals grazed on the plains and those in the forests. Those in the forest get enough grass and herbs to feed on as well as water while those on the plains have virtually nothing to feed on and most rivers will have dried up during this period. So most of them die and those remaining are normally thin and skinny. The forest has permanent rivers such a Siagu which livestock benefit from a lot during the dry

period. Another river called Segu has also erupted from a spring, which erupted from Wandiki hill in the forest during the EL NINO rain. It is now a river that flows throughout the year. Their livestock and even wild animals such as elephants - which are quite many here, leopards, hyenas, antelopes among others now get water from this stream. Generally speaking sheep and goats are grazed on the plains and not in the forest due to availability of leopards in the forest which feed on them. They are mainly grazed on the periphery of the forest but not the interior parts, which have thick forest. The temperature in the forest is generally very cool. This is because of hills and presence of reasonably thick forest. So the forest acts as a home to many species of wild animals, birds and acts as a genetic pool.

The effects of grazing on the vegetation are two-fold; positive and negative. While light grazing may increase the productivity of wild pastures by, for instance the nibbling action which can encourage the vigour and growth of plants, especially during rainy seasons, heavy grazing on the other hand may be detrimental as it can kill plants and lead to a marked reduction in their level of photosynthesis.

Plate 6:Cattle being grazed in the forest.

Therefore leads to a reduction in forest cover and this coupled with occasional bush fires caused as a result of honey harvesting cause reductions in forest cover and open pockets that can be seen from the layers of 1966 and 1996 of the maps produced from both aerial photographs and satellite imageries-compilation, see map 13.

5.5.4 Medicinal Use/Value

As one of the main ways of utilizing the forest resource, the local people are familiar with certain medicinal plants found in the forest in Mukogodo. From the sample that was interviewed 100 percent of the respondents use these medicinal herbs. Maasai people have all along depended on herbal medicine and Mukogodo forest being comprised of different species of trees, which are indigenous, serves as a source of all the herbs they use even in the treatment of their livestock. So it cannot go without emphasizing how important Mukogodo forest is to these people as the main source of their medicine. They have survived quite well through this native way even during epidemics. The parts of trees used include leaves, barks and roots. These are used to treat illnesses such as malaria, stomach-aches and related problems, back-aches and bones. In summary some of the trees with which they treat include: *Catha edulis* for treatment of malaria, *Ficus ghimosa* for treatment of stomach problems, *Rhamnus prinoides* for bones as well as *Aerva javanica* for treatment of East Cost Fever problems among others. When asked how the local people ensure the non-extinction of these medicinal trees, the people insisted on conservation by making sure only what is needed for the medicine is extracted but not felling the tree or over exposing it by removal of excess barks or roots. They make sure that after some few roots are removed, soil is taken back to cover the remaining roots so that the tree does not dry and can be used next time. By following these practices, the local Maasai ensure continued existence of these tree species.

The only uncontrollable threat to them was the over prolonged dry periods and occasional bush fires, which are of course not so common.

5.6 Forest Management and Conservation

Efforts to protect and conserve the forest reserves in the study area are made both by the local people and the forest department.

It is the responsibility of the forest department to balance the utilization of the forest resource and its regeneration for sustainability. In the management and conservation of the Mukogodo forest reserve, the forest department plays an important role in coordinating protection patrols by the forest guards in efforts to curb illegal activities such as charcoaling and harvesting of poles for fencing and construction purposes. However, their efforts are retarded by unrelenting illegal activities from the people around these forest reserves, lack of enough personnel, equipment and a general lack of financial support.

It is important to note that local people play a number of roles in a bid to boost the Government of Kenya's efforts to conserve the indigenous forest in order to achieve resource use sustainability. This is shown by the fact that over 80 percent of the sample interviewed in the area of study is aware of the need to protect the forests. Some of the roles local people play include using the resource sparing, avoiding lighting forest fires and helping to put the fires off in case of any outbreak, advising people on the important of conservation and not grazing in the forest areas when there is grass on the plains as this may encourage starting to clear forested land for other economic activities like farming.

The efforts by the forest department and the local people to manage and conserve the forests sustainably in the study area are however, hampered by some problems. Given the fact that

all exploitation within the forest belt requires special permission, any unlicensed activity is deemed illegal. Some of the illegal practices include: the harvesting of the produce such as firewood, charcoaling, honey-hunting, cutting of poles for construction, uncontrolled grazing among others.

5.6.1 Local people's perception on the Forest Resource availability and Use

The fact that the people living in Mukogodo area have been utilizing the forest resources for quite a while calls for the need to understand how they perceive the existence of these forest in the area. An examination of their opinions regarding the status of the forest shows that these forests are still intact in terms of area covered and species diversity. While approximately 70 percent of the respondents indicated that the forests was declining, 10 percent were not aware of what was happening or had happened to the forest resource.

Based on the reflections about the future of the forest, it is noted that 80 percent of the respondents feel that the forest should be kept intact, about 17 percent of the respondents feel that the forest should be opened up for settlement, while the remaining percentage did not respond. Some of the reasons advanced for the first response include that: Forests attract rainfall, act as a source of river water for the region, source of firewood, and construction material, grazing ground and a saviour especially during very dry spells, source of herbal medicine among others. Those in favour of these areas being opened up for settlement argue that the forest has both water and pasture so they would not need to move from one area to another in search for the same hence a possibility of opening up to other economic activities. Whereas population pressure through in-migration and natural increase are a threat to forest cover, animal grazing and overstocking in Mukogodo happens to be the main threat to forest cover in the study area.

