Land Use and Land Use Change Impacts within Protected Areas and Adjacent Regions of the NE Mount Kenya

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Abstract

NE Mount Kenya is characterised by dense population and small scale farming is the main form of land use. In the region, continual pressure on the forest resources as result of land use is a continuing problem. The NE Mount Kenya Forest Reserves (Imenti Forest Reserve, Mount Kenya Forest Reserve) play an important role in the livelihood of the neighbouring communities. However population pressure, reserve management policies, economic changes, an ineffective land tenure system and poverty are socio-economic factors contributing to land use changes and an intensification of agriculture. Illegal factors like clearing forest vegetation for firewood and grazing areas, at the expense of the protected forest areas, are present.

This study focuses on an interdisplinary approach to analyse socio-economic and ecological factors in NE Mount Kenya relevant to land degradation. This includes remote sensing data (interpretation of satellite images Landsat TM 1987 and ETM 2000) combined with interviews from the land user's perspective. Ethnographic research of this type on this topic has not been done in the region before. This entailed applying both a qualitative (giving farmers the opportunity to identify factors they perceived as important in regard to land use) and a quantitative method of data analysis.

The Mount Kenya Forest region is distinguished by high elevation and a humid to sub-humid climate, while the Imenti Forest region lies lower and is characterised by semi-humid and transitional zones. Land use in the Mount Kenya Forest region is mainly perennial thus eliminating seasonal land use changes. In the Imenti Forest region, 30% of the farmers said they had gone through major land use changes within the last 20 years. The major land use change consisted of a shift from residential farming in the protected areas which offered more farming and grazing areas, to being restricted to individual farm plots which consequently led to the intensification of cultivation thus contributing to land degradation. The satellite images in the same region show a clear decrease in coverage of forest vegetation and an increase in open areas in the Imenti Forest region which the farmers explain influences the tentative land use changes in the region. On the other hand, in the Mount Kenya forest region, there has been an increase in forest vegetation cover which is also evident in the satellite images. Areas that were plantation and cultivated regions in 1987 have forest cover in 2000, which the farmers stated was as a result of their afforestation initiatives.

Nevertheless, indicators of degradation e.g. rill and gully erosion are evident and correlated to the intensified land use in both forest regions. The population impact in the region apparently intensifies land use therefore the identified socio-economic factors in the region should be given priority in integrating development projects that are directly beneficial to park-adjacent communities according to the needs of the particular agro-ecological zone (AEZ). Location specific research can better enhance the understanding of the socio-economic factors influencing land use change. Furthermore, promoting alternative income generating activities, besides the present livestock and crop farming, can help reduce the risks of land degradation.

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Acronyms and Abbreviations

AEZ	Agro-ecological zone
ASAL	Arid and Semi arid Land(s)
DFO	District Forest Officer
ETM	Enhanced Thematic Mapper
FAO	Food and Agriculture Organization (UN)
FD	Forest Department
GEF	Global Environmental Facility
GHG	Greenhouse Gases
GIS	Geographic Information System
GOK	Government of Kenya
GTZ	Gesellschaft für Technische Zusammenarbeit
HADO	Hifadhi Ardhi Dodoma
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
ITCZ	Inter-tropical Convergence Zone
IUCN	The World Conservation Union
JICA	Japan International Cooperation Agency
KARI	Kenya Agricultural Research Institute
KIFCON	Kenya Indigenous Forest Conservation Programme
KSS	Kenya Soil Survey
Ksh	Kenya Shilling (2006 exchange rate: 1€ = approximately 100Ksh)
MEA	Millennium Ecosystem Assessment
MW	Megawatt
KWS	Kenya Wildlife Service
NE	North East
NEMA	National Environment Management Authority
NCA	Ngorongoro Conservation Area
NGO	Non-governmental Organization
NRC	Non-Residential Cultivation
ROK	Republic of Kenya
SRTM	Shuttle Radar Topography Mission
TM	Thematic Mapper (Landsat)
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCED	World Commission on Environment and Development
WCPA	World Commission on Protected Areas

1 Introduction

1.1 Background and Context

Kenya is particularly concerned about the destruction of forests because over 80% of the fuel used in the country is wood-based, resulting in the high rate of destruction of forests. In many forests destruction is due to grazing animals. Only 2% of Kenya's land is forested, and an average of 5,000 ha of forests is lost every year. In the last decade alone, Kenya has lost 12% of its forests (WASS 1995, UNDP and GEF 2002). Land degradation is an ecological characteristic that affects the socio-economics and livelihoods in a given region. The ultimate cause of habitat loss in Africa is human population growth, and the resulting demand for space, food, fuel and other resources as well as widespread poverty, a dependence on natural resources, and economic pressures to increase exports, particularly of agricultural produce, timber and mineral products (DAHLBERG 1994), (MWICHABE 2002, STOCKING 2000, BIOT et al. 1992). A lack of awareness of the value of wild biological resources, and failure to enforce conservation policies have also contributed to the decline in areas of natural habitat (UNEP 2002:56).

Land is the most important resource Kenya has for generating economic resources. Out of the 582,636 km², only 17% is suitable for agriculture without irrigation; 2.2% of the 17% is covered by forest reserves. Arid and semi-arid lands (ASALs) covered by grassland and savannah rangelands account for the remaining 83% of the land. The rangelands are homeland to 85% of Kenya's wildlife and are inhabited by about 14 million people, who practise dry-land farming and pastoralism (MWICHABE 2002:3).

Kenya has been recognised as a country that has one of the world's highest population growth rates, which has been at an average of 2.4% per annum (WAMUKOYA et al. 2002, ROK 1999). This phenomenon can result in the deterioration in public services, whereby a government is no longer in a position to provide acceptable living standards.

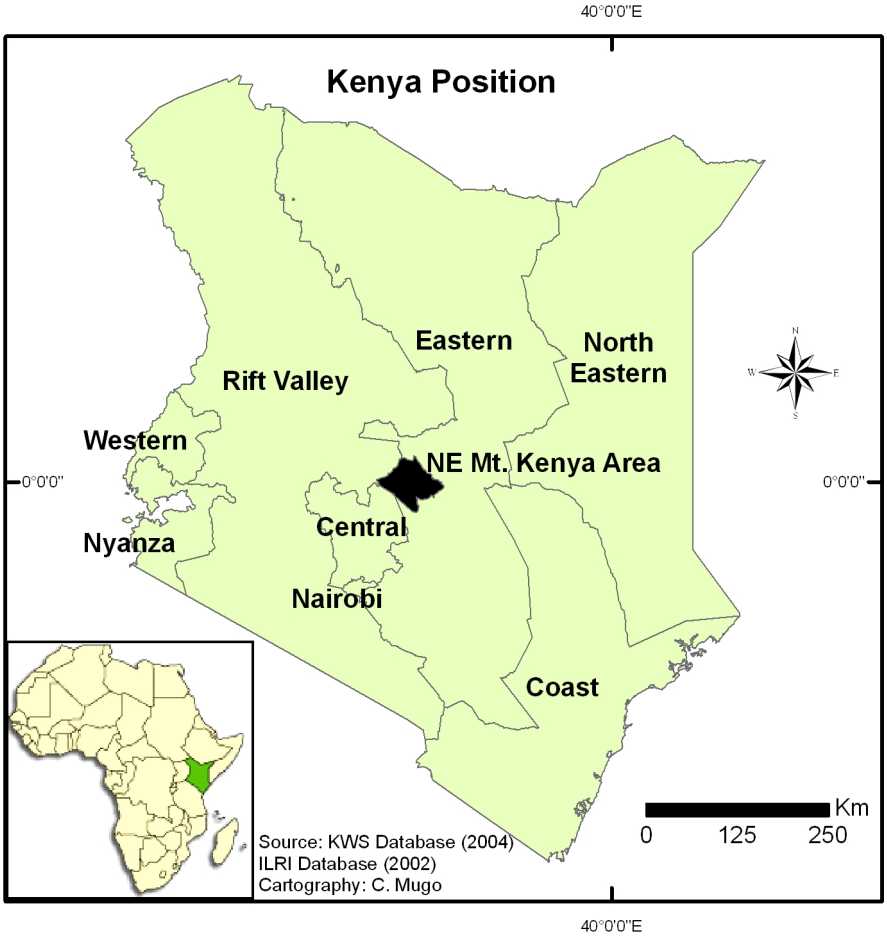


Figure 1: Kenya Position

Kenya lies in East Africa and borders Tanzania southwards, Somalia in the east, Uganda in the west, Ethiopia and Sudan in the south, and the Indian Ocean in the south east. It is divided into nine administrative provinces namely Western, Nyanza, Rift Valley, Central, Eastern, Nairobi, North Eastern and Coast Province.

1.1.1 Land use change and Land degradation

Land degradation has been defined by JOHNSON and LEWIS (1995:2) as the substantial decrease in an area's biological productivity and/or usefulness due to human interference. Land use changes on the other hand are response indicators, reflecting how and to what extent society is responding to meet its changing needs and goals or to adapt to changing environmental conditions (BRINKMANN 1998:95). These two terms are discussed in details in chapter 3. Negative impacts of land use and land use changes are a growing issue of importance all over Africa. The demands of the growing population who are

directly dependent on subsistence farming or pastoralism for their livelihood have a severe impact on the available resources. Many of Eastern Africa's biological resources are used for agriculture, pharmaceuticals, construction, clothing and ornamental products and have a high national and global economic value (UNEP 2002). Natural habitats in Eastern Africa are however under threat from a rapidly increasing human population and from the accompanying demands for space, agricultural produce and economic gains from commercial and industrial exploitation (UNEP 2002). Indeed, even the better soils of many parts of developing regions are gradually becoming less productive; some fertility declines affect the very areas which call for urgent and sharp increases in production (UNPOPIN et al. 1995).

The World Atlas of Desertification, (UNEP and GEF 2002) and others (BRYAN 1994, MWICHABE 2002,) have identified the majority of land in Kenya as very degraded. Declining soil fertility is a serious concern in Kenya. This is because for most cereal and legume crops grown in the country, nutrients removed in the harvest are not returned to the fields (FAO 2004). Also, soil erosion resulting from deforestation and inappropriate agricultural practices on fragile soils and sloping lands reduces agricultural productivity by 2% per year (IFAD 2002). Fragile soils are subject to degradation, due to the loss of soil nutrients and also due to the gradual wearing away of the soil.

1.1.2 Significance of the NE Mount Kenya area

The NE Mount Kenya area lies in the Eastern province of Kenya and has become an area of interest due to the vast destruction of protected forest areas that the region has been facing (GATHAARA 1999, VANLEEUWE et al.2003). Moreover, in 1997 part of the forest area was internationally recognized as one of the most impressive landscapes of East Africa, and therefore made a World Heritage Site (GAATHARA 1999). The NE Mount Kenya study area also has great potential for agriculture, and is consequently densely populated. The area is characterized by fertile reddish brown loam soils (NEMA 2004, SPECK 1987) and small-scale farming is the main form of land use in the region. Cash crop farming is however also present.

The area also consists of protected indigenous forests as well as cultivated forests (AYIEMBA, 1990, EMERTON, 1997, SPECK, 1987). The protected forest regions of

Mount Kenya in the study area (figure 2.) include the Mount Kenya Forest and the Upper and Lower Imenti Forests.

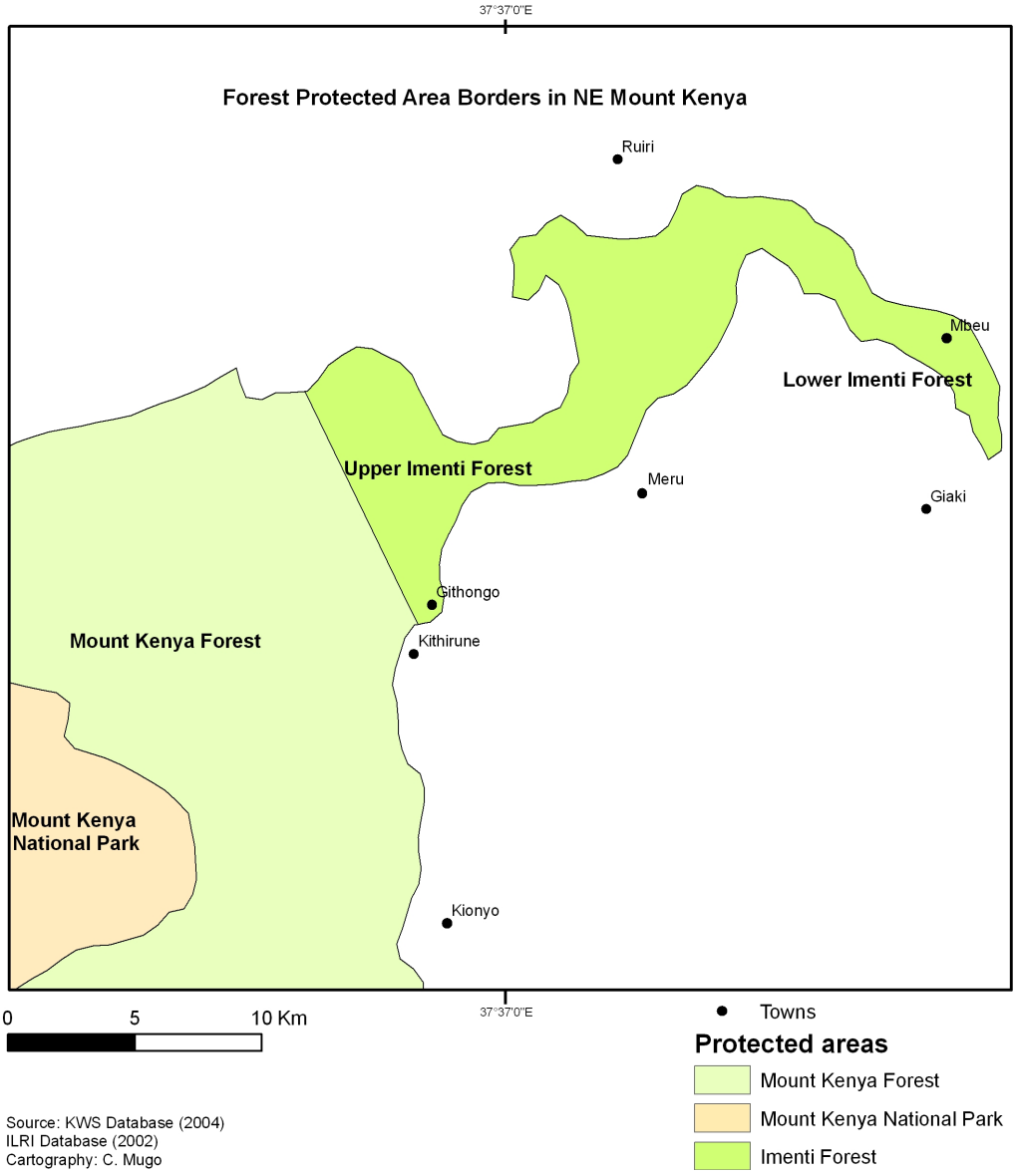


Figure 2: NE Mount Kenya Forest borders

The Mount Kenya Forest Reserve covers an area of approximately 182,000 hectares, out of which 9,665 ha is plantation, and 172,000 ha is indigenous forest (MANEGENE et al. 1996). The forest trees provide firewood and raw material for the adjacent farming communities. The forest also provides an important location for religious and other cultural practices of the communities living around the forest (WASS 1995).

The protected areas are not only an asset to adjacent communities, but also to the nation as a whole by conserving biological diversity and water, and by providing a habitat for wildlife. The mountain, (Mount Kenya) is the source of the country's major rivers, including the Tana River, which is Kenya's largest river and has tributaries within the NE research area. The hydro-electric dams on the Tana provide a large proportion of the country's energy (GATHAARA 1999).

According to the Millennium Ecosystem Assessment (MEA), services and goods provided by protected areas have been divided into four categories, all of which are fulfilled by the NE Mount Kenya Forest Reserves, both at the national and the regional levels. They are:

1. Provisions: these include natural products such as food, fresh water and herbal medicines that have direct use and value to rural communities.
2. Regulating services: these are benefits from the ecosystem such climate regulation and carbon sequestration from the forests.
3. Cultural benefits: for instance religious values, tourism, education and cultural heritage.
4. Supporting services: soil formation, nutrient cycling and primary forest production (SCHERL 2004).

The NE Mount Kenya region has significant land use potential, especially with valuable protected areas. This leaves it vulnerable to intensified land use changes in the region that could occur from factors like the over-utilization of farm land, overgrazing, and forest clearing that may lead to land degradation. However, although the pace and magnitude of the impacts of land use change can largely be associated with population growth, these impacts depend a lot on the perceptions of the communities. Changing land use can occur as a result of legitimate social needs. Most land use changes are made in order to improve lives, to re-establish food security and to fulfil the needs of a growing population.

Unfortunately, impacts of land use changes are felt only after widespread destruction has already taken place. It is thus necessary to document significant changes in site-specific areas where these changes are occurring in good time to regulate and explain to communities any land use changes. Community participation is vital for effective and successful management strategies within protected areas. It is important to appropriately plan and manage natural resources by adopting approaches that provide the most

favourable forms of land use and thus obviate the negative impacts of land degradation. Protecting ecosystems is an essential procedure that can be used to promote better use of land both in the present and future.

1.2 Structure of thesis

In chapter one, the problem in the research area is defined, and the research objectives are stated.

Chapter two presents a comprehensive geographical introduction of the study area.

Chapter three summarises the studies of the mountain region and context of the protected areas in the Mount Kenya region. The emerging research methods and socio-economic approaches relevant to the issues of land use, land use change impacts in specific regions in Eastern Africa are evaluated.

Chapter four illustrates the methods applied to carry out the research. The approach which involved the collection of empirical data by obtaining the perceptions of the local community farmers living adjacent to the protected areas is explained. This procedure explored land use and land use changes impacts both within the farms and in the protected areas in the past two decades. The spatial analysis tool GIS displays geographically-referenced socio-economic data. An unsupervised classification of satellite images through the mapping of changes in vegetation cover, plantation, open areas and settlement areas is interpreted.

Chapter five presents factors of land use and land use change impacts on a regional analysis. This includes a historical review of the protected ecosystems in the study area which helps integrate the past and present history of land use to-date. Case studies present examples of land use in the Mount Kenya region and the Imenti Forest region. The structures of the farming system, as well as the socio-economic factors that influence land use and land use changes are presented. The impacts of population growth, climate and agricultural changes are represented in relation to land use in the study area. The interview and field survey results are presented and the discussion of results and perspectives conclude the chapter.

The final chapter draws the conclusion of the research.

1.3 Problem statement

(JOHNSON and LEWIS 1995:2) have stressed the substantial decrease in "usefulness" (biological productivity) due to human interference as a crucial factor of land degradation. When land is degraded and agriculture is the key to income, the impact becomes even greater due to the intensification of land use. Causes of land degradation are largely anthropogenic such as deforestation, intensified farming methods as a result of growing population dynamics which leads to the loss of ecological equilibrium.

In addition, (WMO 2005, and UNEP and GEF 2002) include natural elements such as water and wind thus defining land degradation as the reduction of resource potential by one or a combination of processes acting on the environment. The processes comprise of soil erosion by wind and/or water, deterioration of the physical, chemical and biological or economic properties of soil, and long-term loss of natural vegetation. (MABUTT (1986) cited in DAHLBERG 1994:13) agrees that it has been convincingly argued that the effects of degradation must be seen in a broader context, constituting a complex phenomenon embracing physical and biological aspects including the human and the social.

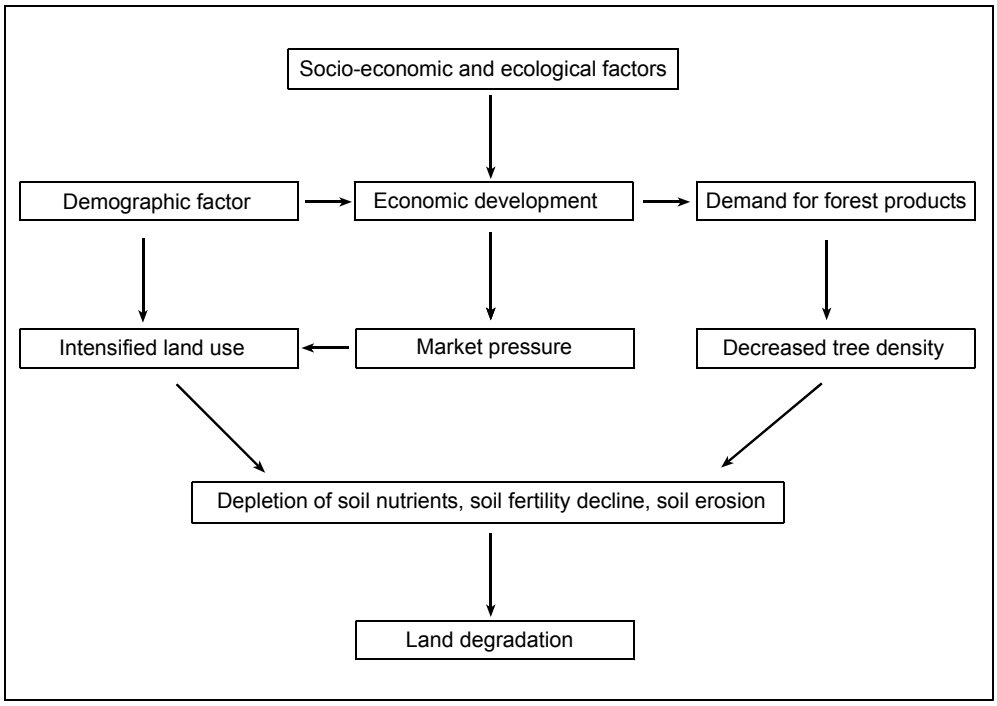


Figure 3: Impacts of land use change

Socio-economic and ecological factors including demographic factors, economic development and market pressure lead to a demand of forest products which decreases tree density and then leads to the depletion of soil nutrients and soil erosion, thus degrading the land.

As Figure 3 implies, it is both relevant and important to investigate connections among the various socio-economic elements that are related to land use change. Unfortunately, social and economic indicators have been considered complex and indirect and therefore avoided in research projects (DAHLBERG 1994:13). Socio-economic pressure on the land, which largely consists of increased demographic factors, destroys the land potential, especially through intensified agricultural production due to the demand for basic necessities such as food. Declined soil fertility, a depletion of soil nutrients, and soil erosion, consequently affects the productivity of land. Economic development can create degradation threats to the protected areas by forest-dependent communities with their needs for firewood and grazing areas in the forests.

1.3.1 The socio-economic factors

The rapid growth of the human population in Kenya and the consequent demand for basic needs, especially food, shelter, clothing, health and related services, has exerted tremendous pressure on natural resources, particularly land (MWICHABE 2002). Kenya has more than tripled its population from only 9 million at independence in 1964 (BHUSHAN 2000, ROK 2002a), to an estimated 33.6 million now (CBS 2005). Over three-quarters of the population depend on agriculture for their survival and livelihoods (IFAD 2002). As a result of the growing population, the poor communities continue to rely on natural resources and agriculture for most of their income. There are limited opportunities to earn a sustainable income, thus leaving the region highly vulnerable to the adverse impacts of environmental degradation (UNEPa, 2002).

Meru District, situated in the NE Mount Kenya study area, is one of the most densely populated regions in the country reaching a population density in a particular region of 1306 persons/km² (ROK 2002, ILRI 2004). Accordingly, the issue that seems to now have a larger impact on the environment is a change in the traditional land use practices by the expanding population with major issues of concern being land scarcity, due to the sequential fragmentation of land.

Population pressure on this high-potential region in Kenya continues to be one of the major factors leading to land use change. With growth in population, issues like the systematic conversion of forest areas into other forms of land use, particularly

agricultural production and human settlements and the seemingly insatiable demand for firewood for rural and low-income urban households can arise (KAMERI-MBOTE 2002). Other land use changes may include overgrazing, poor agricultural farming methods, and the change from traditional land use methods. Also, shifts from farming to livestock keeping, coupled with the intensified cultivation of crops, occur to meet the income requirements (GATHAARA 1999).

It is however difficult to comprehend these situations where the local authorities have been unable to address the ever-increasing demands made on them by the swelling populations due to budgetary and manpower constraints. In Kenya, the local authorities are barely able to even provide for their recurrent expenditure; hence environmental problems hardly get addressed, as noted by the Ministry of Environmental Conservation in the Republic (ROK 1999:79). Land use changes take place even in regions where agroecosystems expand within or near protected areas. In the process, there has been destruction of biodiversity in the protected areas. Illegal activities like logging, grazing, cultivation of marijuana, and the encroachment into forest regions for cultivation purposes that supposedly emanated from the non-resident cultivation practices, have been identified in the Mount Kenya area (GATHAARA 1999, VANLEEUWE et al. 2003, KOHLER 1986).

1.3.2 The ecological factors

In East Africa, throughout the 1980s forest departments were given low priority, resulting in weak or outdated policies, laws and regulations governing forest management. For instance in Mt. Elgon National Park, on the Uganda border with Kenya, agricultural encroachment in the 1970s and 1980s stripped more than 25,000 ha of virgin forest (TAMAL et al.1998). Furthermore, in the Mount Kenya region, between 1995 and 2000, the whole of the indigenous forest in the Imenti Forest Reserve on the slopes of Mount Kenya was illegally converted into cropland (VANLEEUWE et al. 2003).

Kenya has a limited area of gazetted forest land and approximately 240,000 ha will be lost in the next twenty five years (KEFRI 2002). The impacts of deforestation and degradation of wooded areas include increased likelihood of soil erosion and loss of soil

fertility, alteration of local climatic and hydrological conditions and changes in biodiversity (UNEP 2002, KEFRI 2002, WASS 1995).

Mountain and highland ecosystems in the NE Mount Kenya influence climate and are the main water catchment zones. Interference with these ecosystems can have negative impacts on land productivity, water quality, and biodiversity causing some species to be threatened or extinct. The loss of vegetation cover increases runoff and soil erosion, which again affects biodiversity (GACHENE et al.2003).

Farmlands adjacent to protected areas which are considered "delicate areas" can be difficult to manage, especially when owners have a vested interest and can determine the use of their own land, which may intensify degradation. The conversion of natural habitats, such as forests or wetland, for agriculture and cultivation has not only contributed to land degradation, but has also impacted on people's livelihood options (UNEP 2000).

The absence of research on land use in the NE Mount Kenya area and the protected areas consequently leads to poor management. This factor is especially noteworthy when utilization of the protected areas is permitted by the neighbouring communities. Furthermore, a rehabilitation plan for degraded areas within protected regions has not been well established as the government has not perceived the seriousness of the rising social and ecological problem.

1.4 Research objectives

Land use change impacts may take place as a result of the interaction of both natural and socio-economic forces on the environment. It is thus paramount to integrate both factors for research findings. The objectives of this research are to identify and clarify the linked forces (socio-economic and ecological) of present land use and land use changes that have contributed to land degradation in the NE Mount Kenya region within the past two decades. This approach leads to the implementation of action programs that prevent degradation in a well planned foreseeable period.

The main aspects to be dealt with are:

How have land use changes impacted on land degradation in the NE Mount Kenya area? What are the indicators of land degradation?

What are the farmers' perceptions of the impacts of land use and land use change and degradation on their farms and in the protected areas?

What socio-economic factors influence land use change impacts in the region?

An interdisciplinary approach including the combination of spatial images and interviews from a land-user perspective (ethnographic research) that have not been done before will be used to document the empirical quantitative and qualitative perceptions of farmers that further clarify factors pertaining to land use and land use changes in the protected regions and adjacent areas. Relevant factors of land degradation in the protected regions will be obtained from the farmers by collecting data on the significance of the neighbouring protected areas from local populations.

A better understanding of the land use changes can be obtained through considering the actions of the community and the surroundings, which ultimately bring about the land use changes. This will also help establish an interface between the land users' knowledge and scientific facts by quantifying the value of the neighbouring protected areas and by determining the community perceptions and the course of actions that they take in regards to land degradation.

An assessment of changes in forest cover and anthropological impacts will be explored in the Mount Kenya Forest Reserve and Imenti Forest Reserve protected areas to emphasize land degradation impacts in specific areas of the ecosystems. Both natural and human impacts will be explored in the Mount Kenya Forest Reserve and Imenti Forest Reserve protected areas to highlight the impacts of land degradation in these ecosystems.

The land degradation indicators in this study include the field observation indicators aligned with the socio-economic and vegetation indicators as exemplified in UNEP (1997) according to the National land degradation assessment and mapping in Kenya to examine the impacts of land use change in the land users' immediate surroundings.

2 Study Area

2.1 Geographical and administrative borders of the NE Mount Kenya

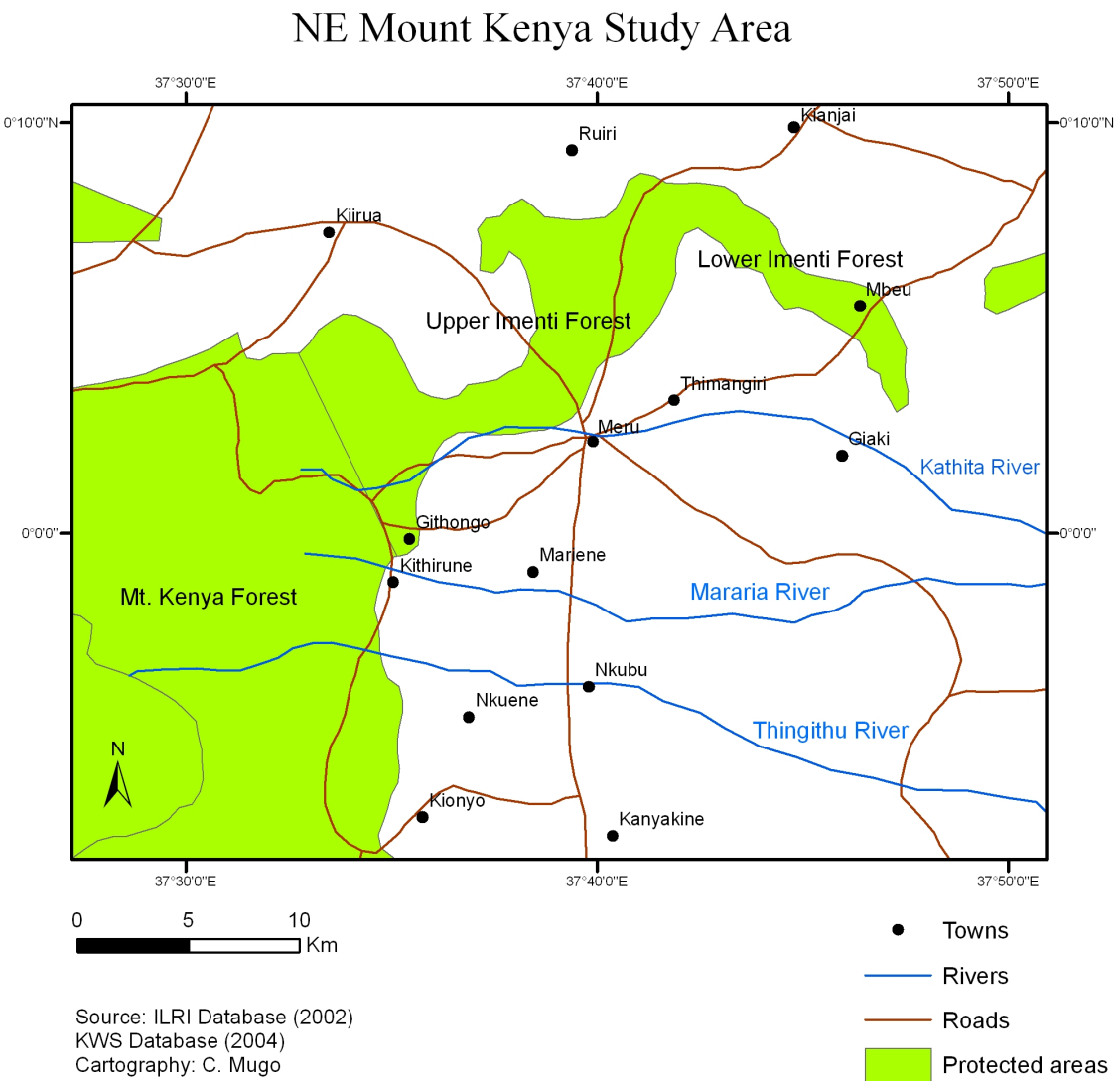


Figure 4: Map of study area

The NE Mount Kenya area lies about 250 km north of the capital city Nairobi between 0° 08' South and 0° 10'north latitude and 37°30' to 37°47' East (refer to figure 4). The study area is located in the Eastern province of Kenya, mainly in the Meru central District and a very minor portion of the study area is found in the Meru North District, Uringu division. In accordance, the larger part of information, statistics and attention in this study is based on the central District. Both Districts occupy approximately a total

area of 6924 km². Meru central District, including the forests occupy 2982 km² (ROK 2001a).

About one third of the Meru Central District is gazetted forest reserve, which covers 952 km² (NEMA 2005a). Meru has undergone major changes in its administrative divisions. In 1918, the two Districts in the study area was one i.e. Meru District (OJANY and OGANDO 1973). Between 1995 and 1997, the Meru District was further divided into Meru Central, Meru North, Tharaka, and Meru South (ROK 2004:24). Today, Meru Central District shares borders with Laikipia to the North West, Tharaka to the south east, Meru south and Embu to the south, Kirinyaga and Nyeri south west, and Isiolo to the North (Figure 5) There are ten administrative divisions within the Meru Central District zone, and eight of them lie within the study area. They consist of the Abothuguchi West, Abothuguchi East, Abothuguchi Central, Nkuene, Abogeta, Mirigamieru East, Mirigamieru West and Buuri (ROK 2001a). Uringu division is part of Meru north which forms part of the borders in the study area.

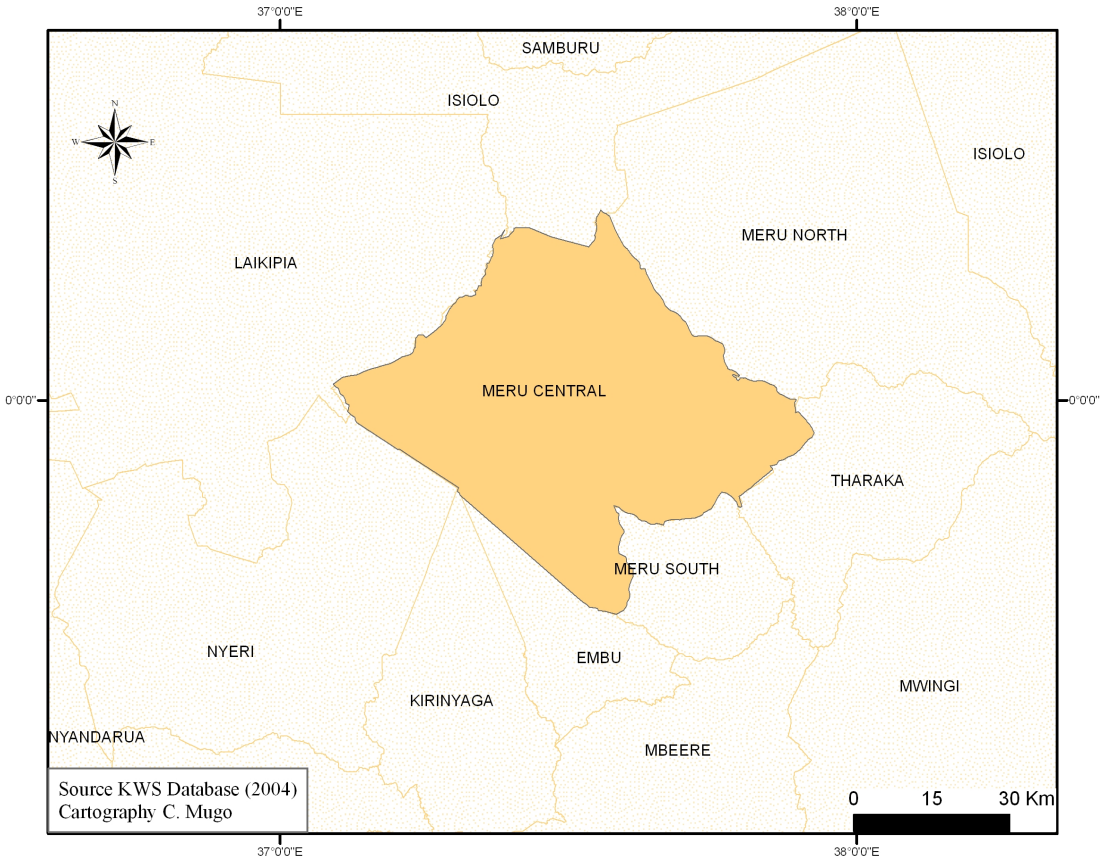


Figure 5: Meru central administrative borders

Dominant physical features that border the study area include the Mount Kenya which is Africa's second highest mountain was formed by a series of volcanic eruptions and is the major physical dominant feature within the region. The twin peak area of the mountain Batian (5199m) and Nelion (5188m) represent the plug of the extinct volcano, the present day summit of which is probably below the crater wall (MAHANEY 1990:14).

Besides the Mount Kenya, the Nyambene Ranges are located in the far north Eastern part of the study area. The Nyambeni Hills are composed of numerous volcanic centres with an irregular crestline of about 1,800m asl, which rises to a maximum of 2,513m asl. The Mount Kenya Forest Reserve has a total of 199,500 ha together with the adjoining Imenti Forest. The Mount Kenya Forest Reserve lies on the Eastern part of the study area, while the Imenti Forest Reserve lies on the Western side of the study area (see figure 4).

The Imenti Forest Reserve is split into two sections by the Meru – Nanyuki highway that runs through it. This creates the Upper Imenti Forest 10,388.3 ha and the Lower Imenti 2,462.1 ha forest reserve (WASS 1995). When combined with the protected areas of Mt. Kenya National Park and the adjacent gazetted forests of Lower and Upper Imenti and the Thunguru Hill, the Mount Kenya Forest Reserve has an effective area of 213,000 ha WASS 1995:14). The Mount Kenya region lies on the Eastern part of the study area, while the Imenti Forest Reserve lies on the Western side of the study area. In December 1999, the government changed the status of the entire mountain forest belt and the area was officially gazetted as Mt. Kenya National Reserve so as to provide enhanced conservation, where management was also shifted from the forest department (FD), to the KWS (VANLEEUWE 2003). The two forest reserves in the study area are collectively known as the Mount Kenya Forests.

Culturally, both the mountain and the forests in the study area have religious and spiritual significance to the local tribes that inhabit the area. In accordance, the Mount Kenya is regarded as a holy mountain by all the communities (Kikuyu, Meru and Embu) living adjacent to it (KWS 1996).

The Meru tribe of Kenya inhabit the region in the study area, and their history can be traced from Egypt where the Meru leaders believed to have originated from. They later migrated through the Congo basin into Eastern Africa to this area they have now settled (BERNARDI 1989, WANGARI 1995).

2.2 Climate

Mount Kenya

The Mount Kenya region has been classified by (OJANY and OGANDO 1973:68) as a "modified tropical climate of the Kenya highlands" because of its high and varied relief. Since the resulting climate is much cooler than a tropical continental climate, it is described as a "highland subtropical climate." Mountain regions tend to influence climate in their surrounding areas. Mountains compel more air to rise which then assists in the development of clouds and precipitation, leading to a wetter climate (WMO 2005). The altitudes of the Mount Kenya and the Nyambeni ranges contribute to the diversity of climate, which then gives way to the different ecological zones in the region. The altitude in the study area ranges from 2200m asl westwards in the mountain slopes, to about 600m asl east, thus being a determining factor in the atmospheric changes from one specific region to the other. In the higher altitude zone, which is around the Mount Kenya Forest Reserve, the temperatures gradually decrease towards the mountain, which then means that the evaporation rate is low.

Imenti Forest Reserve

In the Imenti Forest Reserve area, temperatures become higher in the direction of the lowlands. Due to the country's equatorial position, the seasonal variation in temperature is minimal, not usually averaging more than 5°C, which is less than the diurnal variation (MORGAN 1973). Average temperature in Meru is 18.45°C and the highest temperature in February being 24.5°C, and the lowest temperature in July being 12.4°C. In Meru North, the annual temperatures range from 24.7°C to 13.7°C. However, as altitude decreases the temperatures also rise in the neighbouring District towards the Eastern regions of the study area at the border with Tharaka, Meru National Park and north of Tigania townships at the border with Isiolo. These areas have a relatively flat terrain and a mean annual temperature of 32°C (NEMA 2004).

Rainfall and temperature

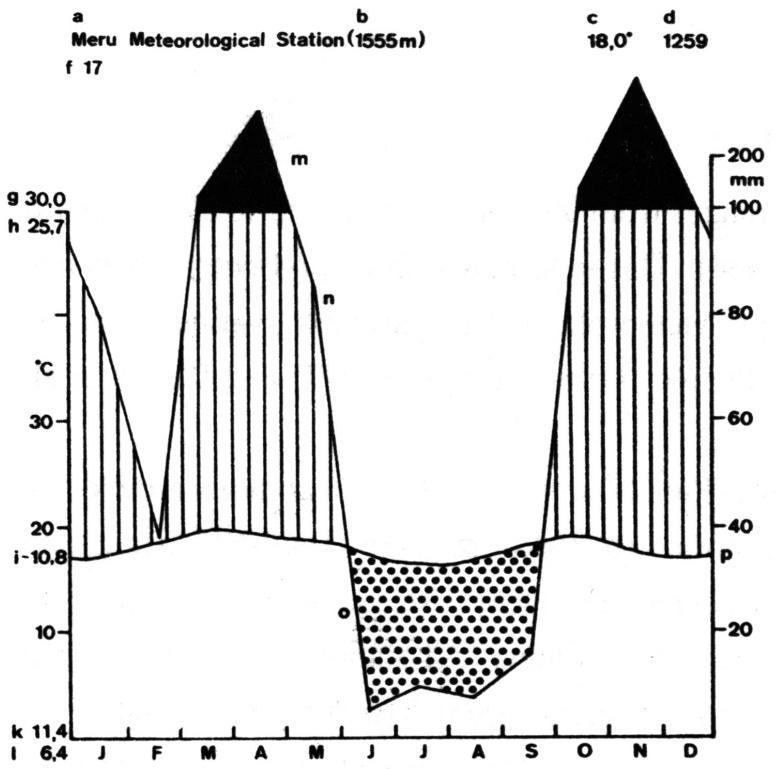


Figure 6: Meru Climate

a: name of the station, b: altitude, c: mean annual temperature, d: mean annual rainfall, f: number of years during which each complete observations were made, g: absolute maximum temperature, h: mean maximum of warmest month, i: mean daily temperature range, k: mean minimum of coldest month, l: absolute minimum temperature, m: rainfall values above 100mm in scale 1:10, n: normal rainfall values, o: arid seasons.
Source: BUSSMANN (1994:18)

The study area experiences a bi-modal distribution of rainfall and has maxima in the periods of March to May, and October to December. These two wet seasons are commonly known as the "long rains" and "short rains" respectively. They occur during the time of year when the Inter-tropical Convergence Zone (ITCZ) has maximum influences over most of East Africa, during which wind from the subtropical zones in the Northern and Southern Hemispheres converge. When the south east trade winds from the Indian Ocean, cross the equator, the air stream becomes the south-east monsoon, and because of the crossing of the vast body of water, they are main responsible source for the rains in Kenya (see OJANY and OGANDO (1973). There is a clearly defined dry period from July to September, where the temperature range remains constant throughout (See figure 6).

According to Ogallo, the Meru area (Compared to Nyeri, Embu, and Nanyuki weather stations) receives the highest rainfall around the Mount Kenya region in both rainy seasons. However, the months between July and September, receive below 50mm annually (see OGALLO 1990:137). Rainfall in Meru is therefore relatively high compared to other neighbouring towns in the country due to its elevation. A historical annual rainfall in 720 months between 1910 and 1973 derived from GHCN 1, (The Global Historical Climatology Network, Version 1) confirms a mean annual rainfall of 1368.8mm, (WORLD CLIMATE 2006) the figures remained constantly in the same range also between 1987 and 1995 (figure 7).

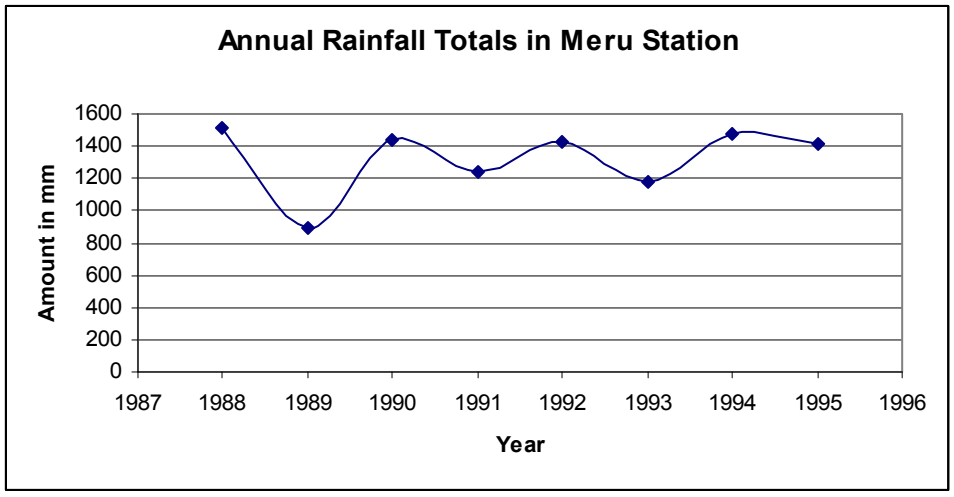


Figure 7: Meru total annual rainfall
Source: WORLD CLIMATE (2006) ROK (2004) (Modified)

The average rainfall in Meru for the long rains is 385,4mm and for the short rains 760,8mm (NEMA 2004), while rainfall ranges from 1,250mm to 2,500mm in the south Eastern slopes of the mountain. The lowlands in Meru North District receive low rainfall as they are on the leeward side of the Nyambeni ranges whereby rainfall ranges from 380 mm to 1,000 mm annually.

Meteorological data from Meru weather station 2003 show that rainfall in March 2003 was 117% of its seasonal long term mean (LTM). In the same year, rainfall in April was considered a lot in the Meru area with 453.2mm which is 186% of it long term mean (ROK 2003a). Moisture evaporates from the forest canopy in the dry season, thereby giving the area (in addition to local vicinity) a milder climate, with more clouds and obscure precipitation (BEENTJE 1990).

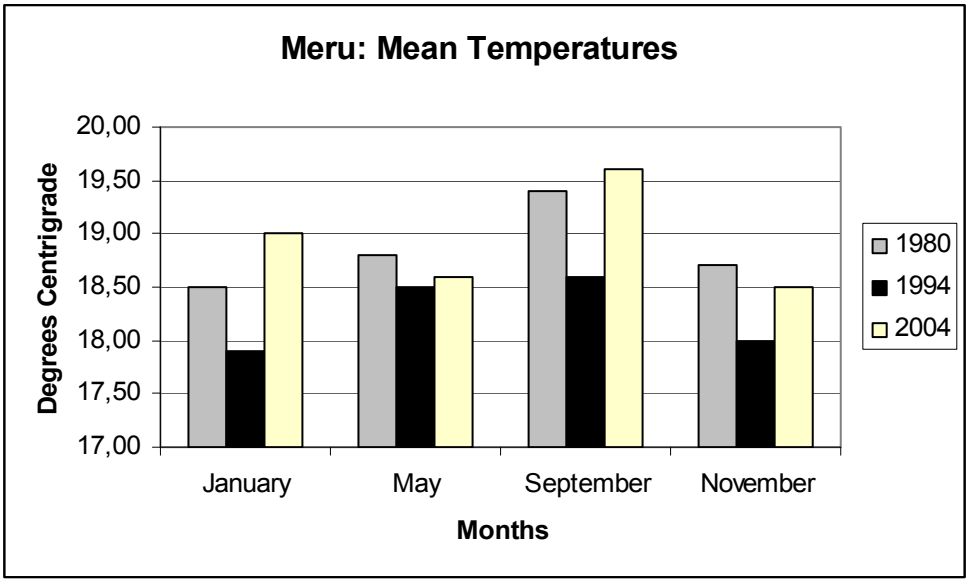


Figure 8: Meru Temperature
Source: TUTIEMPO 2004 (modified)

From a historical weather presentation of Meru from TUTIEMPO (2004) where daily temperatures are recorded to acquire the mean temperature of the month, the years 1980, 1994, and 2000 have been taken into consideration (figure 8). The statistics show that mean temperature for the months of January 1994 was 17.9°C. During the rainy season in May, the mean temperature of the same month was 18.5°C, while in September of the same year, the temperature was 18.6°C, and 18°C in November. Thus the seasonal temperature changes within Meru remain constant and changes in temperature throughout the year are very minimal. Noteworthy is that the temperatures have however increased in all the represented months, especially in the dry months, i.e. January and September since 1994 both by about 1°C, although they had fallen in all the represented months from the 1980 temperatures.

In the study area, the trade winds blow from the northeast and from the southeast and when they meet near the equator the air mass rises. The highlands lessen the effect of high temperatures and also the rate of evaporation so that when this rising air cools, clouds and rain develop and consequently rainy weather conditions occur. The position of the highlands also force rain bearing winds to deposit most of the moisture on the windward side east of Mount Kenya and south of Nyambeni, leaving the leeward sides of both massifs in the rain shadow area and the low lying areas with less rainfall. These areas therefore offer lesser potential for agriculture without irrigation.

2.3 Drainage and Topography

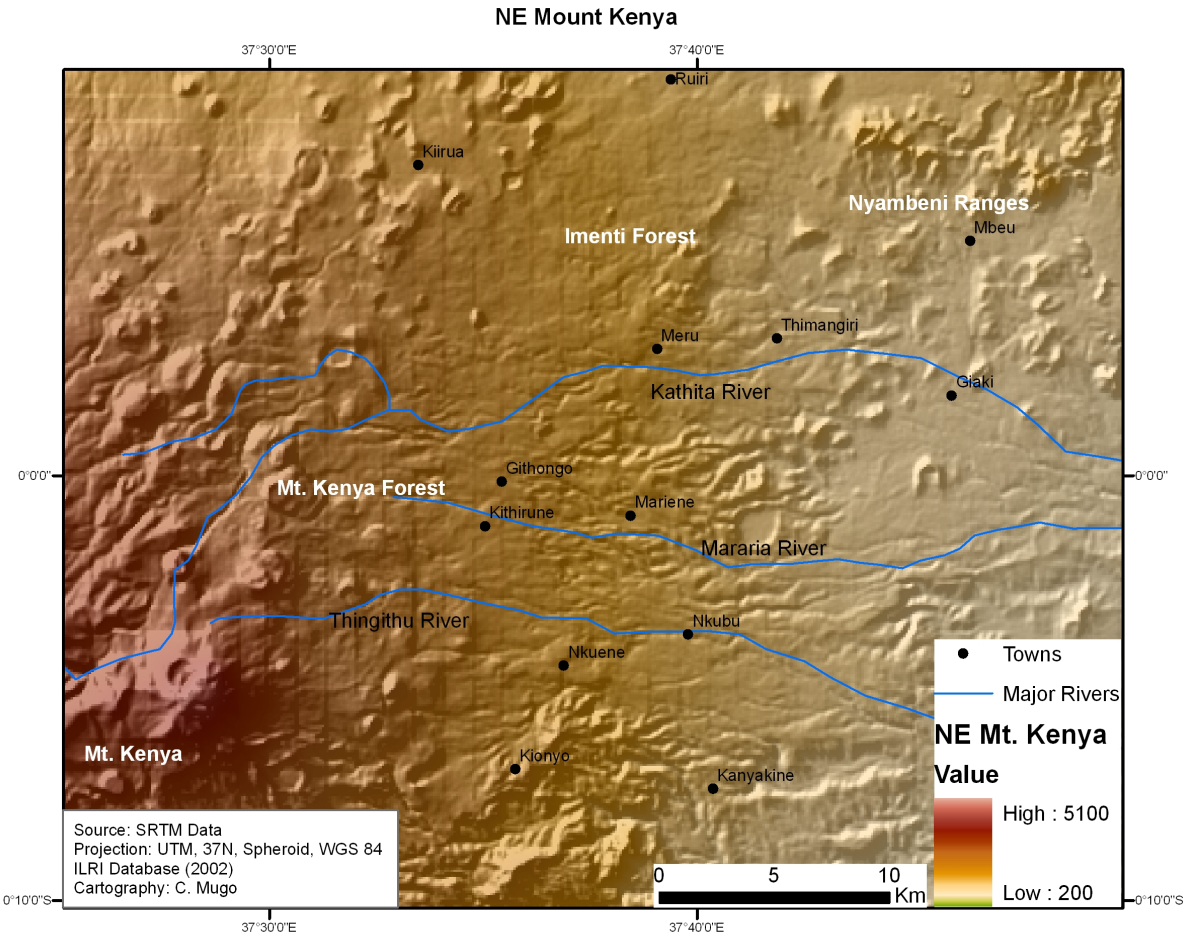


Figure 9: NE Mount Kenya SRTM data

The study area is largely influenced by the two massive elevations surrounding the zone, i.e. the Mount Kenya and the Nyambeni ranges. In the west, the Mount Kenya's volcanic nature gives rise to the nature of the terrain in the study area as the SRTM (Shuttle Radar Topography Mission) illustration displays in figure 9. The Mount Kenya region gradually slopes down eastwards, and eventually unites with the Eastern plateau of Kenya at an altitude of 300m asl. The slopes of the Nyambeni are steeper than those of Mount Kenya but the crests are much lower and flow out onto the basement complex, their profile gradually flattening and lateral erosion becoming predominant (ROK 1989:1).