5.7 Research Findings

Research findings on the aspect of in-migration clearly indicates that there is very little localized migration of the Maasai pastoralists and Samburu neighbouring the forest who come in to graze their animals especially during the very dry spell. There are actually no found cases of in-migrants who have come from neighbouring districts to settle. This could be attributed to the very harsh climatic conditions in East Laikipia as opposed to other regions in the district such as West Laikipia. According to research done in West Laikipia by Omoke 1998 on in-migration, it was found out that majority of the in-habitants came from the neighbouring districts such as Nyeri and Kiambu. There are both push and pull factors attributed to this. The latter were found to be land availability, job opportunity, desire to own land, to farm and low population pressure. This follows the taking over of the former white highlands in West Laikipia by the Kenya Government after the attainment of independence. East Laikipia lacked these facilities due to hostile climatic conditions i.e. low and unreliable rainfall with high temperatures (giving dry conditions throughout the year), hence no immigration

Although the compiled maps from aerial photographs, the satellite imageries, the topographic sheets as well as the ground truthing show that the boundaries of Mukogodo forest are still intact, the overlaid map of 1966 and 1996 map 11 shows reduction in forest cover, though it is not possible to quantify this reduction. When one compares the coverage of the forest in 1966 and 1996 separately it can be seen that the one of 1996 has more open pockets compared to the one of 1966. This reduction in forest cover can be attributed to both naturally harsh climatic conditions as well as human activities in the area.

The researcher also established that a small section of Dorobo people stay in the forest and this, in a way, has interfered with the forest cover. Their constant contact with the forest,

gathering of fruits, honey harvesting, fire wood collection, cutting of poles for the construction of their structures, extra, has caused reduction in the forest cover. It was also established that they have been appealing to the government through the forest department to allow them have more land (a further $10km^2$) cleared for them for settlement. This could also pose a threat to the forest because once the government allows a few of them to settle in the forest it will call for more slowly by slowly hence the forest will be cleared thereby endangering both species of animals and plants - genetic pool as well as climatic imbalance, as the forest acts quite well as a weather balance system as trees do attract rainfall and act as windbreakers. The forest is also the source of river water in the region, so if destroyed, the life of the Maasai is endangered together with their livestock.

As concerns the effect of household wood-fuel consumption on forest cover change, it was found that, it does contribute significantly. This finding is supported by the fact that wood-fuel consumption accounts for over 90 percent of the total household fuel consumption. Using regression analysis there was highly significant positive relationship between total wood utilization and wood-fuel consumption. The relationship was significant at 95% confidence level. It was also established that 44 percent of the households use both firewood and charcoal. Notably, household wood-fuel consumption in the study area varies significantly with household characteristics and education levels as well as the kind of food cooked.

The aspects of other wood uses examined in this study are those of wood for fencing and manyatta construction. The salient research findings in this area are that poles and rafters are the most commonly used wall construction material in the area of study. A substantial proportion of the total wood consumption was used in the construction of the manyattas. The correlation analysis results showed a positively significant relationship between household

size and the number of poles used for household wall construction with a 95% confidence level. It thus, plays a role in depleting the forest densities of the surrounding forests.

The wealth of a typical Maasai is gauged by the size of herd of livestock one has. The more animals one rears the more wealthy he is. Maasai in the study area are typically pastoralists with virtually no other supplementary economic activity. They keep large herds of animals and given that the weather conditions on the plain are normally hostile, the forest become the only rescue. It has been established that the effects of grazing on the vegetation are two-fold; both positive and negative. While light grazing increases the productivity of wild pastures, by for example, through the effect of nibbling which encourages the vigour and growth of plants, heavy grazing on the other hand is detrimental as it can kill plants and lead to a marked reduction in the level of photosynthesis. Since Maasai pastoralists keep very large herds of animals, the latter is the most likely effect of their animals to the forest cover hence reduced regeneration and forest cover. Only the big trees remain in this case while the bushes and grass get depleted.

Being a traditional community that is not so much exposed to outside interactions, they still depend so much on herbal medicine got from the forest. It was established that, they mostly use barks, leaves and roots of trees to extract their traditional medicine. In the process of removal of barks and roots, the trees are faced with the dangers of easily drying hence reducing the genetic pool and, if it is the rare species, extinction then follows. According to the researcher all the respondents of the interview use herbal medicine as treatment to almost all illness.

The researcher also discovered that the local people do harvest wild honey from the forest. However, the method used in harvesting this wild honey is not good since it posses a risk to the forest cover in that, those who do the honey harvesting light bush fires to scare away the

bees. This has resulted in the burning of huge areas of the forest especially during very dry seasons. Since Mukogodo forest lies in a semi-arid zone with scanty and unreliable rainfall, regeneration of the vegetation after such fires is unlikely or if there is, very scantly resulting into shrubs and grass.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The present study set out to investigate the human impact on Mukogodo Forest of East Laikipia. The emphasis was to analyze the effect the pastoral Maasais have on the forest in the absence of settlement and crop farming. Among population characteristics studied in relation to the forest utilization were household size and educational level. This was done in order to arrive at meaningful and useful findings and related conclusions. This would thus pave way for relevant recommendations to policy makers and future researchers in a bid to enhance development in the area of study and the district as a whole. In this chapter, a comprehensive summary of the relevant emerging conclusions and the resultant recommendations is presented in the light of the research objectives and hypotheses stated in chapter one, the research findings are already stated in the chapter five (5).

6.2 Conclusions

In the light of the foregoing research findings and other related personal observations from the fieldwork, a number of conclusions have been drawn. There has been significant reduction in forest cover especially within the forest as opposed to the boundaries. There is a tendency of households in the area of study to over-depend on wood-fuel mainly firewood and charcoal (to a small extent) for their domestic energy requirements. This inappropriate tendency infers that a lot has to be harvested from the forest to meet the needs of the population in the area. The present study also found out that this over-reliance is attributed to the low awareness and unaffordability of alternative sources of energy among the members of

the society, coupled with the people's attitude (some) that the forest reserve in the area belongs to the government and therefore there should be no restriction in its exploitation.