The main river flowing through both forest regions in the study area is the Kathita. This river takes on a simple radial drainage pattern, because of the conical slopes of the Mount Kenya (OJANY and OGANDO 1973). The Kathita river is a tributary of the Tana River whose discharge is derived from the heavy rainfall area of the Aberdares (range of

mountains situated in the east of Mount Kenya) and Mount Kenya (MORGAN 1973). The drainage pattern in the District has been basically influenced by three major factors: the Northern slopes of Mount Kenya, the northeast and south Western watershed of the Nyambene range, and the structure in the basement system (NEMA 2004).

Mount Kenya region

The Mount Kenya area in the Western part of the study area lies between 2,500m asl towards the mountain area, to about 1,700m asl towards the east (Mariene). Nkubu town lies at about 1,500m asl. The upper parts of the rivers are deeply incised with steep sided valleys due to the nature of the mountain and the terrain. These valleys are drained by the rivers and also perennial streams. Other permanent rivers in the Mount Kenya region include Thingithu, and Mariara, which mainly flow in the Eastern Mount Kenya region. These two rivers also join and drain into the Tana River. Minor tributaries and streams include the Kionde, Kinyaritha, Kagene in the central and north Eastern side of the study area and Lugoso, Kathirimo, Lueye and Luedi in the southern part of the mountain area.

Besides these rivers, on the north Eastern flank of Mount Kenya, there are a few parasitic cones and crater lakes. Sacred Lake Nkunga, which is a closed crater lake, lies 0° 05' North and 37° 32' East in a basaltic explosion crater (OLAGO et al. 1999) that is also found within the Mount Kenya Forest Reserve. The community largely depends on the vegetation by the lake for grazing and as a water source The lake is also used as a route or corridor available to elephants when they migrate each year from Mount Kenya out to the grasslands.

Imenti region

From the Western side of the study area, the region slopes gently towards the north and the east completing the Imenti Forest in plains as well as the neighbouring Districts. The Imenti Forest area is therefore the lower part of the study area with an altitude between 1,120m and 1,800m asl. The landscape in the Imenti falls very gently towards the Western part of the study area, and flat areas in the centre and the Eastern part constitutes of inselbergs, several hills and valleys characterised by gentle slopes that range about 1400m asl. Meru town lies at 1,700m, and Giaki lies at about 1,160m asl. The Nyambeni ranges towards the northeast lie at about 2,513m asl. Just like the Mount Kenya, the

Imenti Forest area is also largely drained by the Kathita. Towards the far Eastern part of the study area, the Kuuru is the main river. There are also several intermittent streams, e.g. the Gachioma, and swamps in the Lower Imenti Forest areas. Boreholes and springs are also existent in the region.

In the Northern part of the study area, there is far less surface water or the availability of rivers as the area is characterised by drier regions. Apart from that, porous bedrock in the Northern part of the study area towards the Nyambene allows much of the drainage to flow beneath the surface. This naturally has an impact on the vegetation and crops grown in that area. As a result of the high organic matter content in forest soils, these soils absorb considerable quantities of water, and thus the forest acts as a buffer. The forest stores large amounts of water, slowly releasing it in the form of streams and rivers, whereas other surfaces have much less storage capacity and release water almost as soon as it has precipitated (BEENTJE 1990:49).

2.4 Geology and soils

The geology of the study area is classified into an igenous rock region and pyroclastic unconsolidated material towards the mountain area as figure 10 illustrates (ILRI 2002, MASON 1955 and BAKER 1967). Detailed studies of the geology of the Mount Kenya area have been illustrated by BAKER (1967), as well MASON (1955) for the Meru-Isiolo region and MAHANEY (1990) for the mountain region. The Mount Kenya, which is an important feature in the Western side of the study area, is an extinct denuded volcano (BAKER 1967, OJANY and OGANDO 1973).

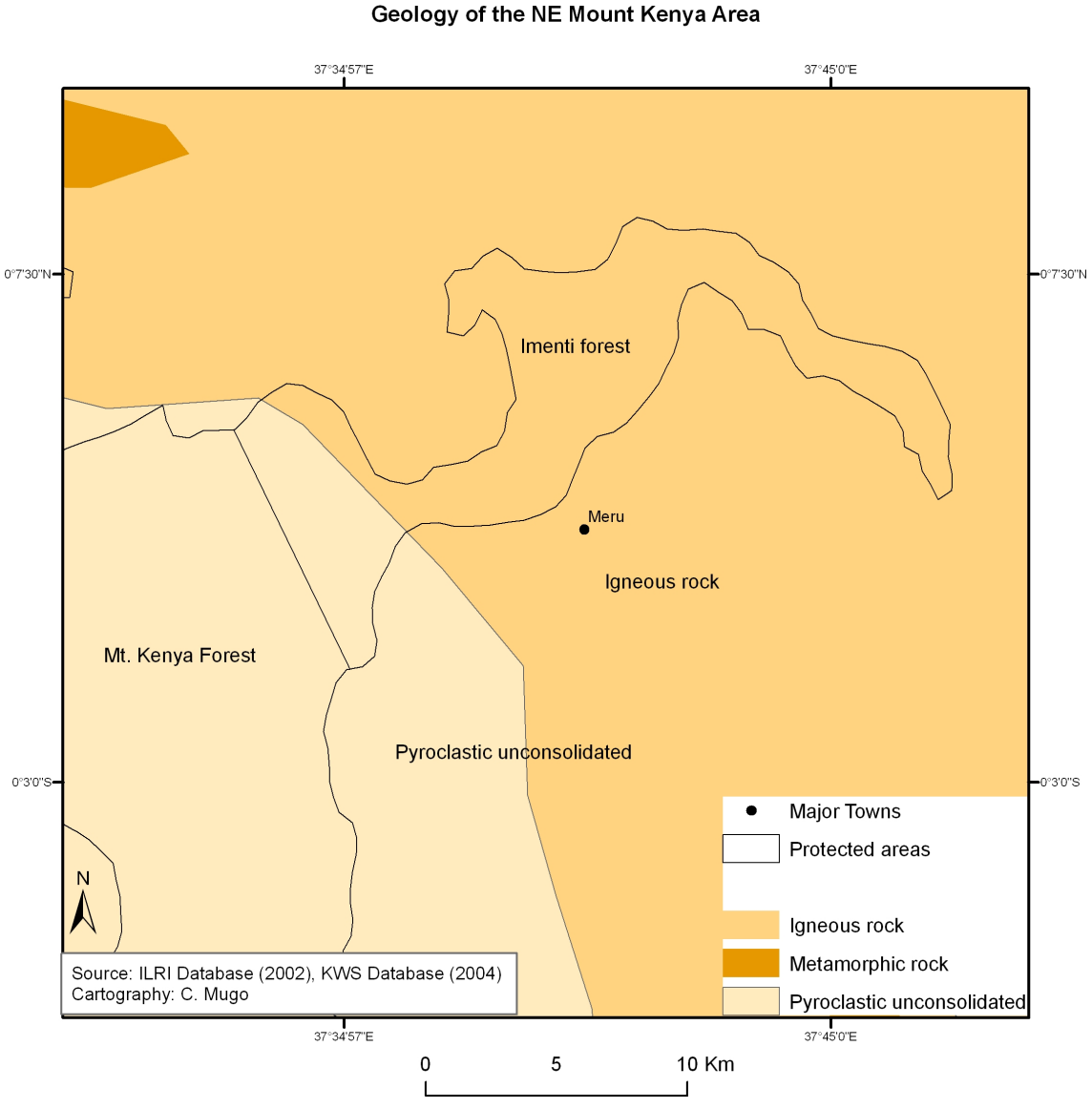


Figure 10: Geology of the NE Mount Kenya

BAKER further notes that the volcanic rocks are known to be among the very youngest and are considered to be of Pleistocene age. The overlying Mount Kenya area consists of all eruptive rocks from the mountain (MASON 1955, BAKER 1967, MAHANEY 1990). Soil characteristics on and around the mountain itself, i.e. soils on the upper and lower slopes and its belt have been studied by SPECK (1983, 1986). There is nevertheless a lack of detailed soil property analysis research in the Meru central and Meru north Districts that account for the north-Eastern base of the mountain area. Nevertheless, the National Environment Management Association of Kenya indicates that the Meru central District largely consists of moderately highly fertile loams (NEMA 2004).

Reddish brown loamy soils have developed in most parts of the NE Mount Kenya region whereby the iron oxides in the clay fraction mainly cause this soil colour (SPECK 1983). This is common in the tropical highlands in the country, where the parent rocks are volcanic. The soils in the lower slopes of Mount Kenya (nitosols and acrisols) have a low silica content which is normal for the red tropical soils, there the highest leaching rates is in the nitosol zone where the geochemical activity is most intense (SPECK 1983:50). Young volcanic andosols also occur in high rainfall areas with steep topography around the Mount Kenya (GACHENE and KIMARU 2003:36). Andosols have a Pyroclastic underlying parent material and have an AC or ABC profile development. Rapid weathering of the porous material results in accumulation of stable organo-mineral complexes and short range order minerals such as allaphane, imogolite and ferrihydrite (DRIESSON et.al.1991:57).

Mount Kenya region

The original soil map database from the Kenya Soil Survey (KSS) adapted from the soil map of the world by the FAO-UNESCO, was improved by the International Livestock Research Institute (ILRI) and used in the research to interpret the soil map. It is important to keep in mind the accuracy of such maps as the variability within a unit is seldom completely explicable in terms of a rational and ascertainable variation in influences of the soil (LANDON 1991:16).

The area westwards near the mountain in the study area is presented with PH-water of 4,5 which is strongly acid, whereby in this case, the pH-water has been used in the soil map to establish the soil suitability for crops and plants. The acidity is common and expected as soils in the highland mountainous regions in Eastern Africa, for instance on the slopes of Mount Kenya, the soils have acidity problems (GACHENE and KIMARU

2003:36). In reference to the soil map of the Mount Kenya Area, 1:125 000 (SPECK 1983), the valleys in the Mount Kenya region are deeply incised V-shaped with narrow bottoms. The soils are dark brown, humic loams that are well drained. The sides of the valleys have dark reddish brown clay, frequently eroded with scattered boulders. The valleys may also be imperfectly drained, and have brown, motteled clay on bottoms that may contain humic Arcisols, dystric Regosols and dystric Gleysols.

Imenti Forest region

The Nyambeni volcanic series are recent and include basaltic pumice and ashes. The Eastern and southern part of the study area is underlain mainly by basalts from the Mount Kenya volcanic series. Others around Nkubu include rocks which are Pleistocene, i.e. the phonolites, kenytes, trachytes, phorphyres, pyroclastics. Few areas of the Imenti Forest area are dispersed with tuffs and ashes near craters and vents from the recent time as well. Ashes and fine agglomerates are well exposed south and west of the Kathita River, and these are overlain by well bedded sandy and pisolitic ashes (BAKER 1967:46). The plains to the north are composed of the Nyambeni lava volcanics, which are low lying and with particularly shallow and rocky soils.

The Nyambene ranges rise to an elevation of 2,133 m and consist of accumulations of basic alkaline basic and intermediate extrusive rocks. Towards the Kiirua market centre, the pH is about 5.6 which is medium acidic, while further east in the study area, the pH is increases to 6.7. In reference to the soil map (SPECK 1983) the areas around Meru, Marine, Nkubu, and Giatune have been characterised as areas with dense small river network. The areas have very deep dark red friable clay partly covered by shallow, dark reddish brown, humic clay, dystric Nitisols or humic Nitisols. Nitisols are well drained soils with a deeply developed argic B-horizon showing a clay distribution which does not show a relative decrease from its maximum of more than 20 percent within 120 cm of the surface; showing gradual diffuse horizon boundaries between A- and B-horizons (DRIESSON et al. 1991:159).

2.5 Vegetation

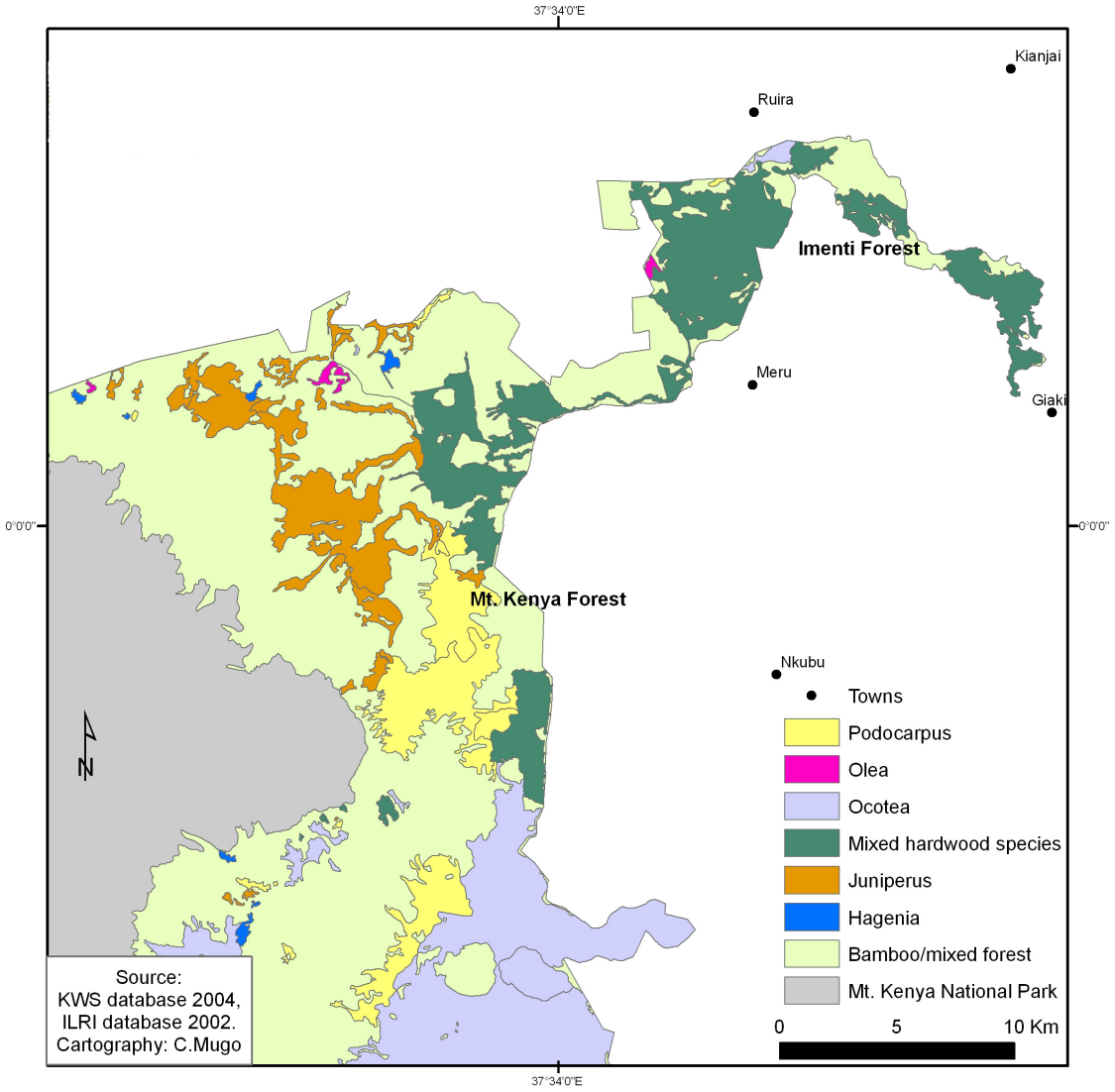


Figure 11: Vegetation types in the protected areas

The vegetation zones in the NE part of the Mount Kenya National Park are characterised by lower montane forest, a bamboo zone, and the Upper montane forest, (2,000-3,500m asl). Followed by the Ericaceous zone, and the Alpine zone (ca. 4,000 to 5,000m asl) where vegetation then ends (BUSSMANN 1994, BEENTJE 1990)

Mount Kenya region

Both temperature and precipitation induce the availability of vegetation in the study area. Intensively cultivated regions represent the forest adjacent regions. A detailed and comprehensive overview of the forest vegetation including parts of the submontane forest, as well as the ecological factors affecting the distribution of plant communities as well as type locations, character and differential species has been given by BUSSMANN (1994). A list of 822 plant species and subspecies of the alpine zone, roadside species

and exotic trees of plantations that have been identified are included. The forests have been divided into six formations: evergreen submontane forests, evergreen deciduous submontane forests, evergreen broadleafed montane forests, evergreen x-eromorphic montane forests, evergreen montane bamboo and evergreen subalpine forests. The evergreen xeromorphic montane forests that cover the NE part of Mount Kenya are dominated by the East African Pencil Cedar, *Juniperus procera* outgrowing all other tree species.

GATHAARA (1999) further specifies the most common species of large trees in the Mount Kenya region as Camphor (*Ocotea usambarensis*), Cedar (*Juniperus procera*), Wild olive (*Olea europaea*), Meru oak (*Vintex keniensis),* Podo (*Podocarpus latifolius*), East African Rosewood (*Hagenia abyssinica*), Croton (*Croton macrostachyus*), mugumo (*Ficus thonningii*). The alpine forest continues in the far Western part of the study area towards the Mount Kenya National Park as figure 11 shows. GIS data was obtained from the Mount. Kenya forest destruction aerial survey carried out by the KWS which gives a detailed account of the forest types that covers the vast area at the base surrounding the mountain (GAATHARA 1999). From the data, the tree species in the study area are composed mainly of mixed forests and mixed hardwood species especially within the Imenti Forest Reserve.

Tea which is grown as a cash crop is only found in the Mount Kenya region where elevation, temperature and also precipitation is favourable. Other cash crops include coffee, tobacco and pyrethrum. Napier grass *(Pennisetum purpureum)* is grown in both regions of the study area.

Imenti Forest region

From a forest destruction study, the KWS has given a detailed GIS account of the forest types that covers the vast area at the base surrounding the mountain (GAATHARA 1999). From that data, the tree species diversity in the study area is composed of mixed hardwood species especially within the Imenti Forest Reserve. Transvaal Beech *(Faurea saligna)* is a species that has been found to occupy a very restricted area near Meru, and grows on extremely step slopes of more than 40° (see BUSSMANN 1994:90). Data from BEENTJE'S (1990) personal investigations show that another rear forest type (*Croton syvaticus*) known to grow only in the Meru area at altitudes of 1,500-1,800 in the Upper Imenti Forest and is only found in that area. There are also ca. 3,000 ha *Croton-brachylaena-calodendrum* near Meru.

As altitude decreases, the climatic data indicate a shift towards warmer conditions in the Eastern areas of this region whereby the climatic conditions is characterised by a stable increase in temperature and aridity. The continuous vegetation begins to become fragmented. Forest regions then gradually give way to dry bushes, scattered thorn trees, savannah grassland, and few deciduous trees and shrubs, especially towards the Northern and Eastern part of the study area. The climatic data indicate a shift towards warmer conditions in the Eastern areas of this region.

In the Thege region there are plantation areas which include horticultural crops, such as tomatoes, french beans, and mangoes. Cash crops also grown in the Imenti Forest region include coffee, groundnuts, wheat, barley, tobacco and pyrethrum. Food crops comprise largely of maize, beans, millet, potatoes, yams (ROK 2001b). Apart from intensively cultivated regions, the Eastern side of the study area is partly characterised by perennial cropland and scattered trees, while the Northern and far Western part is sparsely cultivated and has more savannah grasslands.

The Nkunga Crater Lake is surrounded by a round belt of forest and the surface is covered by vegetation *Nyamphaea* (waterlillies), *Cyperaceae,* (sedges) and *Pteriodophyta* (ferns) (FICKEN et al.1998). From a study done by OLAGO et al. (1999), on the Lake Nkunga, sediment cores illustrate fluctuations in atmospheric CO^2 concentrations (secondarily coupled with precipitation changes) which had a significant impact on the vegetation ecosystems of the mountain and on their distribution, probably exceeding the influence of the temperature effect.

From the geographical features in the NE Mount Kenya, the study area is well represented by the protected dense forest ranges with variegated endemic indigenous tree species. The differing altitude range in the study area defines the temperature and precipitation, which consequently establishes the vegetation density of the area. Temperature influences plant growth as plants have specific requirements of temperature to ensure proper germination, as well as growth enabling a plant to photosynthesize and mature. Atmospheric temperature also determines the rate of moisture evaporation, thus defining ideal conditions for the types of crops to be planted. In most cases, in areas of very high temperature land use for crop farming is limited unless there is irrigation.

As altitudes decrease rainfall also decreases as rain bearing winds deposit most of the moisture on the windward side east of Mount Kenya. The leeward side of the mountain

in the rain shadow area and the low lying areas to the north and east receive less rainfall than the Eastern parts of the study area. Where precipitation is high, there is intensive arable farming, and the growth of tea, potatoes and a mixture of both indigenous and exotic tree species are found in the protected areas in the Mount Kenya Forest region. On the other hand, the Imenti Forest regions, the land is characterised largely by hills and plains, and lower precipitation. Although mixed forest species are evident, the exotic species dominate the area, coupled with perennial cropland and scattered trees. The Northern and far Western region is sparsely cultivated and has more savannah grasslands.

Topography influences the drainage pattern, thus the availability of water for irrigation. The Mount Kenya catchment area assures ample flow of rivers in the Eastern part of the study area that are characterised by sharp incised valleys. The flatter Eastern side has a controlled flow of water that consists of streams and tributaries of the Kathita River that drains into the Tana River.

The volcanic eruptions of the mountains define the soils in the study area that are rich, and suitable for farming. The rich basaltic soils derived from the sediments are however much recent towards the Eastern parts of the study area. Since the soils in the Mount Kenya Forest area have lower PH values and tend to be acidic, the application of lime fertilizers, organic and inorganic fertilizers is necessary to maximize agricultural production. Nevertheless, crops like tea thrive in acidic rather than neutral conditions GACHENE and KIMARU (2003:17). The potential of the soils is strongly related to the climatic conditions which also influence the soil formation in the long term.

3 Literature Review

Until 1893 no publications had resulted from the exploration of Mount Kenya, but in the course of J.W Gregory's first expedition to the mountain, he made significant contributions to the geography of the Afro-alpine zone. Later, in 1899, Halford Mackinder opened up the first climbing route, which would be followed by several generations of mountaineers (MAHANEY 1990). Recently the majority of scientific research however has focused on the ecological, morphological, and glaciological studies, on the mountain itself (RHEKER 1992, MESSERLI 1986 and BRUNNER 1986) have carried out research in other specific regions of the mountain especially the Laikipia area in the north-Western part of the mountain. Recently, CASTRO (1995) came up with a "social history of the forest commons in southern Mount Kenya," while BUSSMANN (1994) has made a detailed contribution on the vegetation of the Mount Kenya Forests, whereby six forest formations, evergreen submontane forests, evergreen deciduous submontane forests, evergreen broad-leafed montane forests, evergreen xeromorphic montane forests, evergreen bamboo and evergreen subalpine forests were described. Thermo-hygric, soil studies and hydrology research of the mountain and its belt has also been carried out by (WINIGER 1986, SPECK 1986, LEIBUNDGUT 1986, and WINGER et al. 1985) respectively.

SPECK (1986) found that although the soils of the mountain and upper slope and the soils under the forest on the lower slopes are unfit for agricultural use due to the physiographic situation, the extended forest belt has very important functions such as water retention and water supply for the dry surrounding area and lowlands. Therefore, appropriate forestry use and land use on the mountain base should be promoted. LEIBUNDGUT (1986) complies with the idea that a large part of the rainwater in the area is used to replenish the underground reservoir. Also, clear regional differentiations appear according to the varying influences of the different wind systems in the equatorial low pressure convergence and the strong modification due to mountain topography. WINIGER (1986) further explains that the temperature and moisture are the dominant limiting factors for the vegetation coverage in the Mount Kenya area. The main areas of focus however have been in the Northern and Western mountain regions. In 1996, the KWS also noted that most scientific research has been done above 3,800m asl of the mountain area and thus more comparative work is needed (UNEP and WCMC 2001).

Although these studies of the mountain area have been well discussed, research output in the adjacent Mount Kenya area has however not been integrated with the land use and impacts context. It is important to comprehend what the community perceives of land use impacts with regard to the immediate surroundings, in order to understand if land user attitudes and perceptions are compatible with appropriate land use methods, or the set rules and regulations of land use in farmlands both within and adjacent to the protected areas. Regardless of the fact that scientific research in the NE region of the mountain has not been accomplished, reports on the protected forest areas carried out by the Kenya Wildlife Service and the Forest Department are available (GATHAARA 1999, VANLEEUWE et al. 2003).

The NE Mount Kenya area consists of two protected forest reserves, namely the Mount Kenya Forest Reserve and the Imenti Forest Reserve, together with the adjacent farming and settlement areas. In the protected areas, forest resource utilization has undergone presidential bans; however, the destruction of the forests in Mount Kenya is evident. Tree species that were destroyed in the late 1990s include Camphor: 6720 trees, Cedar: 1632 trees, Olive: 241 trees, Rosewood: 24 trees, and other indigenous tree species totalling 6,045 trees (GATHAARA 1999:16). Nevertheless, regardless of the ban and closure of illegal access to the forest, the implementation of the ban has been a problem as there was no written instruction or legislation (GATAHAARA 2003, EARTH REPORT 2000). Moreover, despite these forest utilization restrictions, adjacent households rely on a wide range of forest products to fulfil their subsistence needs (EMERTON 2000). This destruction caused countrywide alarm, which led to a rapid representative aerial assessment of the Mount Kenya area by the Kenya Wildlife Service (KWS) (GATHAARA 1999). As a follow-up, another study was carried out between 1999 and 2000, which revealed that land degraded due to encroachment in the indigenous forest, had decreased substantially by 71% (3,152 hectares) between 2000 and 2002 (VANLEEUWE et al. 2003:13).

3.1 Land use change

While actual land use patterns can be obtained by own observations, former land use practices can be reconstructed on the basis of interviews with elders. The reasons of any land use changes should be reckoned, i.e. lack of rainfall, tribal conflicts, influence of

permanent water sources and settlements (MÄCKEL 1995:8). Land use change is defined by BRINKMANN (1998:95) as "generally conscious, volitional responses by humans or human societies to changes in biophysical or societal conditions." It is therefore a response indicator, reflecting how and to what extent society is responding to meet its changing needs and goals or to adapt to changing environmental conditions. This does not exclude the fact or possibility that some land use changes may in turn constitute a driving force for changes in the state of the environment (BRINKMANN 1998).

In Kenya, land use changes have been brought about by issues of population growth, food security and agricultural potential, stifling indigenous skills, knowledge and practices, misapplication of modern technological innovations, poor environment regulation and natural man-made disasters (UNEP 2002, MWAGORE 2002, OMOSA 1993, STOCKING and MURNAGHAN 2000, WINIGER et al. 1990). Population growth has been regarded as an important socio-economic aspect in terms of land use, making it an important factor to consider. The more densely a region is populated, the more chances there are that there will be a change of land use, for instance overgrazing and clearance of vegetation for settlement space of which impacts can be negative.

The change from plantations in larger agricultural areas to small-scale farming is a factor that is on the increase in Kenya. These induce soil erosion, monocropping, deforestation and overgrazing. Land use changes are principally a result of intensification of land use methods combined with economic growth, which lead to the degradation of land. STOCKING and MURNAGHAN (2000) point out that if land degradation is defined as a loss in the productivity, there is an alignment with the interests of farmers whose major concern is the yield that they can achieve from their lands.

Mount Kenya and its immediate environment are richly endowed with diverse natural and human resources. Distinct spatial variations in rainfall, water resources, soil fertility, forestry resources, wildlife, educational attainment and income per capita are some factors that have sustained very different land use activities and have caused population mobility due to spatial variations in perception of environmental utility and risks. AYIEMBA in WINIGER (1990) undoubtedly agrees that there are specific driving forces that facilitate land use changes. Naturally, development of urban centres (e.g. Meru town within the study area) and associated infrastructure of an area encourage population growth which can in turn exert pressure on natural resources, in this case the protected areas. The urban areas thus offer greater prospects for survival and security

(AYIEMBA in WINIGER 1990:37). It is therefore necessary to understand the principal value of the region within which a community interacts and its relevance to the understanding of land use changes that result in land degradation.

3.2 Land degradation impacts

Land degradation is a term that has been used to describe the deteriorating process of a natural resource. A study of quaternary erosion and sedimentation in Africa that was carried out by DARDIS (1989), implies that the present phase of degradation has rapidly increased in the last 250 years as opposed to its formation process 2000 years ago (DARDIS (1989) cited in DAHLBERG 1994:25). Sub-Saharan Africa however has the highest rate of land degradation (WMO 2005). In the long-term, degraded areas that have been abandoned only get worse regardless of the type of impact, whether human induced or natural. Past studies on land degradation have approached the phenomenon from the physical and biological viewpoints ignoring the socio-economic factors, which contribute to both the causes and the solutions (UNEP et al. 1997). However that is changing and now emphasis is being placed on research into the rehabilitation of degraded lands that is aimed at the small farm sector, for example by approaching the farmers first (STOCKING 1992).

WMO (2005) and STOCKING and MURNAGHAN (2000), refer to land degradation as a very broad concept involving the substantial decrease in an area's biological productivity, changes in land resource involving the way in which the environment is managed and how nature reacts to human land use. JOHNSON and LEWIS (1995) further suggest that this decrease of biological productivity or usefulness is as a result of human interference. Taking this fact into consideration, the UNDP (United Nations Development Programme) emphasises that land degradation is a process that weakens the ability of communities to depend on their environment for their livelihoods (UNDP 2001). Although different approaches have been applied to analyse the land degradation issue, it is important to examine the driving forces of land use change that have impacts on the environment. These forces range from the natural, for instance climate change, to the socio-ecologic factors like population dynamics and economics. STOCKING and MURNAGHAN (2000) agree that there are different perspectives within the local society which need to be reflected in any field level assessment of land degradation.

STOCKING and MURNAGHAN (2000), note that soil erosion is the most widely recognised and most common form of land degradation. The loss of vegetation cover can be a threat to further degradation as vegetation cover prevents the soil from being eroded by wind or water, while plants roots retain the soil structure. It would nevertheless be interesting to discover if such a finding applies in the same rates to both areas with high agricultural potential in Africa and/or only in marginal (vulnerable) and arid and semi-arid lands (ASAL). It is also evident that the loss of vegetation cover can also be intensified by soil erosion. In a study based on a typical relative measure of soil loss, STOCKING and MURNAGHAN (2000) display results from a plot on a 9% slope. Table 1 displays the rate at which soil loss takes place with regard to the type of land use and how the area is managed. As would be expected, the poorly managed land use systems are more likely to degrade than the well-managed plots.

Land use	**Soil loss rate (tonnes/ha/yr)**
Bare soil	125.0
Annual crops-poor management on infertile soils	50.0
Annual crops - standard management	10.0
Annual crops - good management	5.0
Perennial crops - little disturbance	2.0
Natural forest	0.5

Table 1: Land use and soil loss

Source: STOCKING and MURNAGHAN (2000:10)

3.2.1 Protected Areas and Management

The definition of a protected area adopted by the IUCN World Commission on Protected Areas (WCPA) is: “an area of land and /or sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources and managed through legal or other effective means” (HAMILTON and MCMILLAN 2004:6). Religion, cultural values and ecological research have all been driving forces in people’s recognition of the importance of the protection of certain regions. Protected areas are therefore a key element in a widely accepted set of natural resource management “best practices” and are managed by a municipality with arrangements ranging from public to communal and private issues (MC NEELY and SCUHTYSER

2003). Ecosystem management is determined by the objectives stipulated for the given area (MAKINNON et al. 1986).

While some local communities would willingly pay to protect ecosystems and adopt land use and crop production systems that support the protected area, others are indifferent and would prefer that the protected areas be converted into more productive uses (MC NEELY and SCUHTYSER 2003). In any case, when the British representatives recommended the idea of conservation in Kenya, they suggested that particular areas should be defined where hunting was illegal. This marked the establishment of Kenya's protected areas. Kenya has long been known for its abundance in wildlife, which has been a main attraction in the country. Due to this fact, it may be argued that a lot of attention has been given to the conservation of wildlife and preserving their natural habitat NYEKI (1993). Such areas were first placed in the care of the Kenya National Parks Trustees, a body that was formed in 1945, after the establishment of the first National Park in East Africa, the Nairobi National Park (OJANY and OGANDO 1973).

3.2.2 Categorization of protected areas

Protected areas are of many types, established with widely different objectives, and designated by many different names - National Park, nature reserve, National Reserve, etc. - in different countries (SCHERL 2004:9). These areas have been divided into categories to enable and simplify their management. The IUCN has had the responsibility of classifying the protected areas into six categories ranging from strict nature reserves and wildlife sanctuaries to areas of sustainable use of natural ecosystems. For a detailed description of the categories and examples of the categories, see the IUCN Guidelines for Protected Area Management Categories 1994 ICUN (1994). However, countries have varied designations for protected areas since the categories are laid down for every protected area of the world, as not every country can meet these designations at a national level.

In Kenya three levels of protected areas are recognised:

(a). National Parks

(b). National Reserves

(c). Marine National Parks and reserves (KING 1993, NYEKI 1993).

National Parks, which fall under Category II in the ICUN guidelines for protected area management, are fully protected and human activity is permitted strictly as an appreciation of wildlife in its natural state. National Reserves (category VI) were conceived in recognition of the need for local communities to continue benefiting from forestry and water resources while at the same time conserving wildlife. Marine parks and reserves (category V) follow the same approach as the National Reserves (UNEP and GEF 2002). When protected areas are managed according to a certain category, it is more efficient because this method can also assist in the comparison of data, or even make the communication between countries a lot more efficient.

When it comes to managing the protected areas, KWS is a self-governing state cooperation within the country responsible for conserving the Kenyan natural environment and its flora and fauna. The KWS was established as a parastatal organisation in 1989 for the conservation and management of National Parks and the protection of wildlife NYEKI (1993). Since over 70% of Kenya's wildlife is found outside the National Parks, the KWS is responsible for the control of movement of wildlife to prevent destruction of crops and ensure the physical safety of the people (UNEP and GEF 2002). Most forested areas in Kenya are gazetted, meaning they are areas that have been surveyed, demarcated on the ground and declared as forest reserves. Forest reserves are legally owned by the government and are managed directly by the Forest Department (FD) and/or the Kenya Wildlife Service on behalf of the state WASS (1995:11).

In the Mount Kenya area, Mount Kenya Forest and Imenti Forest are categorized as forest reserves whereby the areas are protected. However, controlled human utilization of the forests is permitted. The Mount Kenya National Park (71,500ha) established in 1949 lies within the mountain region and is a "National Park" where the area is strictly protected and undisturbed from human use. The Mount Kenya National Park and its immediate surrounding forest reserve area (70,520ha) became a world heritage site in 1997 UNESCO (1998).

It is nevertheless evident that some protected areas like the Mount Kenya Forest Reserve and Mount Kenya National Park, which may be of different categories, unite or share the same landscape features. In spite of that, the two regions are accounted for separately, although the requirement of the co-operation of two authorities is not ruled out (KWS 1993). It is vital to properly manage every category of protected area

according to its outlined feature. The protected areas however need to become more relevant to countries' development strategies and the rights and needs of local people; otherwise many protected areas will come under increasing threat (DUDLEY et al. (1999) cited in SCHERL 2004).

3.2.2.1 Land use and protected areas

The impact of human activity resulting in land degradation both within the protected areas and adjacent regions can be brought about by several factors including overgrazing, especially near water sources, which leads to the destruction of vegetation cover. (JOHNSON and LEWIS 1995) also agree that the limits on degradation are set by nature, because extensive overgrazing near the water source will result in the absence of fodder for the animals. (JOHNSON and LEWIS 1995) indicate that land degradation can occur even if no deficiencies in the nutrient status exist. Underlying physical conditions, like easily eroded basalt and poor standards of farming, have partially explained the severe land degradation in Lesotho, which is apparently the most degraded country in the African continent (STOCKING and MURNAGHAN 2000).

MALONEY (1998) states that the soils of the montane forest areas are often neglected in the academic and agronomic literature. These soils tend to be shallower than those of the lowlands and are less intensely leached, making them more chemically fertile. On that note, for soils to remain productive and maintain their fertility, especially in regions of high agricultural potential like the NE Mount Kenya, suitable measures, such as favourable agricultural practices have to be taken into consideration, in order to enable the soil to regenerate naturally within a given period of time. The removal of vegetation cover leads to soil erosion and this process is made even worse when it occurs on a slope. "In the tropics, over-cultivation leads to rapid loss of soil fertility unless this fertility is renewed over and over again at brief intervals" (GUPTA and ASHER 1998: 94). Once the rich, organic top-soil is lost to erosion, land use practices become very difficult, and in most cases, such land is thereafter abandoned. When land use changes take place, like converting farming land into livestock grazing areas, such a change could intensify the degree of land degradation. Consequently, land use changes adjacent to protected areas, encourage encroachment into the neighbouring areas thus causing degradation of forest ranges.

3.2.3 Land use conflicts

Protected areas have faced challenges in the past, and they are still enduring pressures (LUCAS1989, LUSIGI 1992 NYEKI 1993) both within these areas and in the adjacent regions. This has made the management of protected areas a difficult task**,** especially where no particular boundaries can be defined. Given this difficulty, complexity and variety of conflict situations that occur in protected areas, each situation will require a specifically tailored response that recognizes and adjusts for the cultural, legal and social context of that protected area pertaining to land use change conflicts (LEWIS 1996:7).

Land has for a long time been used by communities as a source of income, but when more farming land is required to keep up with the economic demands and pressures, protected areas usually face major conflicts (LEWIS 1996, MCNEELY et al. 2003). Too frequently there is a lack of understanding of environmental problems on the part of decision makers and priority is often given to short-term financial gain from logging or other forms of exploitation, even where this conflicts with long-term environmental considerations (MAKINNON et al. 1986). In East Africa, managing protected areas can prove to be very challenging, as most of these areas have been the homelands of local communities for decades. Also, the principal characteristics of the ecosystems in which they reside have not been thoroughly examined (YEAGER et al. 1986). This largely leads to conflicts occurring between park managers and the neighbouring communities, which usually happens when the communities have not been incorporated in the management of the protected areas.

The human-wildlife conflict is another major factor that is integral to a management plan. This takes place when an ecosystem is rich in animal species, and they migrate within large areas of the different ecosystems. In these cases, most times several years may go by before a suitable management plan has fully been established. The advantages of living with wildlife are few; the inconveniences and dangers are many (COUPE et al.2002).

The pressure that is exerted on the land by the population is another complex issue as, one has to incorporate land that is available for its economic potential. The human population dynamics have been discussed as a major issue that will remain in the scenarios of protected areas in (MCNEELY and SCHUTYSER 2003). Since the growing population tends to be a driving force in the start of conflicts within protected areas, it is

thus important to analyse the provision of benefits to local people of the protected area, which could assist in the regulation of conflicts in many situations (LEWIS 1996).

When the livelihoods of the protected areas' neighbouring communities directly depend on the available forest resources as their main provision, these areas are then consequently under increasing threat and vulnerability. Poverty can therefore be termed as a consequence and a cause of degradation. For this reason, the reduction of poverty reduces land degradation, and vice versa, since deepening poverty and accelerating land degradation have been shown to be strongly correlated (UNEP et al. 1997:121). There is then a need to incorporate the issue of poverty into any development plan, and especially those found within protected regions.

Suitable management of ecosystems is crucial and MAKINNON et al. (1986) agree that once indigenous forest areas have undergone degradation, they may never recover with the exact same composition of animal and plant species, while in savannah ecosystems, with the appropriate regeneration measures, they can recover in a shorter period of time.

3.2.4 Non-Residential Cultivation (Shamba system)

The shamba system, known as Non-Residential Cultivation (shamba is the Kiswahili term for farm) (NRC) popularly known as the *taungya system,* which originated from south-east Asia, is a method that was first introduced by the colonial administration to provide raw materials for the expanding timber industry and to reduce pressure on natural forests. This method is primarily achieved through the intercropping of tree seedlings with annual agricultural crops. It is a form of agro-forestry practice in which management policy requirements call for the agricultural crops to be phased out in the third year of tree growth. By the third year, the tree canopy would usually overshadow the normal growth of the agricultural crops. The farmer would then have to move out of the allocated plot, if it was no longer available (GATHAARA 1999). The NRC was implemented through the District Development Committees in order to integrate the system into the District Focus for Rural Development Strategy. This gave the Provincial Administration and local politicians a leading role in allocating shambas in the forest, and led to the serious abuse of the system (WANYIRI et al. (2000) in KAGOMBE and GITONGA 2005).

Since the early 1980s the scheme has been mismanaged and by 1999, 75% of the areas (around Mount Kenya) had not been replanted (UNEP and GEF 2002). In areas around the Imenti Forest, the shamba system was totally banned between 2002 and 2003 and the gazing of animals and the collection of firewood is only permitted to licence holders. Factors that led to the total ban of the use of the land for agriculture within the forest reserve included the grazing of cattle in the allocated regions, which resulted in the destruction of the newly planted tree seedlings, or even the establishment of family dwellings within the forest areas. These unrestrained circumstances called for a review of the licensing conditions, which were by then more or less out of control.

In any case, population growth, which leads to an increase in human activities and settlement in marginal areas, also plays a role in the loss of soil productivity, due to the loss of nutrients in the top-soil through destructive farming methods like the over-utilization of the soil and loss of vegetation cover. Evidently, deforestation in such a case is not a rare phenomenon, where human activities that involve land use changes are at an increase.

3.3 Previously applied research approaches

Researchers have been sceptical about the ways of approach and the results that they have come up with in regard to land use and land degradation. Within the various projects, "the research results by country and by region produce interesting data, but both their technical accuracy (e.g. the scale problem) and their usefulness must be questioned" (STOCKING 1992:3). STOCKING and MURNAGHAN (2000) further suggest that developing countries have been littered with technologies that have been promoted and have failed, or recommendations that have been rejected by local people. DAHLBERG (1994) also emphasizes this point and claims that the results have not revealed the true state of degradation. As pertaining to protected areas, studies of the land use of the regions have been from as basic as an observational monitoring approach. An example of such a study is one that was conducted to assist in the conservation of the Usambara forests in Tanzania, that have undergone destruction, where the reasons for the destruction were discussed and proposals were made on extension services needed in order to ease the way for conservation planning and implementation (RUWA-AICHI et al. 1990). This may be a faster way of getting results and making rapidly needed decisions, but minimal groundwork was applied to discover the root causes of destruction and this may cause dispute. BIOT et al. (1992) point out that mistaken scenarios have contributed to a worsening of conditions in Africa and are thus of limited value to both scientists and policy makers in the Ngorongoro Conservation Association in Tanzania.

From the statements made by STOCKING (1992) and DAHLBERG (1994), there is definitely an inadequacy in the approach that is being applied if results have not been up to standard. However, research in East African countries has been coupled with constraints ranging from an insufficiency of background research, or research that has not been area-specific enough as it was carried out on a scale that was too large. This results in the transfer of results from one region to another with insufficient scientific knowledge. Furthermore, it is possible that no measures have taken place to reverse the problems, leading to the failure in the implementation of plans, or possibly the lack of monitoring to follow up.

3.3.1 Land use mapping

The following methods of approach, i.e. aerial survey, aerial photographs, GIS, satellite images combined with ground surveys to begin with, are by far the most popular procedures in land use mapping today. In East Africa, when it comes to mapping land use areas, aerial surveys with ground surveys have been used mainly to study animal migration, animal counts and also human and livestock populations with special attention being given to protected areas (KWS 1993a, PERKIN and STOCKING 1994). In this method, a clear definition of land use together with wildlife populations has played a role in the planning for conservation of natural resources. Today the use of aerial photographs, GIS, and satellite images with a combination of ground surveys are used for the purpose of assessing the levels of ecological destruction, and land use in areas that are not necessarily protected.

RUNGE and SPÖNEMANN (1992) and GATHAARA (1999) have favoured the use of aerial photographs to illustrate and analyse landscape change in Kenya, whereby details of homesteads, forest rivers, and roads and pathways could be identified from the aerial photographs, while vegetation cover was further established by ground truthing. Also, although the illustration of major land use features in satellite images is not as detailed as in aerial photographs, in the study on the Mount Kenya Forests by VANLEEUWE (2003) which was aimed at representing large areas of vegetation cover, combined with field substantiation, satellite imagery proved to be an appropriate approach for the recordings of land use change in the large forest areas. It is important to combine these findings with ground surveys to either verify or expand on results acquired.

The application of SPOT multi-spectral imagery of 20 * 20 m resolution has been used to provide a base for the Mount Kenya Forest area that showed the variation of the zones in relief (AGATSIVA in WINGER 1989:17). These have been rather rare in developing countries as they were associated with high costs. Nonetheless, although the use of satellite and GIS data can contribute to interesting findings, DAHLBERG (1994) notes that authors who have used these methodologies also stressed the importance of integrating other techniques and of adapting them to local conditions, and the importance of the user being conversant with the social and physical characteristics of the area under research.

3.3.2 Interdisciplinary approach

The interdisciplinary approach is outstandingly broad as it normally involves a number of different aspects, i.e. biological, ecological, cultural, social and economical, that are interrelated or issues that could be observed from a single finding. These different aspects contribute to the overall picture. In East Africa, to access human impact on the vegetation in the Nguru Mountains in Tanzania for instance, field visits and collecting botanical specimen, observing changes in vegetation, monitoring encroachment and tree felling (including pit sawing) were undertaken. Interviews were carried out with forest officers on aspects of management and with villagers on matters concerning afforestation (CHAMSHAMA 1990).

A similar approach was used in the Machakos District in Kenya involving a number of scientific aspects that were combined by a team of scientists. These aspects included rainfall, soil erosion, farming systems and local income (TIFFEN et al. (1994) quoted in DAHLBERG 1994). The study by UNEP, et al. (1997) involved a land degradation assessment using the degradation indicators such as climate, vegetation and water erosion, wind erosion indicators, fuel wood indicators, surface water indicators, ground water indicators, and socio-economic and land use indicators, to provide the Kenyan government with a baseline database, that can later be altered or changed to monitor and help eliminate the land degradation processes. PERKIN and STOCKING (1994) note the necessity of additionally using the following approaches in order to maximise the management of multiple use areas**:** land zoning systems, long term ecological monitoring programmes and clear population policies, aimed in the first instance at identifying those groups which have the rights of access to resources.

An interdisciplinary approach enhances results as it can integrate the functions of land use which include: regulation roles (ecological), production roles (economical) and information roles (social). Incorporating the social aspects allows acknowledgement of relevant community issues. Although interdisciplinary approaches can prove to be costly, and it is necessary to put constraints on stakeholders, they are effective and rewarding in the long-run, especially where ecosystems have multiple functions.

3.3.3 Indigenous knowledge approach

Governments have decimated the indigenous rights of local people, undermining their cultural diversity and customary land tenure systems, as well as their traditional knowledge and practices (BARZETTI (1993), cited in TAMAL et al. 1998:260). Considering the fact that the Mount Kenya area is of high density, even periodic non-destructive land use like the gathering of firewood should include socio-economic factors to provide profound local perception pertaining to land use. Community awareness of and participation in any measures are indispensable as there is no way a conservation plan can succeed, if it is written and drafted for protected areas and adjacent communities by any researcher or scientist with the aim of conserving the environment without acknowledging the adjacent land users' concerns. SCHERL (2004:25) also agrees that while much thought has been given to the potential costs and benefits of protected areas, understanding of the actual impact on people's lives is still very incomplete.

Although different groups of people conceptualize nature in different ways, these cultural constructs are only the context in which similar kinds of knowledge are pragmatically understood; there is a need to separate out what people know and can apply, from formal, linguistic knowledge; it should be recognised that "indigenous knowledge is always situational, variable, and changing" (MALONEY 1998:93) An indigenous knowledge approach has become a growing area of interest which involves the study of the local inhabitants' views on issues related to land use. It is basically the study of indigenous knowledge systems and traditional land use practices and community perception on the dynamics of the landscape. The indigenous inhabitants are also aware of the spatial variability of the surrounding biodiversity (FAIRHEAD 1992, STOCKING 1992).

The significance of community participation in any given activity depends on who among the community participates, how, when and under what circumstances. Local communities participate in resource management and conservation activities in different ways and at different levels as they perceive different values and benefits (TAMAL et al. 1998: 259). Moreover, it is important to understand the historical land tenure context in order to understand today's land use methods. Nonetheless, it is also significant to note that even though local communities may lack the resources to invest in more advanced processes of land use, they usually have control over their land. Although STOCKING and MURNAGHAN (2000) state that a farmer's perspective will usually be different

from the cause and effect related to the scientific explanation, farmers that rely on produce from their lands are well aware of a degrading farm for instance due to a decrease in yields. On the other hand, it is important to note that political forces play a large role in the overall decision-making process, which is a factor that should also be taken into consideration when implementing land use plans.

3.3.4 Land use and the economy

Historical settlement patterns and land use patterns can be determined by population census and the distribution of agriculture. This way one can then observe the existing connection between population densities and the establishment of new agricultural areas as well as land use areas that have been avoided over the years. It should be emphasized that population concerns are central to the search for sustainable development (MADULU 2001:3). From a study by the Food and Agriculture Organisation (FAO) and United Nations Educational, Scientific and Cultural Organization (UNESCO) on the evaluation of land use in agro-ecological zones, results showed that land use must be matched with suitability or else degradation will occur. This led to research on the population-supporting capacities of land (STOCKING 1992). However, from a population and capacity study in developing countries, results indicate that in aggregate, Africa should be able to meet its food needs easily from its own land sources, without major investments (STOCKING 1992:3).

Studies in economy are also gaining popularity in research on environmental change and degradation. For instance, DAHLBERG (1994:) suggests a cost benefit analysis, which is the analysis in monetary terms of what continued degradation of natural resources will cost in contrast to an investment in conservation practices. EMERTON (1997, 1999) emphasized the need to do research into the economic factors of land use and especially those that drive people to dependency on natural resources, leading to land degradation. Furthermore, in her extensive contribution to economic studies in the Mount Kenya area, EMERTON (1997) elaborates that by distorting the prices, trade-offs, macroeconomic and sectoral economic policies that aim at stimulating economic growth and development actually accelerate degradation or pave the way for an opportunity for such a condition to occur. Land use in the Mount Kenya Forest region is characterised by small scale farming (below 2 ha) where in total, agriculture in the Sub-locations adjacent to the

forest generates an estimated annual income of Ksh 6 billion (ca.60 Million Euros) (EMERTON (1995), quoted in EMERTON 1997). In addition to this, there has been noticeable co-existence with selective logging activities and commercial timber plantations (EMERTON 1999:32). This all happened despite the fact that local populations were evicted from the forest. In the Mount Kenya area, with an increasing realisation that as long as adjacent communities have no stake in or economic gain from the forests they will not support its conservation, local economic incentives have come to form a major component of the Forest Department and the KWSs approach to forest management (EMERTON 1999:33).

AYIEMBA (in WINIGER 1989) clearly states that research into population and land use has shown links between population growth and the consequences on land use in the Mount Kenya region. Population trends reveal that densities in the Mount Kenya area are on the increase (see BHUSHAN 2000, ROKa, 2001, ROK 2002, ROK 2003, ILRI 2004) and the forest department in Kenya is faced with a challenge to satisfy the demands for forest products and services within the context of a rapidly changing environment (GATHAARA 1999). It is however necessary that more research on land use and population trends be done in Kenya. As GAKAHU et al. (1992) also notes the importance of population issues as they relate to the capacity of land adjoining protected areas or adjoining wildlife dispersal zones to sustain human populations (GAKAHU et al. 1992).

3.3.5 Poverty and land use

The negative impact of poverty as a result of land use change has been known to affect areas of the society where poverty, combined with other factors resulting from it, has become a catalyst for the destruction and degradation of the environment (BRUNTLAND 1987, RAMPHAL 1987, TEXTER 1986 quoted in RUWA-AICHI 1990:20). Concerns over the link between poverty in rural areas and land degradation have been expressed since 1970 when several reports revealed a striking connection between the two were published (UNEP et al. 1997:115). The examination of the links between the establishment and management of protected areas and issues of poverty in developing countries has become a practical and ethical necessity. It is practical necessity because in order to survive, protected areas in the poorer nations must be seen as land use

options that contribute as positively to sustainable development as other types of land use. It is an ethical necessity because human rights and aspirations need to be incorporated into national and global conservation strategies if social justice is to be realised (SCHERL 2004).

The study of poverty and the degradation approach is very applicable as the growing populations tend to make their effort to improve or maintain the quality of their lives, while also going to the point of compromising protected areas or other natural surroundings at any cost. When human interactions are superimposed over the physical interactions, the environmental responses to change become ever more complex (JOHNSON and LEWIS 1995:97). Moreover, KIRK (1999) agrees that people living in extreme poverty are unable to maintain sustainable growth. They are forced to overexploit in various ways the basis upon which they are dependent for their lives and thus deteriorate or completely destroy that of their contemporaries and future generations.

SCHERL (2004) further notes that although poverty has been defined in economic terms against such indicators such as income or consumption, recognition is now growing that poverty is a multi-faceted condition involving several, usually interconnected, economic and social dimensions including: lack of assets, lack of opportunities, lack of voice and empowerment, vulnerability and lack of capacity. These factors represent the broader involvement of circumstances that lead to land use change and thereafter degradation. It is therefore relevant that the context as a whole is understood when explaining degradation.