On the aspect of Manyatta construction, it was established that the poles, bushes and twigs used for the same are got entirely from the forest. This came up in their response to the question "where do you get your construction material from?" This is partly because the forest is the only source of these materials in the area and partly because they believe they still have maximum control of the forest and are therefore free to extract whatever they feel like extracting. However, it is somehow difficult to quantify fencing material to estimate how much is extracted from the forest. Nevertheless, fencing and construction materials contribute to the depletion of the forest in the area of study.

In as much as it is hard to quantify the extent, to which grazing and bush fires contribute to forest depletion in the study area, it is obvious that they do cause depletion of the forest and should thus be monitored at close range.

6.3Recommendations

The recommendations presented below are based on both research findings and related conclusions arrived at in the foregoing sections.

Findings on the effect of household woodfuel consumption on forest cover change indicate the existence of an inappropriate household over - dependency on woodfuel as a source of energy. This calls for urgent measures to establish other alternative sources of energy such as cow dung,energy saving jikos and charcoal mixed with sand. The people should be furnished with information as to the importance of these sources and encouraged to use them to avoid over-reliance on woodfuel. Solar energy should be the best alternative because the heat from the sun is plenty in the area.

Prices of these alternative sources of energy should be adjusted to be in line with the purchasing power of the people, if possible.

There is also need to encourage people to plant trees on their plots to meet their specific household woodfuel needs. This will go a long way with efforts, to effect change in the attitude of people from seeing the forest reserve as an area worth exploitation to areas that should be conserved.

Also there is need to advise the local Maasai in the area to live a more settled life other than the life of wandering from one area to another. The government should encourage this process by digging boreholes especially at the river beds to supply water for both domestic and for watering the livestock. The government should also improve the infrastructure in the area for better accessibility of the area plus encouraging the pastoralists to reduce the sizes of their livestock to a size that can be sustained by the available resources. Other economic activities should be encouraged.

Through improved technology and capital they can tap water from the rivers in the areas through irrigation hence be able to practice crop farming activities, be able to store water in dams for their animals other than having to look for it from very far off places in the forest. Measures should be taken with the aim of discouraging population movement and encouraging an increase in forest cover in the area to strike an equilibrium between resource availability and use.

There is also need to control the rate of population growth both within the area of study and in the district as a whole to keep pace with the forest resource potential. Putting in mind that the area of study is a semi-arid area and the natives fully depend on livestock raring for their

livelihood there is need to step up population control methods through promotion of family planning.

An attempt should be made to improve on both the forest management and conservation policies and practices so as to ensure sustainability in the forest resource. This would be done through decentralizing the forest management for better services, and equipping the forest department with a sound financial base to facilitate law enforcement and increase the area under forest cover. Other efforts include spirited campaigns to enhance public awareness especially through the media, seminars and barazas in order to educate the people on the vitality of the forest resources and thus a call for change of attitude in the local people towards the resource.

For researchers and scholars a number of aspects have not been tackled in the current study, this is mainly due to resources and time at the disposal of the researcher. Studies should be undertaken on all the three main components of population change i.e. fertility, mortality and migration, inorder to appreciate these changes and show how they affect forest cover change, either individually or collectively in the study area.

Studies on the effect of forest cover changes vis a vis climatic regimes in East Laikipia and can also be a very interesting area of research for scholars and researchers alike. There is also need to study the impact of forest cover change on the socio-economic life of the immediate Maasai people in the area of study. Researchers and scholars can find it interesting to make a detailed study of household income in relation to household woodfuel consumption in the study area.

It could also be of great interest for researchers to examine decisions made by women and men household heads as they affect woodfuel consumption, not only in the study area but

also in other parts of the district neighbouring forest reserves. This is inorder to appreciate more meaningfully whether their differences, especially in levels of education, income among other indicators are reflected in the household woodfuel consumption variations.

For planners and policy makers, there is need for them to undertake a compilation of a comprehensive inventoried database on forest cover densities in the area for purposes of regional development planing. There exists a serious dearth of this information at the moment.

Researchers could need to examine the changes in forest cover composition over the decades inorder to appreciate meaningfully the role played by population dynamics in influencing forest cover and composition change in the study area.

There is a greater need for researchers and scholars to carry out detailed studies on the influences of environmental factors possibly determining forest change whether in terms of cover or composition in Mukogodo area. This could be compared well with the impact resulting from population dynamics in the same area.

6.5 The Study Contributions

The research findings highlighted in the foregoing sections of this work should be viewed as contributions made by this study. However, the need to isolate the specific contributions made by the study both in Mukogodo area of East Laikipia and the district in general is imperative. These contributions are provided in the comprehensive summary provided below: -

- Detection and mapping of forest cover change(s) in four designated periods (1966, 1976, 1986 and 1996) in Mukogodo area using an integrated methodology with the help of the Geographic Information System (GIS) tool.
- Pinpointed a number of research gaps within the realm of population and resource utilization nexus under the umbrella of the current broader theme of Population Environment and Sustainable Development. This is essential for further research work by researchers and scholars alike in a bid to enhance development both in the area of study and the district in general.
- Provided recommendations and guidelines on matters of policy as related to the aspects of population dynamics and forest cover change in the study area. This will go a long way into ensuring that there exits a balance between the forest resource potential and use in Mukogodo. This balance has often proved elusive in the population - resource use interrelations.

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Appendix I

QUESTIONNAIRE 1

1. Personal data

(a) Name:

(b) Age Category:

15-19
20-24
25-29
30-34
35-39
40-44
45-49
50+

(c) (i) Sex: Male (M)
Female (F)

(ii) How many are you in the family?

(d) Have you ever-attended school? Yes/No

If yes, to what Level? Primary
Secondary
Post-secondary

(e) District of Origin:
(i) Laikipia
(ii) Meru
(iii) Nyeri
(iv) Murang'a
(v) Baringo
(vi) Other (specify)

(f) Why did you move, incase you came from a different district apart from Laikpia?

(i) Acquired land (bought land)
(ii) Move with relatives
(iii) Influence from neighbours or friends
(iv) Other reasons (specify)

(g) If you came from elsewhere, are there problems you encountered while settling in the new area?
Yes/No
If yes, specify

_____

_____

2. **Land Tenure and Land use systems**

(a) How did you acquire this plot?

(i) Inherited
(ii) Bought
(iii) Leased

(b) (i) Approximately what size is it in hectares?

(ii) How do you own it? individually
communally

(c) What do you use your piece of land for?

(i) Farming crops (specify)

(ii) Livestock Rearing (pasture)

(iii) (a) What kind of livestock (mention them)

_____

(b) About how many of each?

_____

(iii) Where do you graze them? Why?

_____

(d) Now that you stay next to Mukogodo forest, are you aware of some people owning
Pieces of land in the forest?

Yes/No/Not aware

(e) Personally, are you aware of any need to conserve the resources from the forest?
Yes/No

If so, have you ever made any efforts in the past towards the same?

Yes/Not yet.
If yes, mention them: -

(i) _____

(ii) _____

(iii) _____

Woodfuel Utilization

(a) What is your main source of energy?

(i) Firewood
(ii) Charcoal
(iii) Others (specify)
(iv) What kind of food do you mainly prepare?

(b) If firewood, where do you normally collect your wood from?

(i) From forest
(ii) Trees planted at home

(c) (i) Approximately, how many bundles/bags of firewood/charcoal do you collect per week/month?

(ii) What normally determines the amount and frequency of collection.

(iii) Approximately, how many trees do you burn to get a bag of charcoal if you do practice it?

(d) Apart from using the wood you collect at home, do you sell some to earn some money?

Yes/No

(e) Do you encounter any problems with the main source above?

Yes/No

If yes, specify the nature of the problems.

(f) Which is (are) the common species for

(i) Firewood
(ii) Charcoal

(g) Are these species still as common in the forest as before?

Yes/No

(h) What do you think determines the number of bundles of wood/bags of charcoal you use?

4. **Housing**

(a) What kind of materials did you use in the process of constructing your house?

Approximately how many poles per hut?

(b) Fencing your compound and plots

Approximately how many poles for fencing your compound/plot?

If timber, where did you acquire it from?

(c) Are there any legal restrictions in obtaining wood, timber, charcoal from the forest?

(d) Are you for the restrictions or not?

5. **Medicinal Use**

(a) Apart from the above uses of forest resources do you benefit by extracting some kind of medicine in form of herbs from the forest?

Yes/No

(b) If yes, which species of trees do you normally go for?

And what part of the tree/herb do you extract?

Leaves
Roots
Barks
Other (specify)

(c) Are the trees used for medicinal value still as common as before?

Yes/No

If no, why?

(d) What are you as an individual doing to replenish them/avoid extinction?

(e) Do you want the restrictions relaxed completely so that there is complete access to forest resources as will?

(f) Do you take part in forest conservation?

Appendix II

QUESTIONNAIRE 2

District Forest Officer

Name:
Age:
Sex:

(a) What are some of your duties as a Forest Officer?

(i)

_____

(ii)

_____

(b) For how long have you been working in this area?

(c) Did you work elsewhere before coming to this region?

Yes/No

(d) Comparing your previous place of work, if ever you worked elsewhere before, do you have more problems or fewer to address than before?

If so, state some of the problems: -

(i)

_____

(ii)

_____

(iii)

_____

(iv)

_____

(e) Who owns the forest?

(f) What is the current approximate size?

(g) Of what importance is this forest to the district as a whole

(i)

_____

(ii)

_____

(iii)

(iv)

(h) What the main species?

(i)

(ii)

(iii)

(iv)

(i) How often do you visit the forest?

(j) Are there any noticeable reductions in the general extend of the forest cover?

(k) What do you think/know leads to the reduction in forest cover?

(l) Any legal activities in the forest?

(i)

(ii)

(m) Illegal activities

(i)

(ii)

(n) If any illegal activities, what are you doing as a department to curb them?

(i)

(ii)

(iii)

(o) Have the above ways been successful?

Yes/No

(p) If not, what other ways are your trying to use to curb down illegal activities in the forest?

(i)

_____

(ii)

_____

(iii)

_____

(q) Have you ever attempted ways of increasing forest cover?