Evidently, past research on land use or land use change methods and degradation in Kenya have formerly been researched in arid and semi-arid regions, (ASALs), (KEYA 1998, UNEP et al. 1997, MÄCKEL 1995, RUNGE and SPÖNEMANN 1992, MÄCKEL and WALTHER 1993, BRYAN 1994). Since the ASALs comprise about 80% of Kenya's total land area while the remaining 20% are classified as high potential, (MWICHABE 2002, ROK 1999) more studies in land use changes and degradation in regions of agricultural potential in the country also need to be carried out to avoid the transfer of technologies from one region to the other.

Although interest has been shown in regards to land use and resulting conservation efforts all over Kenya, most research has been undertaken on a national level. Accordingly, it is important to analyse the ecological as well as the socio-economic land

use change factors in specific communities/area, keeping in mind the need to apply more than one discipline to cover related, diverse topics of research. Applying both the anthropological and ecological elements as an approach can better clarify the principal causes of land use changes in a specified region.

4 Methodology

The main methodological aspect of this research involves conceptualizing land use change impacts with regard to the perception of the Meru land users living adjacent to the protected areas in the NE Mount Kenya region. A geographical analysis of GIS and satellite data will be used to assess changes in forest cover and human impacts. The main emphasis of the study however is on the data acquired from the primary land users in the NE Mount Kenya region involving their concerns and perceptions, as an interface between the mapping, scientific theory and local perception. Accordingly, land impacts, present knowledge, experience and past practices are considered as well.

With this approach, the research avoids being streamed into purely theoretical scientific research and recognises the ultimate stewardship of the land users from a socio-economic context, to create a balance of perspectives. The results obtained are not only induced by the researcher, but the land users also played an active role in the environmental study. This method provides an opportunity to identify prevailing land use issues in a much more comprehensive way, with broader positive feedback, that can later be more professionally handled.

GIS (Geographical Information System) and satellite images were used to display geographically referenced information and relevant land use data in the study area. GIS offers the possibility of relating numerical data in a spatial context in order to come to a conclusion about possible relationships. GIS can therefore lead to important and new information, which helps in better decision making. The methods used were thus adapted to a particular framework that could enable the maximum utilization of available resources.

In the analysis and interpretation, topographic and geological maps used for reference included the geological map of the Meru-Isiolo area 1:125000, the geological map of the Mount Kenya Area 1:125000 and topographical maps of the Meru sheet 1:50000, Nkubu sheet 1:50000 and Maua sheet 1:50000.

4.1 Fieldwork

An interview process was used to acquire information on the land use changes to determine the prevailing issues regarding the practices of the farmers, their perspectives and susceptible indicators that may have contributed to land degradation in the study area. Some indicators include vegetation loss, poor crop yield, and erosion indicators. UNEP et al. (1997) state that although these indicators do not automatically mean that degradation has occurred, these variables let us know that degradation may have taken place.

Thus, site-specific visual indications and interviews were the main procedures for investigating land use change in the study area. This approach is an effort to recognise and appreciate the context whereby studies on land use changes would not have been self-explanatory. Therefore this dimension makes the implications and explanations within the physical and social context even more meaningful.

4.1.1 Methods of data collection

A semi-structured interview was carried out to obtain both qualitative and quantitative data. This information supplemented the GIS data and satellite images, which cannot replace the perceptions and intentions of the land users in the study area. Semi-structured interviews are conducted with a fairly open framework, which allows for focused, conversational, two-way communication. They can be used both to give and receive information (FAOb). The qualitative data assists in the explanation and identification of topics and areas, which provide a more complete and detailed investigation.

The main aim in developing a closer study of land use change in the past 20 years is to understand the land use behaviour of farmers, and the possible social/community actions that could have been passed on from past generations, so as to understand the land use context. The key informants were farmers, who were mostly the heads of a household. The facts obtained were based on their knowledge of the surrounding environment and, of great significance, the land use changes in the neighbouring protected areas. These were naturally elderly people who readily imparted information during the interviews.

In this approach, the farmers are made to feel a part of the research in their area of residence, as their responses are also of great value. Besides the respondents' requirements which were made clear at the introduction phase of the interview, the farmers also had an opportunity to freely express their needs, and bring up issues such as what they would like to see changed in their environment.

4.1.1.1 Interview selection process

The study area is generally divided into two main regions, i.e. the Imenti Forest area and the Mount Kenya Forest region. Therefore the major division of the selected areas is insinuated by the forest names. Conveniently, the forest names also partly portray differing ecological zones. The farms in these forest zones portray heterogeneity in the farms and vegetation diversity in the edges of the forest areas.

Restrictions included limitations in accessibility into parts of the study area, where infrastructure has not been thoroughly established. Therefore, geographical proximity with easy road accessibility was an important factor used in sampling the farms/households in the areas adjacent to the forest regions. Some farmers were also locally identified, especially as group leaders of the farming projects that the farmers have formed. Other useful indications of suitable farmers to interview were given by a Forest Department warden or KWS employees who were aware of the most informed and appropriate farmers to question pertaining to land use changes. This strategy used to select the various farms and households fostered significant individuals to provide information on land use and also information on the neighbouring protected regions.

4.1.1.2 Interview

The important approach of developing the questionnaire was aimed at understanding the farmers' land use changes and actions in a socio-economic context. The interview process for the fieldwork consisted of fixed sets of closed questions that were read out while marking the respondent's answers on the question sheet. The coding of the questions for analysis is straightforward and can be entered into a computer database. The questions were made up of the three types of data about the respondents that DÖRNYEI (2003) raises: factual, that cover the demographic factor; behavioural that

elucidate the respondents actions, lifestyles, habits and personal history; and attitudinal which is a category that includes attitudes, opinions, beliefs, interests and values (DÖRNYEI 2003:8)

Interviews with a total of 80 farmers were carried out in the study area. This number largely covered the Locations and Sub-locations in the study area. A total of 40 samples were acquired from the Imenti Forest section, which includes the Upper and Lower Imenti Forest areas, in the Meru, Giaki, Kaaga, Mbeu, Ruiri and Kiirua areas. Consistently, 40 interviews were accomplished from the Mount Kenya Forest region. These included the Mariene, Kithurine, Nkubu. Githongo, Kionyo, Nkuene, Kionyo, and Abothuguchi major Locations. The interviews were carried out between July 12th and August 29th 2004. Most interviews were carried out in the community's native language, "Kimeru" or Kiswahili, both of which were translated from the questions in the original English version. This factor naturally conveyed mental comfort to the participants thus, eliminating possible ethical problems.

The farms adjacent to the protected areas were surveyed in accordance to the following points:

1. An account of the area and Location and Sub-location of the farms followed by a short description of the area and diversity of the farms were indicated.

2. Natural attributes of the farm and current land use and notable changes of land use within the last 20 years.

3. Conservation practices, investments, soil fertility management, relevant farming practices and perception of the environment.

4. Impact on neighbouring protected areas, perception of overall importance of the protected areas, wildlife conflicts, benefits and perceived risks of bordering the protected areas.

In consequence, relative issues in agriculture, land use, land degradation, and opinions concerning the neighbouring protected areas were addressed. Majority of the households were single family ones, and the main interview participants were responsible for making decisions in their farm areas.

4.1.2 Case studies

Two case studies were obtained from the Imenti Forest region and the Mount Kenya Forest region. They were cases that reflect the trends and land use changes that were dominant in the study area according to the farmers' in-depth perspective. The case studies allowed for a free discussion directed by the interviewer.

The case studies present essential, qualitative information. Input obtained during the semi-structured interview that revealed major differences of land use in the farms or adjacent protected areas was documented. These results could help to decide what to examine more extensively in future research. Qualitative information mostly involved a relatively brief and detailed description of a topic, including sensitive descriptions of events and farmers' perspectives. This also allowed the farmers to have an opportunity to include any other relevant information as a way of concluding the interview. This caused the respondents to realise that their personal experiences are also significant. The information used in the case studies throws more light on the changes within the typical land use patterns in the study area, as the YES or NO responses were not enough to allow a farmer to express their views at a deeper level.

4.2 Data analysis

The information from the case studies that was generated from the farmers has been presented without much alteration. The remaining results were also analysed separately, according to the division in forest areas, (Mount Kenya and Imenti Forest areas). This process is expected to bring about information that reveals similar land use practices, so as to avoid the effect of large differences in response to land use and land use change practices with land users in the two forest regions.

The data collected was fed directly into the SPSS (Statistical Package for the Social Sciences) version 11.0 data editor, and was used to analyse the quantitative data from the farms adjacent to the protected areas. Initially, the responses were coded according to the categories in the question. For instance in a YES or NO question, the YES was coded "1" and the NO was coded "2" and for cases where no answer was given or the question was intentionally avoided, it was considered missing data and was coded with a 9 or 99. This is a prerequisite in the SPSS program.

4.2.1 Frequencies

During the analysis of the questions, frequencies were used to obtain detailed information on nominal (category) data, which was thereafter represented by frequency bar charts and pie charts. The categories of a data are summarised in groups of cases. The frequencies options include a table showing counts and percentages, statistics including percentile values, central tendency, dispersion and distribution, and charts including bar charts and histograms.

4.2.2 Correlations

Correlation is one of the most common forms of data analysis because it underlies many other analyses. A correlation statistical research method, the *Pearson Correlation* was used to measure the linear relationship between variables such as land use change, soil quality, major land use, household income, and perceptions towards the protected areas. A correlation coefficient has a value ranging from -1 to +1. Values that are closer to the absolute value of 1 indicate that there is a strong relationship between the variables being correlated, whereas values closer to 0 indicate that there is little or no linear relationship.

The significance (2-tailed) – in the results is the p-value that is associated with the correlation (WUENSCH 2005).

A perfect negative -1 (inverse proportional) relationship between two variables means that when one variable increases the other decreases with the same magnitude. A perfect positive correlation of +1 reflects a perfect positive or direct proportional relationship between two variables, meaning that when one variable increases, the other will increase in the same magnitude (BOLMERS et al.2003).

4.2.3 Cross tables

Since frequencies cannot be used to give information about the relationship between categorical variables, the cross tabulation procedure is useful for analyzing this kind of information, as it provides information about the intersection of two variables. The cross tabulation was used to obtain counts that occurred in more than one variable's values. The data output from the analysis were further illustrated in charts, graphs or tables to facilitate the most appropriate display that can visualize characteristics of the results from the analysis procedure.

4.2.4 Remote Sensing

Remote sensing refers to instrument-based techniques used in the acquisition and measurement of spatially organized (distributed) data/information on some property(ies) (spectral; spatial; physical) of an array of target points (pixels) within the sensed scene that correspond to features, objects, and materials. This is done by applying one or more recording devices not in physical, intimate contact with the item(s) under surveillance (thus at a finite distance from the observed target, in which the spatial arrangement is preserved). Techniques involve amassing knowledge pertinent to the sensed scene (target) by utilizing electromagnetic radiation, force fields, or acoustic energy through employing cameras, radiometers and scanners, lasers, radio frequency receivers, radar systems, sonar, thermal devices, seismographs, magnetometers, gravimeters, scintillometers, and other sensing instruments (SHORT 2006).

4.2.5 GIS Tool

Data base in a GIS may contain any type of information that is spatially distributed ranging from socio-economic (e.g., population density), to climatological (e.g., ppm ozone over the city), to fundamental biophysical variables (e.g. surface temperature) (JENSEN 1996:289). This ideally makes the analysis of several sets of data manageable even within large areas of study.

GIS data on the NE Mount Kenya that was already in digital form was acquired from UNEP grid (2004), KWS database (2004), and from the IRLI database (2004) on the NE Mount Kenya area. GIS was used for the systematic data analysis, and for presentation, where Arc map was applied. A GIS was used to emphasize the spatial relationships among the data being mapped. Demographic data, such as population density and household numbers, land use, protected areas, and forest ranges are clearly outlined. The social and ecological data from the organisations was presented in a geographical setting using ArcGis 9.0.

GIS assists in the understanding and patterns of the study area. The GIS data was compiled together to interrelate geophysical factors like soils, land use and population, to find land use conflicts especially within the protected area. Clear borderline definitions of the forests are layered out together with the area specific population densities. This was done by overlaying the different layers so as to come up with a suitable presentation from which one can build adequate conclusions.

The advantage here was that the GIS meet the basic function of map representation. In this case, the GIS data was very appropriate as the applicable information had already been fed into the GIS, and was therefore available and this simplified the addition of primary data from the field study like the land use and settlement changes which could be transferred onto the GIS as an update.

4.2.5.1 Satellite images

The Landsat satellite images used were downloaded from the Maryland University online database. The satellite images include: TM (Thematic Mapper) 1987 February sensors and Landsat ETM+ (Enhanced Thematic Mapper Plus), February 2000. The satellite images were used to assess changes in forest cover over the last two and a half decades,

both within and on the edges of the forest ranges, to complement the physical interpretation of the data already acquired. This method captures large surface areas making it possible to determine comprehensive land use in the study area within the timeframe from 1987 to the year 2000, to complement findings of field observations where accessibility to various sites was encumbered.

The Thematic Mapper is a high resolution seven band scanning radiometer. It has a spatial resolution of 30 m for bands 1-5 and 7, and 120 m resolution for band 6 CIOLKOSZ and KESIK in DENÈGRE (1994) which is a thermal-infrared band. The ETM landsat-7 system is similar to the TM except that there is an added panchromatic band, whereby the resolution remains at 30*30m². The ETM is designed to collect 7 bands or channels of reflected energy and one channel of emitted energy. For any given material, the amount of emitted and reflected radiation varies by wavelength. These variations are used to establish the signature reflectance fingerprint for that material; different objects will have different interactive properties DENÈGRE (1994).

The images were used to illustrate intensified land use regions, increased plantations and vegetation cover changes especially in the protected areas, where vegetation cover was used as an indicator of degradation according to the discussion in UNEP, et al. (1997). These images were all taken during February, which falls in a dry season after the short rains at the end of the year.

4.2.6 Interpretation process

A computer-assisted classification of a digital satellite imagery which is the grouping of a large number of individual pixels into a small, more manageable number of thematic classes or categories was used for the interpretation of the images. The analysis of the satellite images consisted of an unsupervised classification, which enabled the distinction of settlement areas, open areas, and plantations, in forested areas in the NE Mount Kenya region. With the unsupervised classification, the basic premise is that the values within a given cover type should be close together in the measurement space, whereas data in different classes should be comparatively well separated. The classes that result from unsupervised classification are spectral classes SCHONEMAKERS (1995). Thereafter, the classes are assigned to the information group of interest, making it possible to separate the recognisable land use within the study area.

The use of these satellite images was therefore mainly to illustrate land cover changes between the 1987 TM and the 2000 ETM data. The method used for the analysis is the unsupervised classification, which is computer automated in reference to JENSEN (1996) and SRIHARAN et al. (2004). The software applied was ERDAS IMAGINE 8.7 where the unsupervised classification is performed using the algorithm Interative Self Organizing Data Analysis Technique (ISODATA).

In the ISODATA algorithm, the numbers of clusters are automatically adjusted during the iteration by merging similar clusters and splitting clusters with large standard deviations (JENSEN 1996). In this approach, similar pixels are grouped together to form a cluster. The ISODATA repeats the clustering of the image until a maximum number of iterations has been performed, or it reaches the maximum percentage of unchanged pixels in the same iterations.

A trial of several clusters, i.e. 10, 15, 20, 25, tested to identify the most appropriate maximum number of clusters was initially used before the classes were finally merged and recoded. A frequency of 20 classes in both the TM and ETM data was determined whereby the convergence threshold was set to 0.95 (95%), which is the percentage of pixels whose class remain unchanged between successive iterations. A maximum of 10 iterations, which were enough times to produce meaningful mean vectors, was assigned to the ISODATA algorithm. After the first iteration, a new mean for each cluster is calculated based on the actual spectral locations of the pixels assigned to each cluster, instead of the initial arbitrary calculation (JENSEN 1996:238).

The images are represented and interpreted on a false colour base, with the infrared composition bands red, green and blue (RGB): 4, 5, and 6(7). Special focus was given to vegetation changes in the protected areas and land use intensification within and adjacent regions of the protected areas. The images efficiently cover the forest areas in the 2 chosen time series. Here, the forest vegetation cover acts as an integrator of the biological properties of the study area. Forest vegetation cover between 1987 and 2000 helps determine the distribution of vegetation both in the protected areas that are being managed for conservation, and the adjacent farm lands. Vegetation also represents changes of plantations in both regions, displays possible encroachment (settlement and open areas) in the protected areas, and makes visible any intensification of land use in the study area.

The pixels of the images were distinguished from the raster data layer by changing selected rows, and the entities were grouped into specific land cover classes. These included forest, open grasslands, towns, settlement areas, plantations and cultivated areas that could be distinguished. For more accuracy, this information is used together with available field data collected in specific parts of the study area as well as available GIS spatial data. This is useful where tone reflection in the use of satellite images was not totally favourable. The selected areas were those accessible by road, whereby a description of land use and degradation indicators was recorded.

5 NE Mount Kenya Regional Analysis

This chapter outlines the historical, social, economical and structural context of the research area in reference to land use. BERNARDI (1989) has listed the ethnic sections (subgroups) of the Meru folk, and the areas of Meru that they occupied. Bernardi further states that the Meru form a single folk of people who generally regard the forests of Mount Kenya as their original abode. The inhabitants of the study area in Meru Central and Meru North Districts are predominantly Christian which reflects the work of missionaries in the colonial period.

The Meru, (also known as the Ameru) constituting of 6% among Kenya's largest ethnic groups (CIA 2004) are the major ethnic group of the NE Mount Kenya region. They practise mixed farming, which includes crop cultivation and animal husbandry. The majority of the farming is carried out on privately owned land. There are many small-scale farms which range from 0.12 ha to 12 ha, while large-scale farms go up to 700 hectares (ROK 2001a, BEENTJE 1990).

5.1 Historical perspective of land use

The historical issues presented are crucial in order to obtain a background that contributes to explaining the perception of the Meru land users today. SPECK (1983) states that although no information is given about the settlement era of the Meru (Bantu) in the Mount Kenya area, it is clear that the region is suitable for agriculture due to the tribal settlement distribution which includes the Kikuyu tribe in the west and south, the Embu in the south east, and the Meru in the Eastern part of the mountain, who are all mainly arable farmers. The soils formed from volcanic deposits, in the high potential agricultural region was known as the "White Highlands" before independence, and this area was set aside explicitly for white settlement, where European commercial agriculture was the main focus (KOHLER 1986, YEAGER, 1986, PROTHERO 1972). The historical use of these regions has been strongly influenced by the British settlers. In the Northern part of the mountain area, there has been no forest vegetation cover and unfortunately no data available on this factor, so the reason remains unknown (KOHLER 1986). KOHLER however suggests that human land use impacts, that included the burning of grazing areas, could have destroyed that part of the forest, or even made the land completely unproductive (KOHLER 1986). It is however noted that settlement in

central Kenya by Bantu speaking peoples was accompanied by extensive clearing of primeval forest (MURIUKI (1974) quoted in CASTRO 1995:26).

5.1.1 Pre-colonial and colonial era

Protectorate officials passed regulations governing forest use as early as 1897, but a forestry bureaucracy was not formed until 1902. Kenya adopted a similar model to the centralized and custodial oriented forest administrations established in India, South Africa and other parts of the British Empire (TROUP (1940), GUHA (1990) cited in CASTRO 1995:66). The 1902 and the 1911 ordinances severely restricted local use of state forest lands, and they prohibited dwellings, cutting trees, setting fires, farming or herding in the forest without official authorization. It also prohibited goats from grazing in the reserve, whereby violators faced jail or fines (CASTRO 1995:67). This was basically a measure to ensure that the forests were protected and not exploited to the point of depletion.

After 1908, there were increased restrictions on movement. This meant that boundaries of each location were mapped out and designated into small-scale native reserves whereby a form of pass system was introduced. Natives were forbidden to leave their own locations for any reason, except with the permission of their chiefs. If they travelled outside their designated areas, they were required to carry a chiti (chit, pass) proving their right to do so. No one was permitted to travel uphill into the forested areas, which were reserved for the crown, and travel in any groups of any size was totally forbidden. Seasonal movement of cattle to the star-grass areas was prohibited (FADIMAN 1993:144).

The forest had indigenous communities who were permitted to have small plots in the forest reserve as they helped out with duties like land clearing, tree planting, road maintenance and nursery upkeep (CASTRO 1995). This was a system that continued to be used in the NE Mount Kenya study area until very recently, 2004. Nevertheless, the combination of tree planting and farming in the forest area remained intact. In this system, forest areas were totally cleared and prepared for the second stage by forest workers who were by then changing to arable farming. After at least 1 year and a maximum of 4 years, the areas were afforested with 98% exotic trees, mainly pine

(OJANY et al., 1973 cited in SPECK 1987). This technique insured a continuous supply of raw materials, and the provision of crop food with reduced pressure on natural forests.

In Meru, Kikuyu land owners were known as “tree eaters” because of their propensity to clear land of all tree cover prior to cultivation. In contrast, the Meru held all trees in common, except those planted by individuals, and cutting down a tree required communal permission from an appropriate local organisation “kiama.” British officers and Meru elders thus shared a common concern when during the late 1930s small bands of Kikuyu moved into the border region between the star grass (populated) and black (mountain) forest zones and began to farm. In Meru strips of land immediately beneath the lower forest rim had traditionally been protected, by Njuri (highest council in Meru) proclamation, from cultivation, woodcutting, grazing or any other activity that might harm trees. The result was the creation of an unmarked but universally respected buffer zone between human activities and the forest (FADIMAN 1993:344).

At that time, uses of the Mount Kenya Forest included forest rubber extraction, farm labor, sawmills, fuel wood contractors, beekeeping and honey hunting. Early proponents of opening Mount Kenya to industrial forestry had emphasized the possibility of selling timber overseas. Wood exports began in 1920, but Kenyan sawmills found it difficult to compete in world timber markets. High production and transport costs, plus poor communication, hindered their efforts (LOGIE 1962, cited in CASTRO 1995:72). In addition, colonial policy encouraged the introduction of exotic species to replace indigenous ones. With regard to forests, indigenous trees were cleared to make room for exotic fast growing species which ensured the continual flow of timber both for use within the colony and for exportation to the colonial power. (Colony and protectorate of Kenya (1931) quoted in KAMERI-MBOTE (2002:65).

During the 1930s, the white highlands comprised a total of 43,253 km², and the onset of the Second World War led to a substantial increase in the demand for timber, fuel wood and other forest products for the expanding timber industry. In consequence, after the war, forestry officials acknowledged that wood extraction from government reserves had been exploited (OJANY and OGANDO 1973). Large scale forest exploitation for timber began in earnest during colonialism and reached its peak during the construction of the Kenya-Ugandan railway line with the need for wood rising to meet both fuel and timber needs. Previously, exploitation of indigenous forests was restricted to removing small

amounts of timber from the forest for house construction and fuel (ONGUGO and MWANGI (1996) quoted in KAMERI-MBOTE (2002:112).

5.1.1.1 The missionaries

Throughout the duration of the age of the early Christian missionary in Meru, spirit forests existed everywhere. They were sacred in that they were reserved for the ancestors. These forests consisted of dense tracts of vegetation and woodland, surrounding a gigantic wild fig tree. The fig tree was the most sacred point within the grove and home to the spirits that lived around it. The Meru did not allow hunting, livestock grazing or even cutting of wood in those forest areas to avoid being cursed (FADIMAN 1993:208). However, after the missionaries had secured their land, Horne (A British conqueror of Meru) strongly supported the efforts of the Catholics and the Methodists by giving them a government grant of unlimited logs from the Imenti Forest for the construction of church buildings (FADIMAN 1993: 211).

Mount Kenya contained several traditional ritual sites where sacrifices to "God" were performed to ensure local prosperity. When the forest reserve was established, the men whose duty was to carry out the rites continued to go "by stealth over the old boundary offering the sacrifice as of old" (KLC (1934:96), cited in CASTRO 1995:53). The forests were also used in ceremonies marking important rites of passage to adulthood like circumcision, which is a very important custom in the Meru tribal customs (BERNARDI 1989, WANGARI 1995). It is interesting to note is that in the early 1900s the women were given no voice in decisions FADIMAN (1993). This factor is reflected in the land use decisions in the study area to date.

The first alterations of the forest boundaries took place in the 1950s, and this process was under the colonial administration. Throughout the colonial period, land was repeatedly excised from African areas whenever the colonial administration thought it was necessary, and areas boundaries were also placed in protected areas in order to stop the migration into new agricultural regions (ACHOLA 2001). This must have supposedly only created more conflict, especially because the protected areas were a lot larger in size than the areas the natives were allocated.

The Kenya land commission had proposed placing forest reserves entirely in the white highlands under the control of the highlands board, whose main function was to protect

the economic interests of the European farmers (CASTRO 1995:85). Cereal was grown in large farm areas as an easy and fast way of making money. In this event, the negative impacts of monoculture on the soil occurred, which then called for an introduction of crop rotation. This allowed land to lie fallow, while increased crop and animal husbandry was advocated in the white highlands (ACHOLA 2001). At the time however, small-scale farming was still popular among the local communities in the Mount Kenya area, as the living standards were still very low, and subsistence farming was needed to cater for each family member. A case in point is that even during this period, government leaders were already addressing, and demonstrating the benefits of, soil conservation (see ACHOLA 2001).

5.1.2 Independent Kenya

Mount Kenya and its reserved areas remained a prohibited area until 1958, and entry controls remained in effect even after independence, in 1963. However, there were cases of people still violating forest regulations. The forest department management strategy nevertheless served as the basis for the independent Kenya, as the policies and administrative structures remained the same (CASTRO 1995). The reservation of the highlands for Europeans by administrative practice was ended by the Land Control Regulations made in 1961 under the authority of the Kenya Land Order Council in 1960 (PROTHERO 1972:211).

In precisely the same way that human impact is considered a threat to natural resources today, it was believed that man living in domestic domiciles was the most dangerous threat to the reserve, and this remained a central tenet of forest policy. Regardless of this fact, the restriction on local forest access was eased by the government of the first president of Kenya, Jomo Kenyatta. In February 1965, the government relaxed the rule requiring a permit to enter the forest. The government however retained long-standing restrictions on removing forest products, grazing, and other uses of the forest reserve (CASTRO 1995).

There were relatively few cases of forest destruction through the years that followed including the 1970 and early 1980s and CASTRO (1995) implies that this was due to the availability of fuel wood at a very low price under the terms of which prices had barely

changed within a period of 50 years. The tickets to access the forest were widely affordable.