If yes, mention the ways: -

(i)

_____

(ii)

_____

(iii)

_____

No. of sampled Households	Mean monthly household wood fuel consumption volume (m^3)	Mean yearly household wood fuel consumption volume (m^3)	Total household size	Approximate number of poles used in wall construction of Manyatta	Educational levels
34	0.168	2.016	10	23	8
35	0.056	0.672	9	21	2
36	0.056	0.672	8	18	2
37	0.056	0.672	7	14	0
38	0.056	0.672	5	12	8
39	0.056	0.672	3	12	2
40	0.112	1.344	9	26	0
41	0.112	1.344	9	24	2
42	0.112	1.344	11	20	0
43	0.112	1.344	10	24	0
44	0.336	4.032	12	23	0
45	0.112	1.344	8	17	5
46	0.112	1.344	9	21	0
47	0112	1.344	8	17	0
48	0.168	2.016	11	15	0
49	0.056	0.672	10	16	5
50	0.28	3.36	13	27	0
Total	**8.288**	**99.456**	**653**	**881**	

Appendix III

Household characteristics

No. of sampled Households	Mean monthly household wood fuel consumption volume (m^3)	Mean yearly household wood fuel consumption volume (m^3)	Total household size	Approximate number of poles used in wall construction of Manyatta	Educational levels
1	0.112	1.344	8	6	2
2	0.112	1.344	3	8	2
3	0.336	4.032	9	12	0
4	0.28	3.36	6	12	0
5	0.112	1.344	5	12	0
6	0.28	3.36	13	18	5
7.	0.336	4.032	10	24	2
8	0.336	4.032	9	17	0
9	0.168	2.016	7	16	0
10	0.168	2.016	6	20	2
11	0.168	2.016	7	20	5
12	0.224	2.688	5	12	5
13	0.112	1.344	10	19	0
14	0.112	1.344	9	21	0
15	0.224	2.688	5	12	0
16	0.224	2.688	8	16	0
17	0.224	2.688	3	12	8
18	0.112	1.344	10	14	0
19	0.112	1.344	11	16	0
20	0.28	3.36	12	23	0
21	0.28	3.36	14	20	8
22	0.224	2.688	9	14	8
23	0.28	3.36	13	12	5
24	0.168	2.016	14	21	0
25	0.168	2.016	15	23	2
26	0.224	2.688	8	20	0
27	0.224	2.688	7	19	2
28	0.112	1.344	10	18	0
29	0.112	1.344	8	24	0
30	0.112	1.344	13	19	0
31	0.112	1.344	12	17	0
32	0.056	0.672	4	16	2
33	0.112	1.344	7	18	2

Appendix IV

Woodfuel consumption and Use of Building poles by household size and education

			Total household size													
	Educational level	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	
Mean monthly woodfuel consumption by volume (cubic metres)	Sum	No formal education			.336	.280	.224	.672	1.008	.448	.392	.728	.392	.168		4.648
		Primary	.168	.056		.168	.336	.168	.168	.336					.168	1.568
		Other			.224		.168	.112		.056			.560			1.120
		Total	.168	.056	.560	.448	.728	.952	1.176	.840	.392	.728	.952	.168	.168	7.336
	N	No formal education			2	1	2	4	5	4	3	3	2	1		27
		Primary	2	1		1	2	2	2	1					1	12
		Other			1		1	1		1			2			6
		Total	2	1	3	2	5	7	7	6	3	3	4	1	1	45
	Mean	No formal education			.16800	.28000	.11200	.16800	.20160	.11200	.13067	.24267	.19600	.16800		.17215
		Primary	8.4000E-02	5.6000E-02		.16800	.16800	8.4000E-02	8.4000E-02	.33600					.16800	.13067
		Other			.22400		.16800	.11200		5.6000E-02			.28000			.18667
		Total	8.4000E-02	5.6000E-02	.18667	.22400	.14560	.13600	.16800	.14000	.13067	.24267	.23800	.16800	.16800	.16302
	% of Total N	No formal education			4.4%	2.2%	4.4%	8.9%	11.1%	8.9%	6.7%	6.7%	4.4%	2.2%		60.0%
		Primary	4.4%	2.2%		2.2%	4.4%	4.4%	4.4%	2.2%					2.2%	26.7%
		Other			2.2%		2.2%	2.2%		2.2%			4.4%			13.3%
		Total	4.4%	2.2%	6.7%	4.4%	11.1%	15.6%	15.6%	13.3%	6.7%	6.7%	8.9%	2.2%	2.2%	100.0%
	Maximum	No formal education			.224	.280	.168	.224	.336	.112	.168	.336	.280	.168		.336
		Primary	.112	.056		.168	.224	.112	.112	.336					.168	.336
		Other			.224		.168	.112		.056			.280			.280
		Total	.112	.056	.224	.280	.224	.224	.336	.336	.168	.336	.280	.168	.168	.336
	Minimum	No formal education			.112	.280	.056	.112	.112	.112	.112	.112	.112	.168		.056
		Primary	.056	.056		.168	.112	.056	.056	.336					.168	.056
		Other			.224		.168	.112		.056			.280			.056
		Total	.056	.056	.112	.168	.056	.056	.056	.056	.112	.112	.112	.168	.168	.056
Mean yearly woodfuel consumption byvolume (cubic metres)	Sum	No formal education			4.032	3.360	2.688	8.064	12.096	5.376	4.704	8.736	4.704	2.016		55.776
		Primary	2.016	.672		2.016	4.032	2.016	2.016	4.032					2.016	18.816
		Other			2.688		2.016	1.344		.672			6.720			13.440
		Total	2.016	.672	6.720	5.376	8.736	11.424	14.112	10.080	4.704	8.736	11.424	2.016	2.016	88.032
	N	No formal education			2	1	2	4	5	4	3	3	2	1		27
		Primary	2	1		1	2	2	2	1					1	12

		Other			1		1	1		1			2			6
		Total	2	1	3	2	5	7	7	6	3	3	4	1	1	45
	Mean	No formal education			2.01600	3.36000	1.34400	2.01600	2.41920	1.34400	1.56800	2.91200	2.35200	2.01600		2.06578
		Primary	1.00800	.67200		2.01600	2.01600	1.00800	1.00800	4.03200					2.01600	1.56800
		Other			2.68800		2.01600	1.34400		.67200			3.36000			2.24000
		Total	1.00800	.67200	2.24000	2.68800	1.74720	1.63200	2.01600	1.68000	1.56800	2.91200	2.85600	2.01600	2.01600	1.95627
	% of Total N	No formal education			4.4%	2.2%	4.4%	8.9%	11.1%	8.9%	6.7%	6.7%	4.4%	2.2%		60.0%
		Primary	4.4%	2.2%		2.2%	4.4%	4.4%	4.4%	2.2%					2.2%	26.7%
		Other			2.2%		2.2%	2.2%		2.2%			4.4%			13.3%
		Total	4.4%	2.2%	6.7%	4.4%	11.1%	15.6%	15.6%	13.3%	6.7%	6.7%	8.9%	2.2%	2.2%	100.0%
	Maximum	No formal education			2.688	3.360	2.016	2.688	4.032	1.344	2.016	4.032	3.360	2.016		4.032
		Primary	1.344	.672		2.016	2.688	1.344	1.344	4.032					2.016	4.032
		Other			2.688		2.016	1.344		.672			3.360			3.360
		Total	1.344	.672	2.688	3.360	2.688	2.688	4.032	4.032	2.016	4.032	3.360	2.016	2.016	4.032
	Minimum	No formal education			1.344	3.360	.672	1.344	1.344	1.344	1.344	1.344	1.344	2.016		.672
		Primary	.672	.672		2.016	1.344	.672	.672	4.032					2.016	.672
		Other			2.688		2.016	1.344		.672			3.360			.672
		Total	.672	.672	1.344	2.016	.672	.672	.672	.672	1.344	1.344	1.344	2.016	2.016	.672
Approximate number of poles used in wall construction of manyatta	Sum	No formal education			24	12	30	77	97	75	51	63	46	21		496
		Primary	20	16		20	37	24	45	24					23	209
		Other			12		20	17		16			30			95
		Total	20	16	36	32	87	118	142	115	51	63	76	21	23	800
	N	No formal education			2	1	2	4	5	4	3	3	2	1		27
		Primary	2	1		1	2	2	2	1					1	12
		Other			1		1	1		1			2			6
		Total	2	1	3	2	5	7	7	6	3	3	4	1	1	45
	Mean	No formal education			12.00	12.00	15.00	19.25	19.40	18.75	17.00	21.00	23.00	21.00		18.37
		Primary	10.00	16.00		20.00	18.50	12.00	22.50	24.00					23.00	17.42
		Other			12.00		20.00	17.00		16.00			15.00			15.83
		Total	10.00	16.00	12.00	16.00	17.40	16.86	20.29	19.17	17.00	21.00	19.00	21.00	23.00	17.78
	% of Total N	No formal education			4.4%	2.2%	4.4%	8.9%	11.1%	8.9%	6.7%	6.7%	4.4%	2.2%		60.0%
		Primary	4.4%	2.2%		2.2%	4.4%	4.4%	4.4%	2.2%					2.2%	26.7%
		Other			2.2%		2.2%	2.2%		2.2%			4.4%			13.3%
		Total	4.4%	2.2%	6.7%	4.4%	11.1%	15.6%	15.6%	13.3%	6.7%	6.7%	8.9%	2.2%	2.2%	100.0%
	Maximum	No formal education			12	12	16	24	26	24	20	23	27	21		27
		Primary	12	16		20	19	18	24	24					23	24
		Other			12		20	17		16			18			20

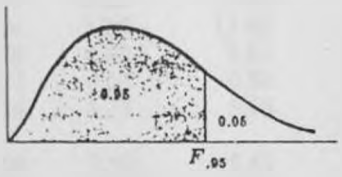
		Total	12	16	12	20	20	24	26	24	20	23	27	21	23	27
	Minimum	No formal education			12	12	14	16	12	14	15	17	19	21		12
		Primary	8	16		20	18	6	21	24					23	6
		Other			12		20	17		16			12			12
		Total	8	16	12	12	14	6	12	14	15	17	12	21	23	6

Appendix V

95th Percentile Values (0.05 Levels), $F_{.95}$, for the F Distribution

ν_1 degrees of freedom in numerator

ν_2 degrees of freedom in denominator



ν_2	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	∞
	161	200	216	225	230	234	237	239	241	242	244	246	248	249	250	251	252	253	254
	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.5	19.5	19.5	19.5	19.5	19.5
	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.37
	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96
	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Source: E. S. Pearson and H. O. Hartley, *Biometrika Tables for Statisticians*, Vol. 2 (1972), Table 5, page 178, by permission.

Appendix VI

Critical Values of Student's t

Degrees of freedom	Significance level (one-tailed) 0.05	0.025	0.01	0.005	0.0005
	Significance level (two- tailed) 0.1	0.05	0.02	0.01	0.001
1	6.31	12.71	31.82	63.66	636.62
2	2.92	4.30	6.97	9.93	31.60
3	2.35	3.18	4.54	5.84	12.92
4	2.13	2.78	3.75	4.60	8.61
5	2.01	2.57	3.37	4.03	6.86
6	1.94	2.15	3.14	3.71	5.96
7	1.89	2.37	3.00	3.50	5.41
9	1.83	2.26	2.82	3.25	4.78
8	1.86	2.31	2.90	3.35	5.04
10	1.81	2.23	2.76	3.17	4.59
11	1.80	2.20	2.72	3.11	4.44
12	1.78	2.18	2.68	3.05	4.32
13	1.77	2.16	2.65	3.01	4.22
14	1.76	2.15	2.62	2.98	4.14
15	1.75	2.13	2.60	2.95	4.07
16	1.75	2.12	2.58	2.92	4.01
17	1.74	2.11	2.57	2.90	3.97
18	1.73	2.10	2.55	2.88	3.92
19	1.73	2.09	2.54	2.86	3.88
20	1.73	2.09	2.53	2.85	3.85
21	1.72	2.08	2.52	2.83	3.82
22	1.72	2.07	2.51	2.82	3.79
23	1.71	2.07	2.50	2.81	3.77
24	1.71	2.06	2.49	2.80	3.75
25	1.71	2.06	2.49	2.79	3.73
26	1.71	2.06	2.48	2.78	3.71
27	1.70	2.05	2.47	2.77	3.69
28	1.70	2.05	2.47	2.76	3.67
29	1.70	2.05	2.46	2.76	3.66
30	1.70	2.04	2.46	2.75	3.65
40	1.68	2.02	2.42	2.70	3.55
60	1.67	2.00	2.39	2.66	3.46
120	1.66	1.98	2.36	2.62	3.37
	1.65	1.96	2.33	2.58	3.29