Although the governing administrations of Kenyatta and Moi often pledged their support for the continued conservation of Kenya's forests, there had been mounting demographic and economic pressures to excise state forest lands for agricultural purposes (CASTRO 1995). Interestingly, the forest department staff, and the forest guards were not strict with regard to who utilized the forest and record keeping was casual and not properly maintained. These are traits that are also evident today.

On the other hand, in February 1985, the Ministry of Environment and Natural Resources announced a plan to grow tea in the nation's forest reserves, whereby the scheme called for creating a 100 m belt of tea on gazetted land along the rim of the Kirinyaga and Meru areas among others (CASTRO 1995). These tea zones were purposely set up to serve as buffer zones by limiting encroachment from the local communities.

Therefore the changes in land use in the Mount Kenya area were basically brought about by colonialism as that was the time period when the Kikuyu, Meru and Embu tribes started changing their farming methods from growing food crops to adapt to the growing of cash crops. In the 1950s the first alterations of the forest boundaries started taking place under the colonial administration. This was long before population pressures started expanding in the county as a whole. Therefore, the change in land use from subsistence to cash crop (monoculture) farming with economic gains as a goal, could have definitely contributed to the degradation of soil or exhaustion of soil at that time already.

5.2 Land tenure

Kenya is a free market economy where land tenure gives the individual access rights, usage rights, and thus mastery over the environment (UNEP et al. 1997:117). In the study area, customarily heads of families have always subdivided land as their children grew older and were ready for marriage but this practice is unfortunately not effective as the actual size of farms decreases with each generation.

Agricultural land ownership in the white highlands became available even to the native Kenyans in the early 1960s, as already stated. Allocations were made to various households. Today, in the Mount Kenya region, individuals, local authorities and the

state own land. The government has not changed the land tenure system. On privately owned land, the landowners are allowed to develop their land according to their desires and interests, while other open spaces for recreation, schools, and hospitals is compulsorily acquired for public utilities (ROK 1989:97).

The Ministry of Lands and Housing in Kenya provides land administration services to assist in regulating the subdivision of land, changes of land use, allocation of land, and dealings in agricultural land through land control boards, planning of land use in urban areas and keeping records of dealings in registered land. However, the Meru District response to these national policies of the ministry has been very poor due to a number of factors. One of these are: the Districts indigenous population, which has been over-sensitive on land issues and therefore tended to overreact even on small issues. This has slowed down the pace of land adjunction in the District with the result that areas declared 20 years ago have not been able to get their titles due to the number of land adjunction cases that have been filed. Common property resource management schemes sometimes fail in regulating users of resources due to population increase, policy failures and the expropriation of resource rights and ownership by individuals (KAMERI-MBOTE 2002:29). The second factor is: some sections of the District's population lack the awareness of the need to have their lands demarcated and registered and therefore have not co-operated with the adjunction committee (ROK 1989:97). These reasons plus the frequent fragmentations, the dispersed settlement patterns, and poor infrastructure could account for the delay in defining boundaries.

5.3 Socio-economic system

Subsistence agriculture involving mixed farming of crops and livestock is the main economic activity in the Meru central District. The small-scale agricultural sector is the largest source of employment in Kenya absorbing over 51% of the labour force (FAO 2004). Both food crops and cash crops are grown in the Meru area. The most important cash crops include coffee, tea, wheat, barley and tobacco. The staple crops include maize, beans, millet, potatoes, green grams, arrowroots, bananas, vegetables and yams (see ROK 2001a).

Today, socio-economic pressures from the demographic expansion, equitable access to available land resources and the availability of alternative sources of livelihood that reduce direct dependence on land for subsistence can therefore be good indicators of the

probability (risk) that the available land resources will be exploited beyond their carrying capacity resulting in degradation (UNEP et al. 1997:8). The forest ranges have a traditional value among the Meru, and in earlier years, the forest was quite intact and well conserved through traditional laws. Given that a large proportion of the country's biodiversity occurs in forests, forest areas should comprise an integral and major part of an effective protected areas system (WASS 1995:20).
A decline in the cultural and religious beliefs saw an increase in the destruction of the forest (UNDPa 2004). In the study area, the Lake Nkunga was considered sacred; elders would stop by on their way to the top of the mountain and wash their hands and feet in its holy waters.

The typical rural settlement homes of the Meru are made from wooden walls and iron roofs, whose construction is the responsibility of the men. Authority among the Meru is represented by the elders (men) and the man in the family is the only person entitled to speak for the family as a whole (BERNARDI 1989). Women in the study area take a more active part in all farm activities compared to the men. Women are primarily responsible for domestic chores like collecting firewood, the preparation of food and fetching water. On the farms, they tend the livestock, prepare the land for planting, weed, grade and sort the harvest, and market locally. However, they are not usually responsible for decision making on the use of the farm areas.

5.4 Utilization of protected areas

The Mount Kenya Forest catchment supplies water for the Meru town region, the market places, for irrigation on the farms and for domestic uses. Unfortunately, the generation of hydro-electricity in the Tana into which all the rivers in the study area flow is endangered by increased sedimentation, which might well have been brought about by expanded and intensified land use in the catchment area (KOHLER 1986:102). Apart from that, the growing water problems caused by the consumption of water on the slopes of Mount Kenya, hindering it to reach downstream have led to conflicts between both small- and large-scale farmers, cultivators and pastoralists, the wildlife, and the community as a whole (MOUNTAIN AGENDA 1998). The benefits of the forest protected areas consists

of both ecological and "social-economic" values, and therefore the local communities living next to the forest play a large role in its conservation matters.

In the protected reserve areas, conservation regulations have not been strictly observed and evident to this is the destruction of the Imenti Forest. In the study area, detailed maps found in the forest stations have been developed to simplify management, and specified areas where the community can use the forest are clearly illustrated. This information is further provided to the public who utilize the forest resources. The period of utilization and degree of use is also stated on the licences. Forest authorities supervise these activities. This approach is supposed to reduce the exploitation of the protected areas (personal communication with KWS Meru Station warden - Gathiari).

5.4.1 Encroachment and illegal activities

Mount Kenya Forest was one of the first Kenyan forests to be logged commercially, supplying sleepers for the construction of the Uganda Railway as well as providing for the timber needs of an expanding colonial administration and settler population. From the aerial survey undertaken by the KWS in 1999, (GATHARA 1999), it was clear that the 1986 presidential ban on logging had little effect, and as a result a new ban was placed in 1999. Reduction or loss of biological productivity and complexity of ecosystems or vegetation is an important indicator of land degradation (UNEP et al.1997:42). The alteration of ground cover by human activities is probably the greatest cause of increased erosion rates throughout the world (JOHNSTON and LEWIS 1995). As a result, the abundance, productivity, species composition and canopy structure of natural vegetation are valuable indicators of land quality (UNEP et al. 1997:7).

The presence of many stumps of *Juniperus procer*a in the Mount Kenya Forest and the various gaps in the respective canopy regions indicate that the Cedar has been removed only recently by logging for timber and had previously been an abundant canopy species with a cover of about 25% before (BUSSMANN 1994). The loss of indigenous forest to encroachment and destruction of the forest reserves by agriculturalists and also fire is not a new issue in the study area and was been present even in the early years before independence (see BAKER 1967). This has caused great disturbance of the natural balance of the ecosystem, where ecological threats occur as it may the influence wind, temperature and rain in the area.

5.4.2 Management

Elements that have been identified as essential in a strategy for the sustained management and conservation of Kenya's indigenous forests include policy and legislation, institutional support, local participation, reduction of pressure on indigenous forest resources and control of exploitation (WASS 1995:5). When it comes to planning and development, the involvement of the community in development planning at the local level still seems to be a struggle as it was in the early 1970s. LEONARD (1973) noted that any attempt to bring about village democracy would have to start by strengthening the local communities and relevant institutions. The work of the Ministry of Agriculture extension workers consists primarily of visiting individual farmers and providing them with information and services (LEONARD 1973).

The District wardens from the KWS in Meru station are responsible for both the Central Meru and North Meru Districts. The forest department liaises with the administrative areas and the KWS in the study area especially to help provide forest plantation areas in the buffer zones of the protected area. The KWS has only been able to undertake limited activities for the long-term planning, management and monitoring of wildlife and biodiversity in the protected areas. Staff constraints as a result of the continuous demands for control of the movement of wildlife outside the protected area; have limited the capacity of the KWS to engage in community conservation programmes and rehabilitation of indigenous forests (personal communication with KWS Meru Station warden -Gathiari).

The phases and management of Mount Kenya Forest have come from the growing state regulation of forest, gradual loss of community rights to manage and utilize forest, increasing national, commercial and local exploitation of forest, rapid forest degradation from the early 1900's to the 1980's to a shift of community conservation paradigm in the 1990's (EMERTON 1999:3). From the aerial survey undertaken by the KWS in 1999 (GATHARA 1999), it was clear that the 1986 presidential ban on logging had little effect, and as a result a new ban and shift of management was put in place in 1999. Evidently the forest resources are not used only by the local communities adjacent to it, interest from the outside boundaries is on the rise. RHEKER (1992) notes that it has become clear that the Kenya Forest Policy based on the principle of sustainable utilization of forest areas for conserving their ecological and economic functions

generates conflicts between production and protection, although of course only the protected indigenous or planted forests will persist as sources of raw material.

In the study area, there is construction of electric solar fences like the Kithoka, Mukundu area fence which is 30km, and the Naari fence which was completed in 1996. The solar fences have reduced the number of conflicts with the wildlife, which have been a major problem in the Imenti Forest regions, in the Northern part of the study area, where there is no fence (personal communication with KWS Meru Station warden -Gathiari). In parts of the Mount Kenya Forest area, belts of tea plantation are used to reduce encroachment into the forest regions (photo 1).

Photo 1: Buffer zone in the Mount Kenya Forest region

Solar fence combined with a tea belt with the forest region in the background. The buffer zones assist in protecting the forests from human encroachment, while at the same time averting human wildlife conflicts (C. Mugo, August 2004).

5.4.2.1 Management constraints

Although human interference towards the World Heritage Site (Mt. Kenya National Park) that lies on Mount Kenya is low, there is vegetation destruction in the gazetted forest area at lower altitudes (BUSSMANN 1996). The threats to the forest area are thought to be similar to other areas of indigenous forest in Kenya which consist of the factors already mentioned (illegal logging, firewood collection, charcoal burning, settlement and encroachment).

The forest department itself lacks financial autonomy. Revenues earned from the forest reserve flow to the central government, and budgetary allocations returned to the management of the Mount Kenya Forest Reserve are not linked with these earnings. Establishing a clear mechanism for retaining the revenues earned by Mount Kenya Forest could enhance the financial accountability and sustainability of the government forest management (EMERTON 1999:17). Since the Forest Department works on a very limited budget, and they have to largely rely on the cooperation from the communities they prioritise ensuring that the communities are involved in their projects. They have groups that are responsible for the upkeep of the tree nurseries, usually women at the DFO headquarters in Meru town, while the men sometimes also have the authority to patrol and make sure that there are no illegal uses such as poaching, grazing without permits and even charcoal burning within the forest. In reciprocation, they are allowed to collect firewood for their personal use (personal communication DFO Meru station-Abuto).

The KWS employees within the study area claim that they lack enough staff, and even enough vehicles for mobility in the area, which is necessary to balance the requirements of the communities as well as to conserve the forest and its biodiversity (personal communication KWS warden Meru station-Gathiari).

Infrastructure is the issue that aggravates the problems of managing the protected areas and the adjacent regions. Great deficiencies in telecommunication contribute to the infrastructural misery of the forest stations at Mount Kenya. Some stations do not possess a telephone at all; elsewhere they are often out of order or disconnected (RHEKER 1992:29).

5.5 Impact of population on land use

Demographic changes in a region tend to have an impact on the way the communities use their land, while on the other hand, land use could also impact on the demographic development in the region. About 26 million Kenyans derive their livelihood directly from land-based natural resources as farmers, herders, gatherers and quasi industrialists. This search for economic security based on limited resource endowment has directly translated into steep consumptive pressure on the natural resources (MWICHABE 2000:1). Kenya's population is reported to be depleting its natural resources faster than the country is saving and investing its benefits for the future which has an impact on the government's provision of social services (ROK 1999:96).

So far Kenya has had a total of six censuses (table 2). The first two held in 1948 and 1962, were organised by the colonial government, while the decimal censuses, since 1969, have been carried out in the independence era (ROK 2002:1).

Census	**Population**	**Percentage Increase between censuses**	**Rate of Growth per annum**
1948	5497599		
		57.1	3.2
1962	8636263		
		26.9	3.4
1969	10956501		
		39.9	3.4
1979	15327061		
		39.9	3.4
1989	21448774		
		33.6	2.9
1999	28660534		

Table 2: Kenya population census totals 1948-1999
Source: Republic of Kenya (2002)

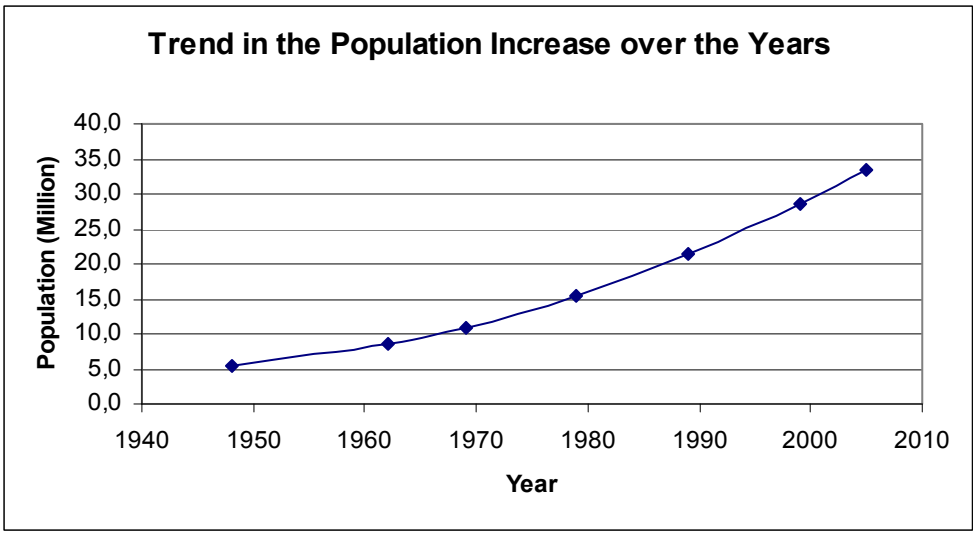


Figure 12: Population trends
Source: ROK (2002)

Figure 12 shows that Kenya's population has increased nearly six fold in the fifty years, 1948-1999. The figures show the total population counts obtained from the seven censuses of Kenya, with the inter-censal rates of growth declining only slightly (ROK 2002:58). Kenya's population growth rate of 3.3% per annum is having a major impact on both food availability and the proportion of the population at risk of deficient nutrition (UNEP et al. 1997:114).

To better understand the socio-economic and environmental settings in the NE Mount Kenya area, a reflection on land use and demographic changes is useful. Most importantly, the fertile Andosols and Nitosols in the study area that promote agriculture have created a basis for the migrating communities in search of better livelihoods. In the Mount Kenya area, more than 200,000 people live within 1.5 km of the edge of the forest, where levels of rural poverty are high and land is extremely scarce (EMERTON 1999:1). Most farmlands in the country are found in the high potential agricultural lands. More than a quarter of the country's wood supplies are located in the high potential areas, whereby most of these resources are in protected forests regions (UNEP et al. 1997:78).

5.5.1 Implementation of GIS

Spatial information that has been referenced in the study area reveals where deforestation and the socio-economic changes and pressures have taken place. The attribute data also

makes it possible to provide additional information concerning particular areas which can then be mapped out to analyse the geographic information. The GIS also provides base information for assessing land use and the changes over the years.

The Meru District has undergone various administrative divisions since the 1970s at both Locations and sub locations, with some areas retaining the same names while others gaining a totally different name. The sub-division of the Districts resulted in the creation of new divisions, Locations and also Sub-locations. This complicates the simple indication of population trends between the regions on a simple illustration. Nevertheless, in the NE Mount Kenya region, the following can be clearly drawn out from the demographic data:

The 1979 Location census, the 1989 and the 1999 population censuses were acquired from the ILRI and UNEP GIS data. The original data source was from the Kenya Central Bureau of Statistics (CBS) whereby the 1979 population census showed coverage done at the Location level. The 1989 and 1999 coverage represented total populations numbers, and population density, as well as households and household densities done up to the sub Location level, which is the smallest administrative unit in Kenya. The data shows a distinct increment of high population densities on much smaller areas of subdivided land at District level, Location level and also the Sub-location levels as figures 13 and 14 illustrate. The figures represent the density of people in the Location/sub location per km^2.

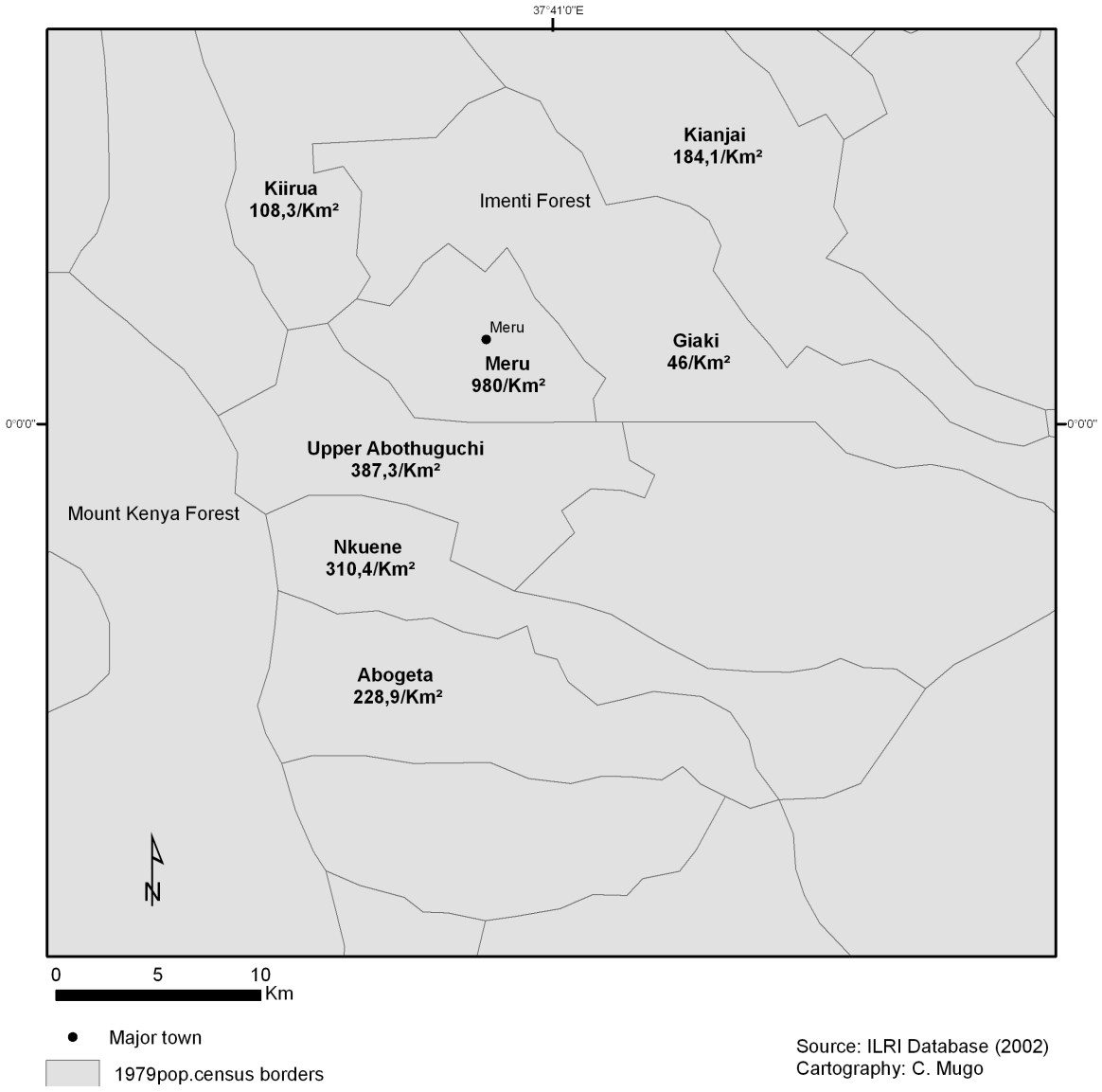


Figure 13: GIS illustration 1979 population density

The population density figures on the map represent the Location/Sub-Location areas adjacent to the Mount Kenya and Imenti Forest protected forest regions in the study area.

In 1979, the Nkuene region had a population density of 310.4 people per km² (310.4/km^2) which went up to 622 people per km² in one decade. Note that this figure represents a subdivided area of the former Nkuene regions, which represented 131.1 km² in 1979 and 16.5 km² in 1989 within the Meru District. Giaki had a density of 46 people per km² in 1979 within an area of 225.1 km² and the figure rose up to 189 people per km² in 1989 in an area of 42,8 km²(compare tables 3, 4 and 5). The major town in the study area (Meru) which partly lies in the protected regions of the Imenti Forest also shows a great increase of population density from 980 people per km^2 in 1979 to 1,306 people per km² in the 1999 census. Settlement and building are concentrated in the major town

(Meru), which naturally has the highest number of households and density in the study area.

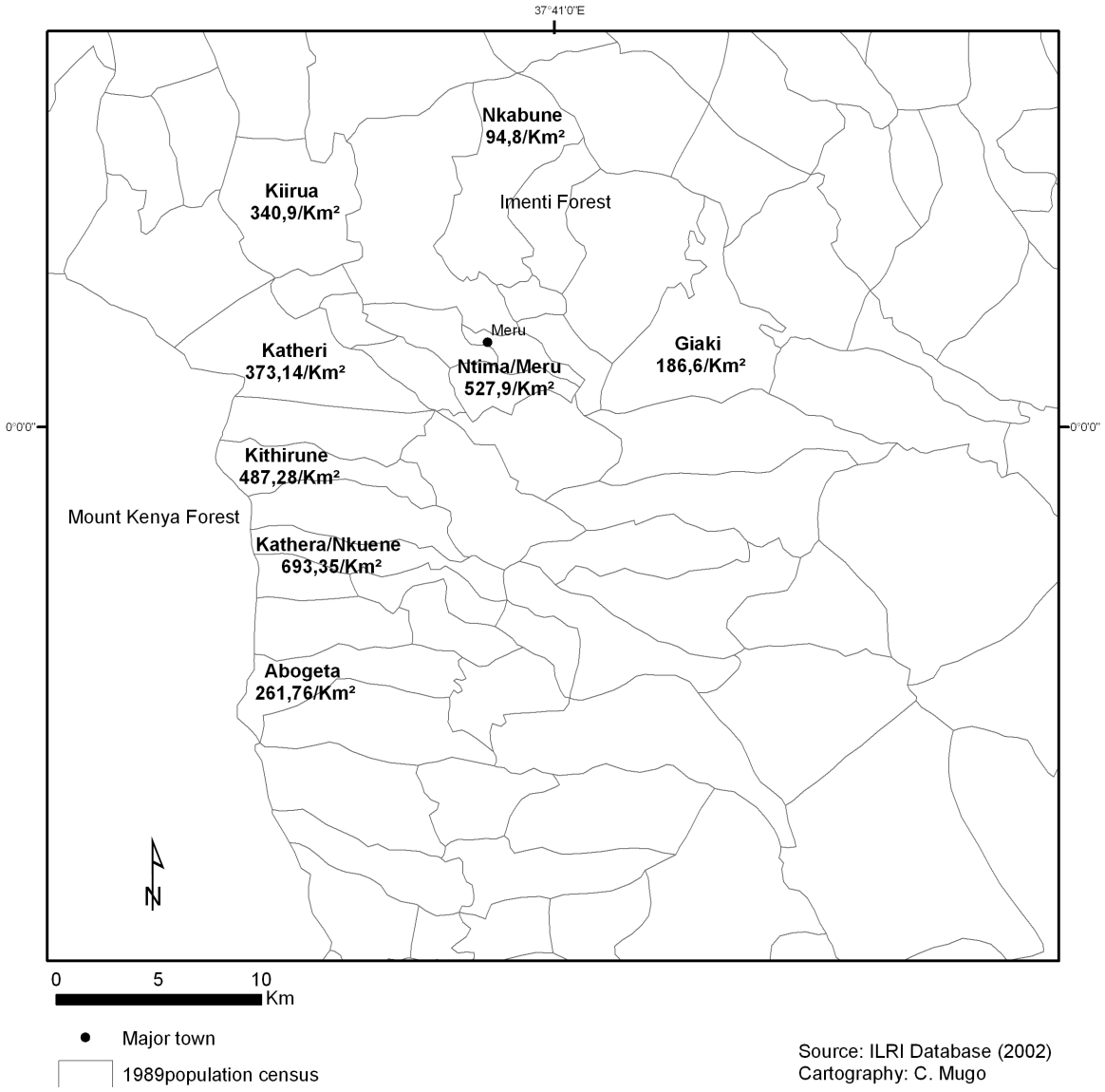


Figure 14: GIS illustration 1989 population density

As presented in figure 13, the population density figures on the map represent the Location/Sub-Location areas adjacent to the Mount Kenya and Imenti Forest protected forest regions in the study area.

An increase in population density brings about an increase in agricultural land use which also leads to less fallow periods; therefore the fertility of the soils is not maintained. Furthermore, degraded land also forces population displacement whereby hundreds of thousands of hectares are abandoned because of being too degraded for cultivation or even grazing. This may mean that the population which depended on those areas for subsistence must seek other lands to settle on (UNPOPIN et al. 1995).

Location/Sub location	**Area (km^2)**	**Density (people/km²)**
Abogeta	139.3	228.9
Giaki	225.1	46.7
Meru Municipality	73.4	980.3
Nkuene	131.3	310.4
Upper Abothuguchi	120.5	387.3

Table 3: Site-specific densities 1979
Source: ILRI database (2002)

Location/Sub location	**Area (km^2)**	**Density (people/km²)**
Kithangari/Abogeta	23,5	261,7
Giaki	42,8	186,6
Ntima/Meru	9	592,1
Kathera/Nkuene	16,5	693,3
GithoNGO/Abothuguchi	21,2	334,9

Table 4: Site-specific densities 1989
Source: ILRI database (2002)

Location/Sub location	**Area (km^2)**	**Density (people/km²)**
Abogeta	148,5	381
Giaki	20	224
Miriga Mieru /Meru	53,2	1306
Nkuene	131,4	415
Abothuguchi West	147,1	381

Table 5: Site-specific densities 1999
Source: ILRI database (2002), ROK (2001)

Settlement areas become scarce due to rising population pressure, which exerts increased pressure on the neighbouring protected areas. Since the government eased forest restriction access, both marked and unmarked buffer zones between human activities and

the protected regions were broken. This facilitated the clearing of indigenous trees, as there was a need of more agricultural and farming land.