Reject H_0 if calculated value of t is **greater** than critical value at chosen significance level.

Appendix VII

Random Numbers from a Normal Distribution

1.54	-2.46	1.16	0.86	0.72	0.79	0.35	0.05	-0.08	-0.02
-0.45	-0.74	-0.87	3.15	-1.23	-1.52	2.35	2.31	-2.00	-2.28
1.52	1.48	-2.76	0.92	0.70	0.66	0.48	0.11	-0.10	-0.14
-0.32	-0.68	-0.89	3.02	-1.10	-1.46	2.31	2.18	-1.87	-2.23
1.48	1.35	-2.63	0.97	0.67	0.54	0.60	0.16	-0.14	-0.26
-0.20	-0.63	-0.92	-1.05	2.96	-1.41	-1.70	2.15	2.11	-2.18
-2.46	1.33	1.29	-2. 93	0. 73	0.51	0.48	0.30	-0.07	-0.29
-0.32	-0.50	-0.86	-1.07	2.82	-1.28	-1.64	2.12	1.99	-2.05
1.60	1.29	1.16	-2.80	0.78	0.48	0.35	0.42	-0.02	-0.32
-0.45	3.61	-0.81.	-1.10	-1.23	2.76	-1.59	-1.87	1.96	1.92
-2.35	1.36	1.14	1.10	-3.10	0.54	0.33	0.29	0.11	-0.26
-0.47	3.48	-0.68	-1.04	-1.25	2.63	-1.46	-1.82	1.93	1.79
-2.22	1.41	1.19	0.97	-2.98	0.59	0.30	0.17	0.23	-0.21
-0.50	-0.63	3.41	-1.00	-1.28	-1.41	2.56	-1.77	-2.05	1.77
1.73	-2.53	1.17	0.95	0.91	-3.28	0.36	0.14	0.10	-0.07
-0.44	-0.65	3.28	-0.86	-1.22	-1.43	2.43	-1.64	-1.99	1.74
1.60	-2.40	1.22	0.92	0.79	0.85	0.41	0.11	-0.02	0.05
-0.39	-0.68	-0.81	3.22	-1.18	-1.46	2.41	2.37	-1.95	-2.23
1.58	1.54	-2.70	0.98	0.76	0.72	0.54	0.17	-0.05	-0.08
-0.26	-0.62	-0.83	3.08	-1.04	-1.40	2.38	2.24	-1.81	-2.17
1.55	1.41	-2.57	1.03	0.73	0.60	0.66	0.22	-0.08	-0.20
-0.14	-0.57	-0.86	-0.99	3.02	-1.35	-1.64	2.21	2.18	-2.12
-2.40	1.39	1.35	-2.88	0.79	0.57	0.54	0.36	-0.01	-0.23
-0.27	-0.44	-0.80	-1.02	2.89	-1.22	-1.58	2.18	2.05	-1.99
-2.34	1.36	1.22	-2.75	0.84	0.54	0.41	0.48	0.04	-0.26
-0.39	3.68	-0.76	-1.05	-1.17	2.82	-1.53	-1.82	2.02	1.98
-2.30	1.42	1.20	1.16	-3.05	0.60	0.39	0.35	0.17	-0.20
-0.41	3.54	-0.62	-0.98	-1.20	2.69	-1.40	-1.76	1.99	1.86
-2.17	1.47	1.17	1.03	-2.92	0.65	0.36	0.23	0.29	-0.15
-0.44	-0.57	3.48	-0.94	-1.23	-1.35	2.63	-1.71	-1.99	1.83
1.79	-2.47	1.23	1.01	0.97	-3.22	0.42	0.20	0.16	-0.01
-0 38	-0.59	3.34	-0.80	-1.16	-1.37	2.50	-1.58	-1.94	1.80
1.66	-2.34	1.28	0.98	0.85	-3.09	0.47	0.17	0.04	0.11
-0.33	-0.62	-0.75	3.28	-1.12	-1.40	2.47	2.43	- 1.89	-2.17
1.64	1.60	- 2.65	1.04	0.82	0.78	0.61	0.23	0.02	- 0.02
-0.20	- 0.56	- 0.78	3.15	-0.98	- 1.34	2.44	2.30	- 1.76	-2.11
1.61	1.47	- 2.52	1.09	0.79	0.66	0.72	0.28	- 0.02	- 0.14
-0.08	- 0.52	- 0.81	- 0.93	3.08	- 1.30	- 1.58	2.28	2.24	-2.06
-2.35	1.45	1.41	-2.82	0.85	0.63	0.60	0.42	0.05	- 0.17
-0.21	- 0.38	- 0.75	- 0.96	2.95	-1.16	-1.52	2.25	2.11	- 1.93
-2.29	1.42	1.28	-2.69	0.90	0.60	0.47	0.54	0.10	- 0.20
-0.33	- 0.26	- 0.70	0.99	-1.11	2.89	-1.48	-1.76	2.08	2.05
-2.24	1.48	1.26	1.22	-2.99	0.66	0.45	0.41	0.23	-0.14
-0.35	3.61	- 0.56	- 0.93	-1.14	2.76	-1.34	- 1.70	2.05	1.92
-2.11	1.53	1.23	1.09	-2.86	0.71	0.42	0.29	0.35	-0.09
-0.38	-0.51	3.54	-0.88	-1.17	-1.29	2.69	-1.65	-1.94	1.89
1.85	-2.42	1.29	1.07	1.03	-3.16	0.48	0.26	0.22	0.05
-0.32	-0.54	3.41	-0.74	-1.11	-1.32	2.56	-1.52	-1.88	1.86
1.73	-2.29	1.34	1.04	0.91	-3.04	0.53	0.23	0.10	0.17
-0.27	-0.57	-0.69	3.34	-1.06	-1.35	-1.47	2.50	-1.83	-2.11