5.5.2 Use of firewood

The population census revealed that firewood, paraffin and charcoal continued to be the main sources of cooking fuel in Kenya. At a national level, 69% of the households used firewood as the main cooking fuel with a significant proportion (84%) in rural areas – a drop from 73% in 1989 (ROK 2002a :43). In Meru 90% of the people depend on both firewood and charcoal for cooking and heating energy (WANGARI 1995:57).

In the Mount Kenya area, electricity is either not available or too expensive. The high demand for fuel wood within the region is met by the sale of two kinds of licences: while the so-called "monthly fire wood licence" authorizes a private person to collect one head load of firewood per day, merchants or institutions may acquire annual licences. In the case of annual licences, sale and pricing are done on the basis of stacks (one stack is about $3m^3$) charges being higher for the better burning indigenous woods (e.g. olive) than for the exotic ones (RHEKER 1992).

Excessive removal of wood for fire removes vital resources from the forest, as well as nesting material and shade for many species. Human demands on forest resources have resulted in wood deficiency leading to increased dependency on costly imports. Dependency on firewood also causes people to walk further and spend longer hours in search of wood to meet their daily requirements and they are therefore turning to alternatives (UNEP 2002:142).

5.6 Impact of agriculture on land use

Of all human activities, agriculture is the most sensitive to both weather fluctuations and climate change (BURROUGHS 2001:128). Prior to independence, the success of government settlement schemes in Meru was attributed to the farmers' greater willingness to innovate and strong government efforts, where the Meru adapted to principles of modern farm management, crop rotation, growing pure stands of crops, planting on the contour, use of fertilizers etc. (PESTALOZZI 1986) when the white highlands were very fertile.

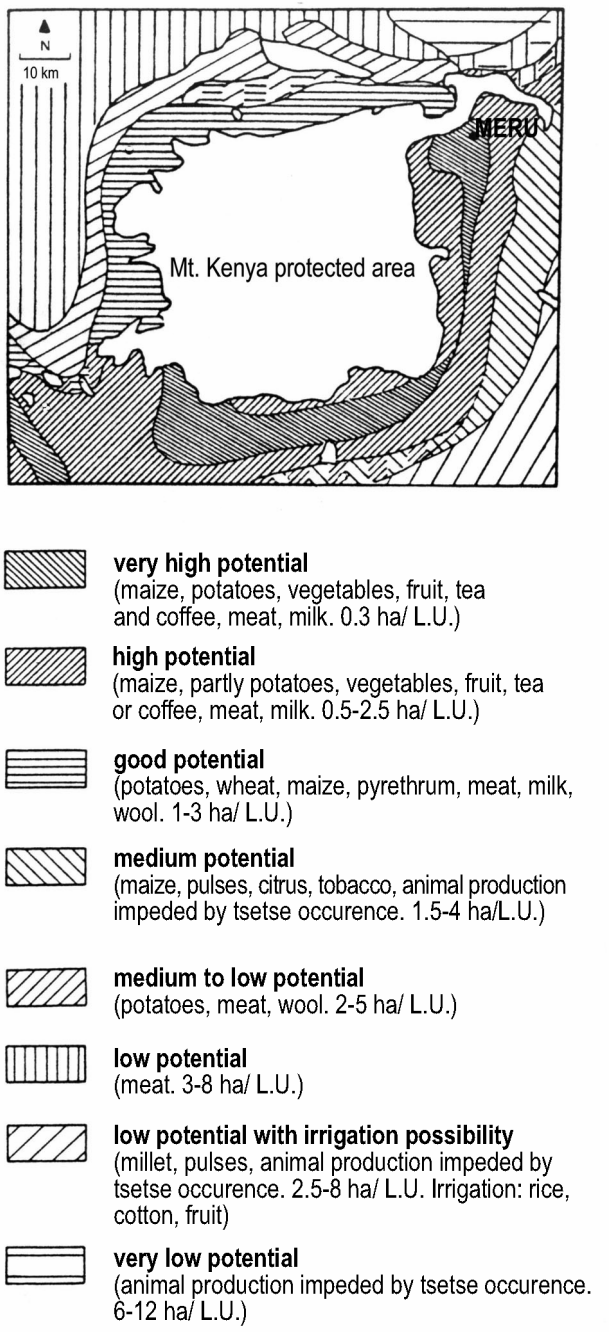


Figure 15: Classification of land use potential in the Mount Kenya region
Source: PESTALOZZI (1986) (modified)

From a land use classification by PESTALOZZI (1986:112), the region the study area represents has been classified mainly into very high, and high potential regions, where cash crops like tea and coffee are grown (figure 15). Small areas to the east and north are of good potential, medium potential to low potential. The low potential areas however have irrigation possibilities (PESTALOZZI 1986:112).

The growing of coffee, tea, potatoes, and maize in the Meru area has also led them to be important income generating crops, and their growing fields are dominant both along the Mount Kenya Forest regions as well as the Imenti Forest regions. Coffee is widely grown in the Western part of the Mount Kenya region, and partly in the Imenti Forest region where the land is suitable (figure 16). However the majority of the coffee in the Mount Kenya area is grown within the southern region of the mountain.

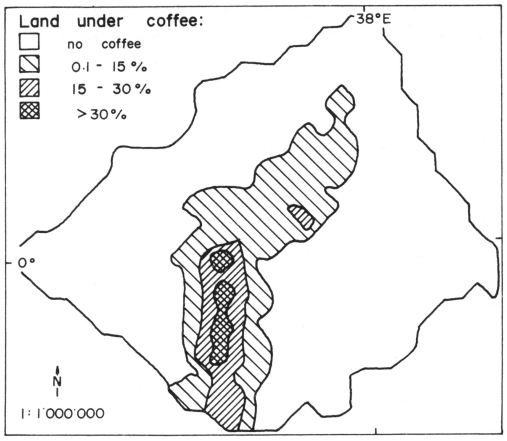


Figure 16: Land areas under coffee cultivation in Meru District 1985

The distribution of land under coffee cultivation in Meru shows a concentration of cultivated areas within the central regions of the District in the upper midland zones where annual temperatures range between 18 and 21°C.
Source: SINANGE (1989)

5.6.1 Agro-ecological zones in the study area

According to ILRI GIS data based on the Farm Management Handbook of Kenya, digitized by KSS (Kenya Soil Survey), Kenya Agricultural Research Institute (KARI), Jaetzold and Helmut Schmidt, Volumes 1-3, Kenya Ministry of Agriculture and German Agricultural team of GTZ (1983), the agro-ecological zones in the country have been classified according to temperature belts (maximum temperature limits within which the main crops of Kenya can flourish) and the main zones meeting the climatic yield potential. This distinguishing factor is used to provide a framework for the ecological land use potential i.e. temperature and crop suitability.

From a general coverage showing land use classes derived from Landsat data by the Japan International Cooperation Agency, JICA, and National Water Master Plan Kenya

compiled by ILRI, the study area can be divided into two categories: dense agriculture on the Western side (Mount Kenya Forest) and sparse agriculture on the Eastern side (Imenti Forest). The agro-ecological zone classification in the study area ranges from UM1 (Upper midland – humid area) in the Kithirune region in the Western part of the study area, to LM3 (Lower Midland – Semi-humid) in the Giaki in the Eastern area (figure 17).

Agro-ecological zones in specific sites of the study area from figure 17 include:

Location in NE Mount Kenya	Agro-ecological zone
Githongo	Upper Midland coffee, tea zones
Nkuene	Upper Midland, main coffee zones
Nkunga, Lake	Upper Midland, marginal coffee zone
Ruiri	Upper Midland maize zone
Kiiura	Lower Highland wheat zone
Muchene	Lower Highland, maize zone

Table 6: Area specific agro-ecological zones

From the data, the most dominating part of the study area is characterised by the upper midland temperature zone. Temperature increases gradually eastwards of the study area where the Northern areas merge and are transitional. Tea and potatoes are popular in the humid and sub humid zones in the Mount Kenya Forest regions. In the transitional zones in the study area, (Ruiri and Kiirua) livestock keeping which is on the increase and the growth of more tolerant crops like maize and groundnuts are favoured.

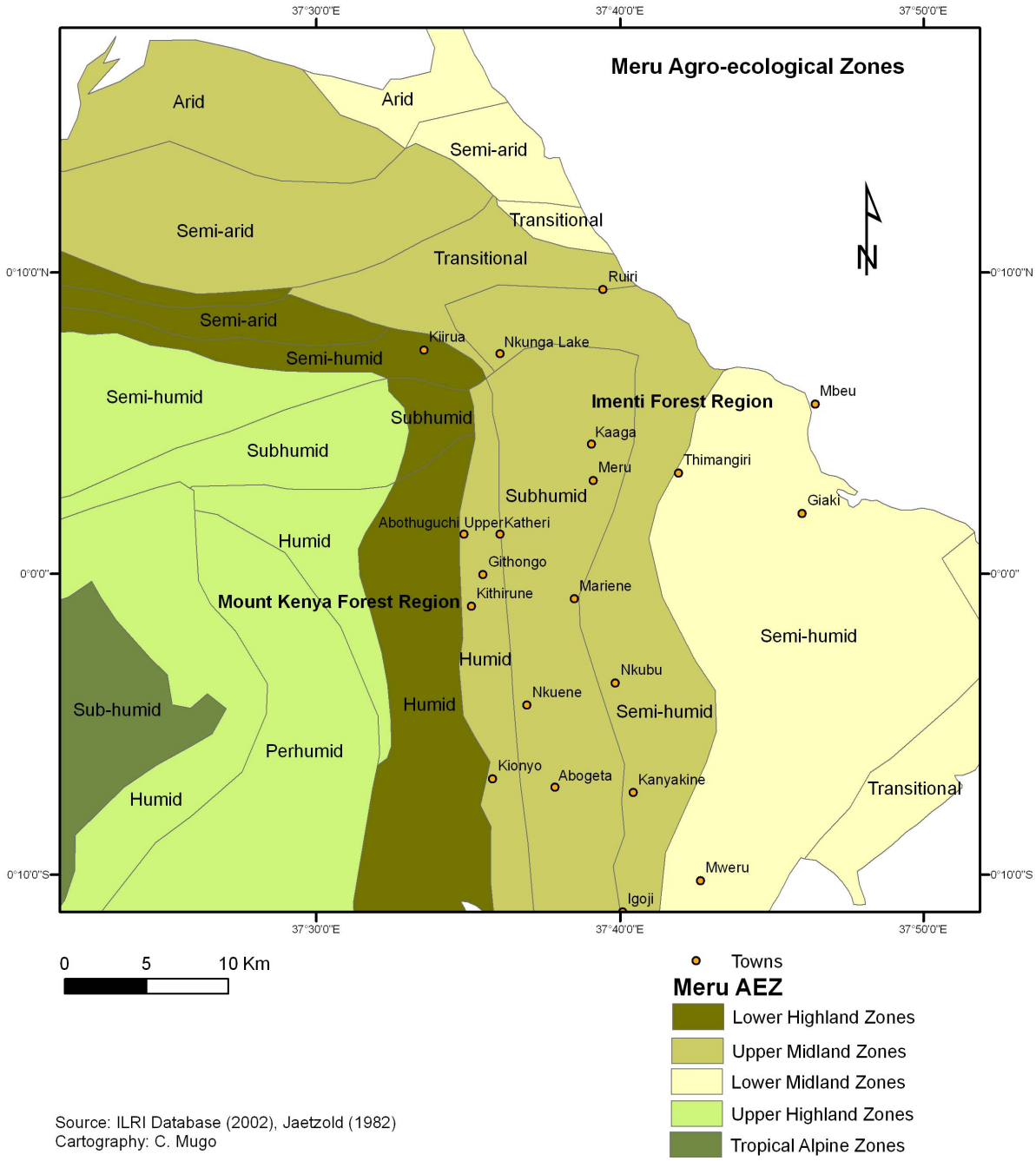


Figure 17: Meru agro-ecological zones

Numerical digits were used to represent land use potentials which include (0) Per Humid (1) Humid (2) Sub-humid (3) Semi humid, (4) transitional, (5) Semiarid, (6) arid (7) Per arid. Land uses consist of tea and coffee zones, maize zones, livestock zones and forest zones in the study area.

The ILRI database uses letters which are found in the initial position representing the type of landscape, and the annual mean temperatures. The temperatures are thus represented as follows:
(TA) Tropical Alpine 2-10° (Annual Mean Temperature)
(UH) Upper Highland 10 – 15°
(LH) Lower Highland 15 – 18° min. 8-11, normal no frost
(UM) Upper Midland 18 – 21°
(LM) Lower Midland 21 – 24° (JAETZOLD 1982)

A mixture of livestock, beans, maize, green grams, and bananas, are grown in the mid altitude, semi humid areas. Temperature zones thus play an important role when it comes to determining the type of crops to be planted.

Land use strategies in the transition areas (sub humid, semi-arid) must be able to cope with a wider range of moisture related conditions than in more humid locales. Unlike humid and arid areas, the expected ranges in precipitation in these climatic zones are often cross-critical moisture boundaries. Because climatic conditions usually remain persistent over brief periods of time (dry and wet periods usually occur in cycles of a few years in duration), human systems must be sensitive to these fluctuations, and it must not be assumed that either the wetter or the drier conditions will persist: that is, neither is the norm (JOHNSON and LEWIS 1995:66). On the other hand, ploughing the soil in a semiarid area can be detrimental as when rains fail, the loose and exposed soil will continue to become drier and make the area increasingly susceptible to wind erosion (JOHNSTON and LEWIS 1995:66).

5.6.2 Livestock grazing

Licences are issued for the grazing of cattle since the small farm areas are insufficient to produce enough fodder for the animals, especially in the dry seasons. Since the KWS took over the management of the protected areas, the charges for grazing each cow are 100 Ksh (ca 1 Euro) per month, from 40 Ksh (ca 40 Cent) which the Forest department previously charged (personal communication with KWS warden Meru station-Gathiari).

Other grazing issues include a report from the Pan African News Agency about the siege of Mount Kenya Forest from pastoralists, where the Maasai tribe were authorised to move their animals into the Mount Kenya. The communities then demanded to be allowed to grow crops in the fertile forest. Chris Murungaru who was by then a legislator in Kenya sided with the community and said that farmers should also be allowed to grow crops in the fertile forest so as to prevent the destruction of their crops by livestock moving into the area (OKOKO 2000).

5.7 Impacts of climate on land use

Human activities, such as deforestation and inappropriate management of land and water resources can contribute to the frequency and impacts of natural climatic events (UNEP 2002:28). Climate change is increasingly becoming an important factor that contributes to land use changes, and consequential land degradation. Main factors affecting the climate of an area are latitude, altitude, character of prevailing winds, the distance from the sea or sizeable water body and topography (OJANY and OGANDO 1973). With relevance to land degradation, average values along with other temperature and moisture attributes (e.g. the number of months that have temperatures of less than 0°C, the number of months with moisture deficits, and the inter-annual variability of rainfall) are needed to describe an area's climate (JOHNSON and LEWIS 1995:58).

There are a total of 700 rainfall stations, and 62 temperature stations and 27 synoptic stations in Kenya. MORGAN (1973) illustrates that 72% of the land in Kenya received less than 508 mm of annual rainfall in four years out of five. Figure 18 shows the inter-annual rainfall characteristics for the month of April between 1931 and 1989, where there is no significant shift in the inter-annual and seasonal rainfall characteristics at Meru station. Nevertheless, minor recurrences of above and below anomalies were common.

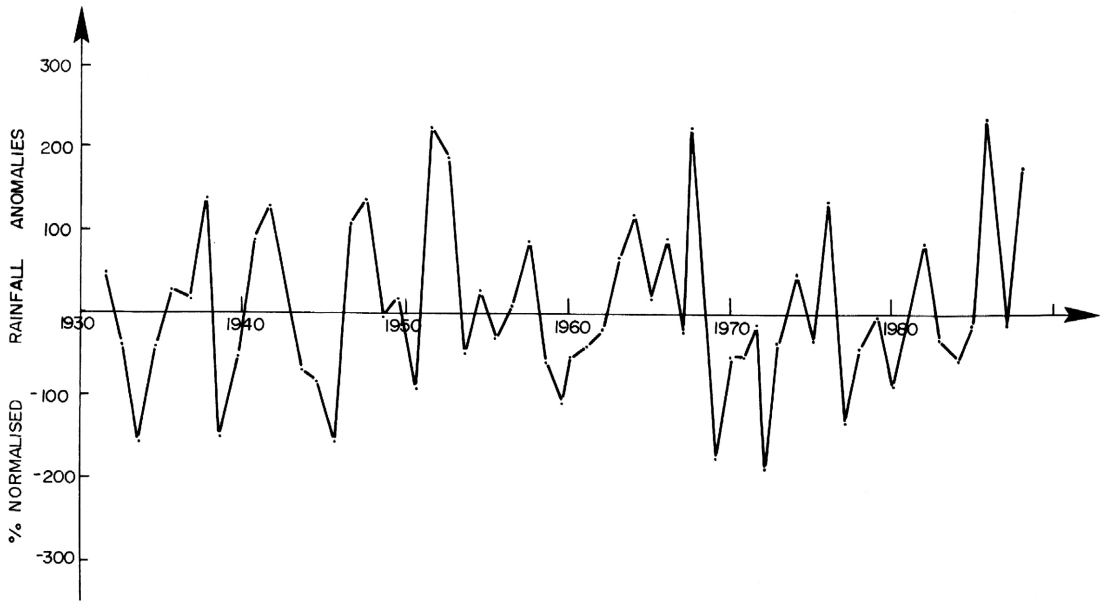


Figure 18: Normalized April rainfall anomalies in Meru, 1931 - 1989
Source: Ogallo 1990, in WINIGER et al. (1990:138)

The monsoonal wind systems are the major sources of moisture flux into Kenya. The flow of these winds is significantly modified inland at the low and middle levels by the complex topographical patterns, the existence of many large inland lakes and mesoscale circulations of thermal origin. The regional factors give high spatial and temporal variations in the precipitation over the region (OTTICHILO 1991:19). Kenya is dominated particularly by three distinct air masses. During the months from November to March, very dry winds from the Sahara Desert dominate the Western part of the country. This dusty air mass is called the harmattan (or Egyptian air). In the Eastern parts of the country, the equivalent air stream has an Arabian source and is thus known as the Arabian or Indian northeast trade winds (OJANY and OGANDO 1973:56). The northeast monsoon carries dry air masses from Egypt and the Sudan region from November to the end of April, and the southeast monsoon carries moist air from the Indian Ocean from June to October (Figure 19).

Although marked changes in climate in a region occur on a long-term basis, it is necessary to emphasise any impacts that could lead to a change of land use. The Mount Kenya area lies in an affected region where cases of food shortages have been on the rise since the early 1970's because of drought incidences (MWAGORE 2001). Unlike the Imenti Forest region, in the Mount Kenya Forest region, the cooler air masses towards the mountain are also increased by the transpiration of the forests, which naturally raises the humidity in the area, and thus the likelihood of more precipitation.

One of the most crucial ecological factors limiting biological activity is temperature. Both high and low temperatures are critical environmental attributes (JOHNSON and LEWIS 1995:69). The climate changes according to the temperature, which is also associated with floods, or even droughts that lead to the loss of vegetation, whereby degradation is the outcome.

The presence of forest cover has an effect on climate, although the impact directly relates to the size of the forest. Parameters that have been used to give indications of the past and present conditions of climate change around Mount Kenya include studies of the Sacred Lake (OGALLO 1990, OLAGO 1999, FICKEN 1998). Changes in land use, especially deforestation and agricultural expansion, have reduced the overall quantity of plant biomass, thereby releasing large amounts of CO_2 (GOUDIE 1982:241).

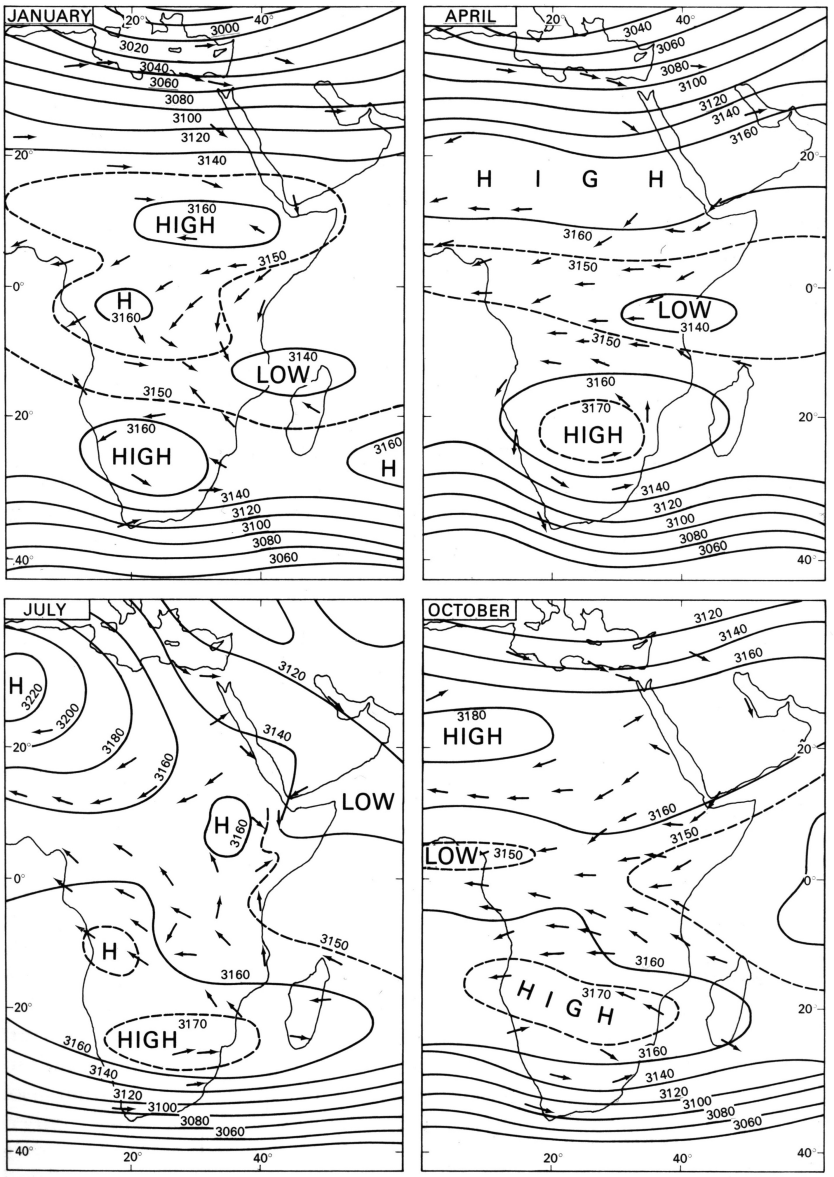


Figure 19: Pressures and airflow over Africa
Source: Morgan (1973)

Both earth science and agricultural studies agree that the precipitation properties of an area are one critical set of environmental conditions affecting an area's stability, especially once it is disturbed by human activities (JOHNSON and LEWIS 1995:58). KIRSCHBAUM and FISCHLLING (1996) cited in MALONEY (1998:38) further agree that tropical forests are likely to be more affected by changes in land use than by climate change as long as deforestation continues at its current high rate. Nevertheless, when considering future trends, an accurate assessment must be made of how the consequences of changes in the climate compare with other threats confronting society (BURROUGHS 2001:137).

5.8 Implementation of Satellite images

After carrying out an unsupervised classification of the sat images, the pixels identified for the land cover categories for the ETM data were classified as follows (table 7 and 8):

CLASS	CLUSTER NUMBERS	COLOUR	LAND COVER
1	1-3	Green	Forest regions
2	12, 14-20	Seville orange	Settlement/open pasture
3	4-11, 13	Sky-blue	Plantation

Table 7: Land sat ETM classification February 2000

CLASS	CLUSTER NUMBERS	COLOUR	LAND COVER
1	1,2	Green	Forest regions
2	5, 6, 8-11, 13-20	Seville orange	Settlement /open pasture
3	3, 4, 7, 12	Sky-blue	Plantation

Table 8: Land sat TM classification February 1987

The maps illustrate the distribution of land cover in both the Imenti and Mount Kenya protected areas. The images were appropriate to map land cover where vegetation was the dominating constituent. In both data, the forest reserve areas were clearly zoned off from other features, making factors like encroachment, settlement, or the extension of plantations near the forest reserves perceptible. During the classification of the satellite images, open lands and settlement areas contain the same signature since the spectral signatures are similar. The same case happened to areas of plantation and cultivated regions.

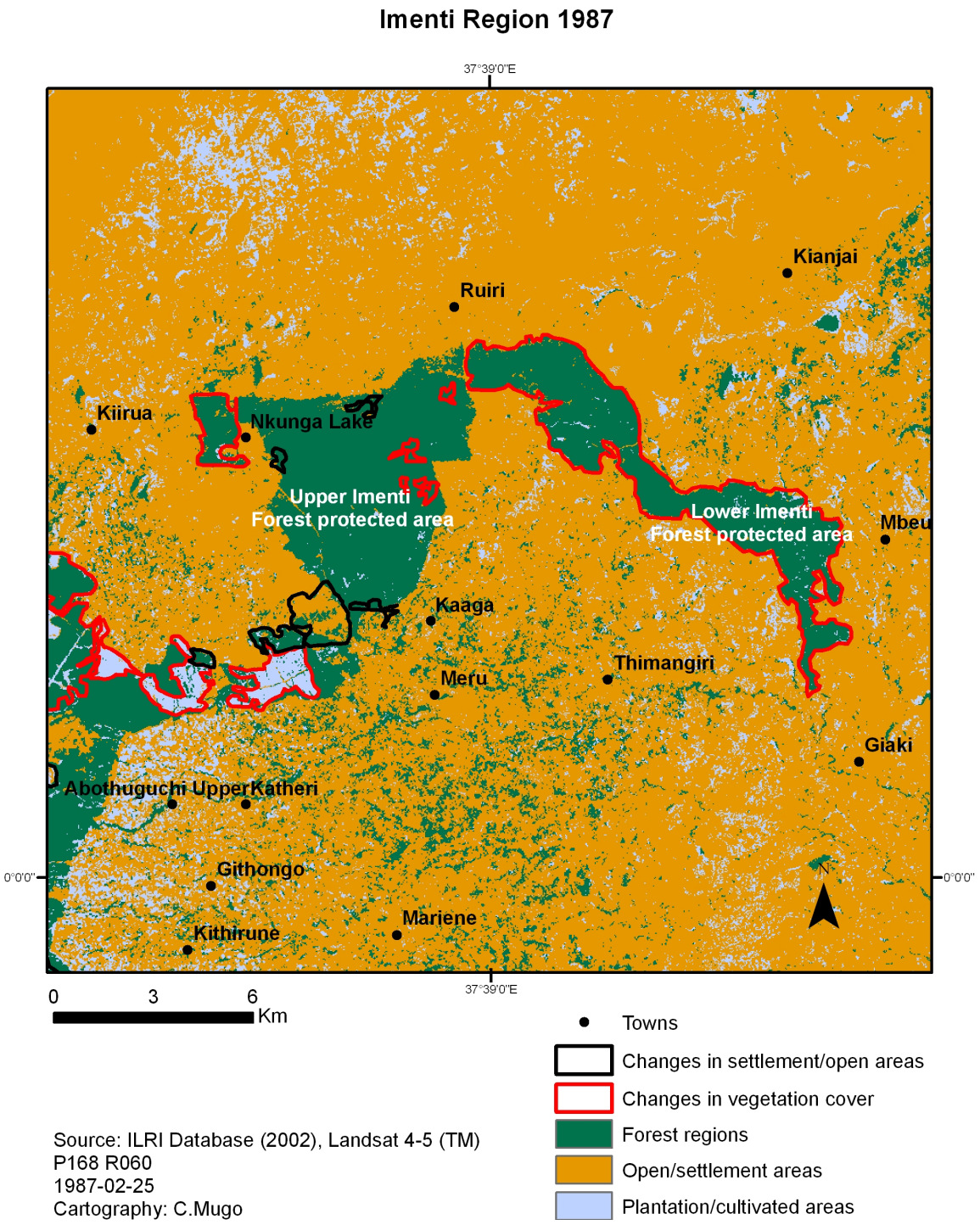


Figure 20: TM classification Imenti Forest region 1987

The quantitative changes in forest vegetation cover, changes in settlement, open areas, and in plantation area signatures can be compared to figure 21 (the ETM classification)

The TM classification of the Imenti region in 1987 (figure 20) is characterised by plantation and cultivated regions north of the Katheri and Abothuguci Upper regions in the study area. Identification of cultivated and plantation areas was derived from sources including field observations, the topographical maps of the Meru sheet 1:50,000, Nkubu sheet 1:50,000 and reports from the KWS aerial survey reports (GATHAARA 1999).