Appendix VIII

List of Trees in Mukogodo Forest

Masai Name	Botanical Name
Ol- Meideimei	Barleria grandicalyx
Olorpil Lo-munyi	Justicia odora
Eleishwa-Ekop	Aerva javanic
Ol-morijoi	Acakanthera longiflora
Ol-morigye	Acokanthera schimperi
Cesege	Cordia quarensis
Ol-sogoni	Warburgia salutaris
Ol-meraa	Catha edulis
Ol-donyananangui	Mystroxylon aethipicium
Ol-oiyabase	Aspilia pluviseta
Ol-makirikirenya	Gutenbergia fischeri
Ekum	Spilanthes mauritiana
Ol-kinye	Euclea divinorum
Ol-pogoni	Euphorbia candelbrum
Ol-Mame	Euphorbia cuneata
Enkushuri	Euphorbia uliligiana
Ol-osarie	Trimeria grandifolia
Ol-kijulira	Garcinia livingstoneri
Bennete	Cassia italica
Ol-Giringiri	Acacia brevispica
Oiti-pi	Acacia mellifern
Ol-Erbat	Acacia nilotica
Ol-munishuri	Acacia senegal
Ekirikitii or ol-Goroshe	Erythrina abyssinics
Ol-Oinini	Sida cuneifolia
Ol-Nyerima	Turrnea mombassana
Ol-oboni	Ficus capensis
Ol-segetit	Myrsine africana
Ol-sinoi	Lippia jaramica

Osgurtuti	Cissus fischeri
Kedong	Dracaena ellenbec-kiana
Engaidedeyai	Aneilema aequinoc-tiale
Embase Baba	Asparagus africanus
Ol-orien	olea africana
Emerio	Polyganum setosulum
Ol-Kokola	Rhamnus staddo
Ol- Kokola]	
Ol-Konyel]	Rhamnus prinoides
Ol-Konyol]	
Ole-Gerian]	
Ol-Orten]	Faurea saligna
Ol-Koijuk	Prunus africana
Olengeriaritus	Galium aparinoides
Gemnyet	Gardenia joris-tonantis
Ol-Orogilele	Oldentandia monanthus
Ol-Obai	paretta subcana
Olebarmonyo	Toddalia asiatica
Olebaromonyo	Zanthoxylum chalybeum
Lassessi	Osyris abyssinica
Ol-Kisigang	Pappea capensis
Othulelei	Solanum mauense
Ol-Subukiau	Dombeya goetzenii
Ol-Sitee	Grewica bicolor
Ol-Dule	Anthrisenssylvestris
Olabai-Oibor	Microglossa pyriofolia
Olamurunyai	Maytenus undata
Olairagai	Bridelia murantha
Ol-Airagai	Syzygium cordatum
Ol-Airai	Cissus rotundifolia
Ol-Airebirebi	Synthula polycephala
Olaiyenyishu-Elikidongo	Cyathula schimperana
Olaiyenyishu-Ngidongo	Cynthula cylindrica
Olairuwai	Bridelia microantha
Lugumeta	Macaranga Kilimand-scharica

Eletan	Fiens glumosa
Ingaloloi	Fiens sycomorus
Retegi	Ficus
Kwarabariet	Rapanea maleano-phloeos
Laikarai]	Syzygium guineense
Leperoi]	
Naisho-o-ntare	Boerhaavia diffusa
Modonkorit]	Ochna insculpta
Ikootum]	
Ichenimarn]	Stombogia scheffleri
Ichemikeri]	
Liliontai	Linociera Battiscombei
Lorien	Olea africana
Nkirenyi	Olinia rochetiana
Loirabirab	Portulaca foliosa
Loirabirab	Portulaca oleracea
Leshurshin	Talinum portulaci-folium
Naitasingisho]	Chematis brachiata
Nkolekole]	
Santaitii	Berchemia discolor
Barassinti	Canthium schimperanum
Lemojioi]	Canthium Setiflorum
Legarmon]	
Ntoriki	Rothmania
Sanakuri]	Uncarai africana
Loilalei]	

Ikirai	Teclea simplicifolia
Ikirai	Vepris eugeniiifolio
Loisuki	Zathorxylum calybeum
Losesiai	Osyris abyssinica
Litegomi	Cardiospermum-corindum
Imurguti	hapocoelum foliolosum
Nkilejo	Aningevia adolfi-friendericí
Nchogis	Mamilkana discolor
Kenyora	Ghikaena speciosa
Shikawai	Solanum arundo
Mpatapata	Solanum hastifolium
Ikarasha	Sterculia stenocarpa
Idule	Torilis arvensis
Naigorr-o-losowan	Girarchnia condensata
Lnegr	Panzo parasitics