The red outlined regions on figure 20 represent areas whereby changes in vegetation cover have taken place between 1987 and the year 2000. The black outlined regions represent areas where settlement and open areas had increased or decreased.

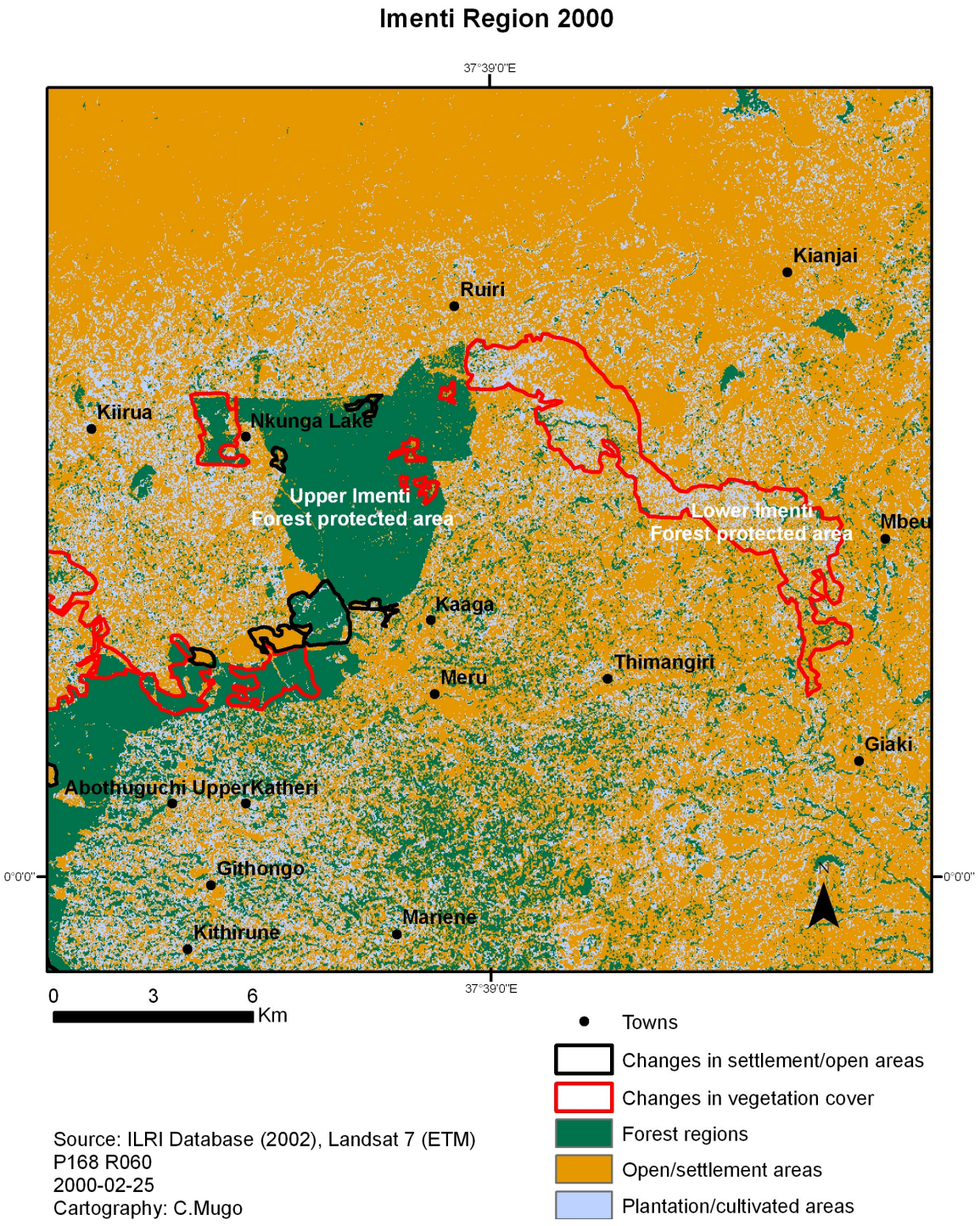


Figure 21: ETM Classification Imenti Forest region 2000

The quantitative changes in forest vegetation cover, changes in settlement, open areas, and in plantation area signatures can be compared to figure 20 (the TM classification)

After the classification, analysis of the ETM Imenti Forest region 2000 figure 21 illustrates a clear loss of forest cover in the Lower Imenti Forest region in the 13 years between 1987 and the year 2000. The Western area of the Imenti Forest also displays a loss of vegetation cover which has not been given particular attention in past forest destruction documentation. Plantation and cultivation areas are also apparent in the Lower Imenti Forest region whereby some areas were still under the NRC in the year 2000. Furthermore, the shamba system (NRC) was widely spread in the Upper Imenti Forest, though at the time of research no areas were under cultivation in the protected areas. The KWS aerial survey shows that logging of indigenous trees is highly concentrated in the Lower Imenti Forest region with many logged areas of more than 10 ha in the whole protected region (GATHAARA 1999). Nevertheless, the ETM images show that there has also been an increase of forest regions in areas where there were plantations within the forest reserve near Meru town.

Human encroachment has not only reduced vegetation in the protected areas, but also reduced wildlife habitat. There is an increase of open areas in the forest reserve in the Upper Imenti Forest region. There has been an increase of cultivated and plantation regions all around the forest area. There is an increase of both cultivated areas and open regions and settlements near Lake Nkunga where the forest reserve is diminishing. Kaaga, Ruiri, and Kiirua towns and the surrounding areas also experienced extensive increases in cultivated regions within the 13 years. Forest decrease is also apparent to the North-west of Meru town giving way to settlement areas. South of Kiirua, from a population of 180 people per km² in 1979, the area has an increased to 468 people per km² in a much smaller region. In this area, the forest vegetation and plantation regions have clearly given way to open and settlement areas.

From the KWS and ILRI GIS data, livestock keeping has been mostly concentrated in the North-western part of the study area in Kiiura and Githongo. The Meru town area and the Northern section of the Imenti Forest also have high densities of livestock according to the KWS report (GATHAARA 1999). On a general note, livestock is evidently distributed more in the Imenti Forest region, than in the Mount Kenya Forest region. However, degradation processes taking place due to overgrazing are also evident in the protected regions of the Mount Kenya.

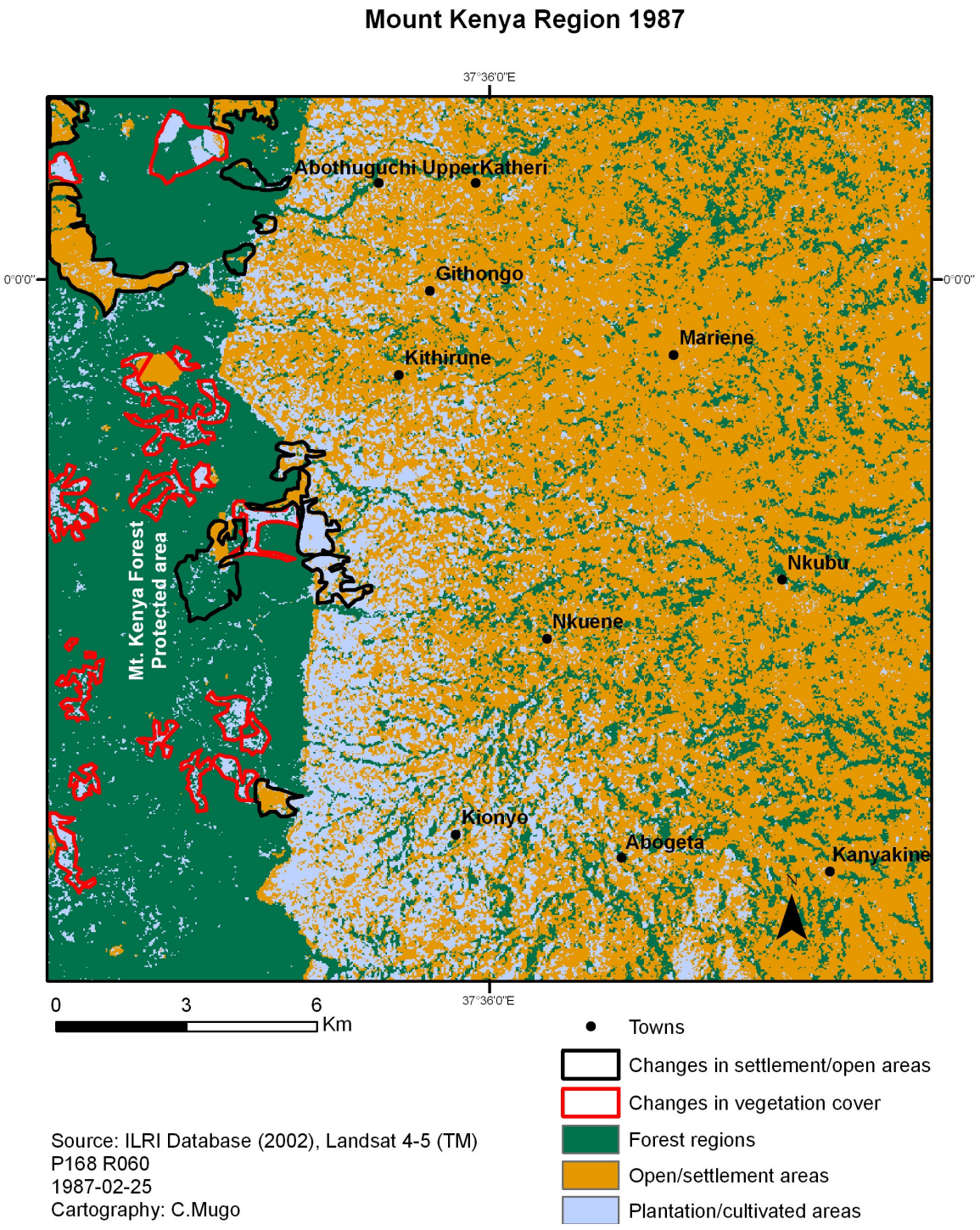


Figure 22: TM classification Mount Kenya region 1987

The quantitative changes in forest vegetation cover, changes in settlement, open areas, and in plantation area signatures can be compared to figure 23 (the ETM classification)

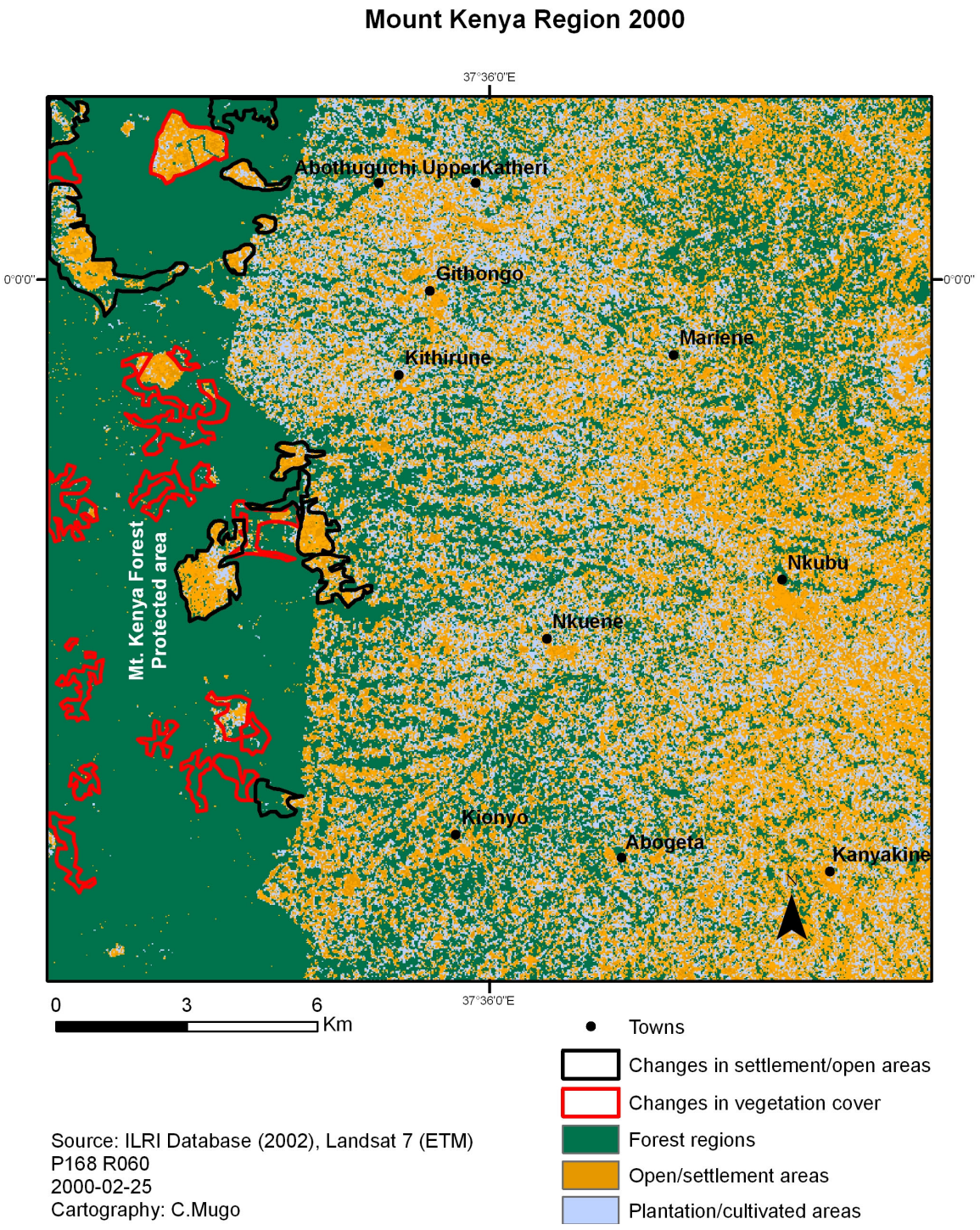


Figure 23: ETM classification Mount Kenya region 2000

The quantitative changes in forest vegetation cover, changes in settlement, open areas, and in plantation area signatures can be compared to figure 22 (the TM classification)

In the 1987 Land sat TM image, cultivated and plantation areas are more evident in the Mount Kenya region than in the Imenti Forest region. From the TM classification, tea plantations are evident along the forest regions. Although plantation areas are also evident in the forest regions in the Mount Kenya Forest (figure 23), these areas are no longer present in the ETM 2000 classification because of the banning of the NRC around

1995 (personal communication with KWS Warden). The red outlined regions largely represent areas that were under cultivation in 1987 and afforested areas in 2000.

In the 2000 ETM data, cultivated and plantation areas distinctly increase in the Githongo, Katheri, Githirune, Upper Abothuguchi and Nkuene regions. Although encroachment toward the forest areas is evident in both reserves, open regions are common in the Mount Kenya Forest area that is used for grazing. The satellite images also show an increase of size of the open areas between 1987 and 2000 even though the 100m tea belt buffer zone has created a clear boundary between the small-scale farmer and the protected regions. This however does not ensure that illegal logging in the forest regions by corrupt government officials does not continue within the tea belt, and the solar fencing on the protected regions. Open and settlement regions outlined in black are much larger in size in the year 2000, which could also be as a result of the increased numbers of population and an enlargement of grazing areas due to more pressure in the forest regions.

According to the KWS aerial survey of the forest regions, there has been destruction of tree species through illegal clearing. Although the logging of Camphor is not so common in the study area, the logging of Meru Oak has been concentrated in the Abothuguchi upper region near the protected area. Indigenous trees on the edges of the forest in the Mount Kenya Western areas are also to some degree logged (GATHAARA 1999).

5.9 Case studies

The study cases present a summary of existing farmers' experiences based upon the field research. The case studies in the NE Mount Kenya study area reveal and represent examples of land use practices and trends in both the Mount Kenya Forest region and the Imenti Forest region. The study cases give farmers' overall perception of land use methods in the farm areas in relation to the questions asked. The farms in the study area are structured on a household level, where each household decides how the farm is to be organised and what crops are to be cultivated and livestock kept if any. .

A study case allows for a conclusion of both study areas to be made by identifying identical and distinguishing land use and land use change aspects of the two adjacent forest regions. This approach is significant in the final analysis and conclusions made concerning land use change and its impacts in the study area. Although the same interviews were administered in both regions, detailed information was acquired by

allowing the respondents to elaborate on relevant issues concerning the impacts of land use and land use change, land degradation, the protected areas.

5.9.1 Imenti Forest region

Photo 2: Farm in the Imenti Forest region

A farm with banana plantations and open pastures used for grazing within the Meru municipality. The protected area forest transition regions are present in the background (C. Mugo, July 2004).

Mrs. Muchiri a 49 year-old woman lives on an acre of land in the Giaki Location with her 5 children. Mrs. Muchiri has 5 cows, 3 sheep, 6 goats, and chickens too. The number of sheep and goats had increased within the last 5 years. The cattle are grazed in the forest reserve, while she has to collect fodder for the sheep and goats that are not allowed into the reserve due to the destruction of young trees.

The family mainly cultivate maize and beans for their livelihood on their terraced farm. They now just have a small portion of the farm area near their home where she plants vegetables, (kale, tomatoes, and cabbage) and has a couple of banana trees, fruit trees and a newly started small field of ground nuts. She claimed that for some reason, water from the river does not get to their farm, and that the flow has been blocked further upstream by selfish users.

This factor makes the irrigation of her vegetable garden more difficult. However, the greatest land use change that has resulted in a problem they face is that since the year 2001, they are no longer allowed to cultivate crops in the forest reserves. Mrs. Muchiri states that the soils on her farm are unproductive, particularly when she compares them to the soils in the neighbouring forest reserve. She has to invest more in the input of manure and fertilizers to obtain the same yield on the same size of field. Moreover, when the rains fail as they usually do, they are largely affected. She expressed that rainfall was more reliable about 20 years ago, making it possible to estimate regular harvest quantities especially for income planning purposes.

The farm's neighbouring regions largely includes the Imenti Forest protected areas. Mrs. Muchiri considers this forest to be of great importance for their daily livelihood. The family relies on the forest reserve where they collect fodder for the livestock as well as firewood. However, Mrs. Muchiri states that the forest vegetation borders seem to be moving further and further away. Regions that were once forest are bare, and now there are just a few shrubs. Mrs. Muchiri explains that there were more trees about 20 years ago and they are now mostly destroyed. She is however convinced that this destruction was not because of the neighbouring communities' utilization of the forest through collecting firewood, or grazing the animals, or even farming in the reserve, but that the increasing numbers of elephants have played a large role in the destruction of the natural forest.

Furthermore, she explained that since the farm area adjacent to the protected area is not fenced, and since vegetation in the forest had been destroyed, elephants and other wildlife now have decreased habitat areas and this results in their looking for food on the farms. She hopes that the forest area they live in will be fenced off, which will encourage her to try and improve the quality of the soils and possibly even try horticultural farming like her neighbours, which she explained has become an interesting area of income in the region.

She would highly appreciate government assistance by being assured of sufficient water, especially for domestic use. The family would also appreciate the continued use of the forest reserve areas especially because the farm areas continue to decrease through fragmentation which only increases the problem of the over-utilization of farms.

5.9.2 Mount Kenya Forest region

Photo 3: Farm bordering the Mount Kenya Forest Region

Protected area transition areas with tea plantations on the steep convex slopes in the Mount Kenya Forest region (C. Mugo, August 2004).

Mr Kerugara age 60, has 7 acres of land which is a relatively large farm area compared to most of his neighbours. He further emphasised that he is yet to divide the farm between his 4 sons. He has 3 cows and a few chickens that are free range. The cows are kept solely for the production of milk under the zero grazing system. Any additional milk produced is sold in the local market. He also had a few goats in the past, but since they were prohibited in the forest because of the destruction of trees, he sold them all.

Mr. Kerugara has a tea plantation which is about 5 acres large, and on the rest of his farm, he plants maize, beans and potatoes, which he rotates seasonally. His farm is terraced to avoid soil erosion due to the steep slopes. On the borders of the terraces of the maize, bean and potato farms he plants Napier grass that he uses to feed his cows.

Mr. Kerugara stated that his land has been relatively productive over the years and he invests in both organic and inorganic fertilizers that help keep his soils fertile. He additionally expresses that chemical fertilizers have become very expensive over the years. He has also changed from growing his vegetables from near the homestead, and

now grows his vegetables (tomatoes, kale, bananas, and carrots) in the bottom slopes of his farm. The vegetables are both for subsistence use and as a source of income. His neighbours now also benefit from the same method of planting their subsistence crops near the water source as they no longer face any conflicts with wildlife since the protected areas were fenced off in the year 2002 by donors.

Mr. Kerugara regards the forest area highly, and considers it as a storehouse for the water that flows from Mount Kenya which is then distributed to all the surrounding areas. The forests also play a large role in the provision of fresh air in their environment. However, he does not directly utilize the forest reserve. Occasionally, when necessary, the family collects firewood from the reserves with the permits that they acquire from the forest department.

Mr. Kerugara's major and only constraint that he mentioned was that the tapped water they have near their homestead is rationed, and has to be used very sparingly. This is an aspect he would like to see the government to improve.

A comparison of the two study cases reveals that the size of farmland differs in the two regions of the study area which influences the decisions about land use, i.e. subsistence or crop farming. Mr. Kerugara mainly has a tea cash crop plantation which is a source of income. In addition, he has the cows, and the vegetables and food crops grown on the rest of his farm that bring extra income. The income allows him to make investments on his farm, like the use of fertilizer for better yields. On the other hand, Mrs Muchiri's land is one acre in size and she cultivates maize and beans chiefly for subsistence use.

Mrs. Muchiri's land use change involves an increase of farming on the farm itself due to the banning of the NRC in the forest reserve, which left farmers with less land to cultivate. She is however not satisfied with the soils on the farm, especially in comparison with the soils in the forest reserve. Differing AEZ influences the crops cultivated on the farms and Mrs. Muchiri mentions that unreliable rainfall has caused her to alternatively increase livestock numbers. The similar concern raised in both farm areas was the unavailability of tapped water in the region. Both farmers would appreciate government support in acquiring water.

Since Mr. Kerugara is content with the yields on his farm, the chances are that he will make fewer changes in the uses of his land. The only major change that has taken place on his farm is relocating the vegetable garden to the bottom valley, where irrigation is

more efficient. Both farmers have however created terraces as a measure of preventing soil erosion on the farms, which signifies the awareness of soil protection measures.

Fencing off the protected areas would encourage Mrs. Muchiri to make more investments on her land and would be more worthwhile in the long run. This implies that the insecurity of wildlife conflicts largely influence the land use decisions made by Mrs. Muchiri.

The Muchiri family still rely on the protected areas for forest products even after rigid access laws. She grazes the cattle in the reserves, making the forest very important for their livelihood. Mrs. Muchiri is therefore very concerned about the vast destruction of the Imenti Forest vegetation. Although Mr. Kerugara stated that he does not directly benefit from the forest reserve, he appreciates the forest.

5.10 Interview and field survey results

5.10.1 Present land use

The excessive dependency on land as a major natural resource is very important in the study area considering that infrastructural and economic conditions are not fully developed. In a typical farm setting in the study area, the homestead is usually on the highest elevated level on the farms, and crops like vegetables, fruit trees and banana plants for family consumption are grown near the home. Tubers like arrowroots, sugarcane and yams are cultivated at the bottom of the valleys, mostly near the river sources. Not far from the homestead are the animal pens, and gravesides which are preceded by the larger cultivated areas. The farms in the study area are characterised by the use of family labour, whereby hand tools dominate the farming equipment used.

5.10.1.1 Interview analysis

The variables for the farmers and farm area characteristics included the gender (binary: one for male and zero for female), age (continuous variable), owner of farm (binary: one if yes and zero if no), and size of farm in acres (categorical). The circumstances representing the location of the farms were divided into the Mount Kenya Forest adjacent farm regions, and the Imenti Forest adjacent farm regions.

5.10.2 Landownership

Landownership of farms within the study area customarily signifies a well established social status. In 94% of all the interview cases, the farm areas were owned by men, who represented the families as household heads. It was important to interview the owners of the farms as they have the overall control of land use, and have good background information about the farm area. The female respondents however also stated that they owned the land as the wives of the men. However customarily land inheritance laws in the study area apply mainly to male children, making them the owners of the land.

Land use conflicts could arise because women are socially never considered household heads, and do not directly make any land use decisions themselves. On the other hand the women carry out the majority of farming activities, which largely involves the cultivation

of agricultural crops. The adjacent protected areas of the Mount Kenya and Imenti Forest regions are controlled and owned by the government, which thus involves state intervention in the land use and land related systems in the study area.

An assessment of the land available at a household level was sought to represent socio-economic conditions and circumstances that could impact land use in the study area. Availability of farming land is significantly influenced by the amount of land inherited. Seventy-seven point five percent of the farmers in the Imenti Forest region owned less than 2 acres of land, while 65% of the farmers in the Mount Kenya Forest areas owned less than 2 acres of land.

Figure 24: Mount Kenya Forest region

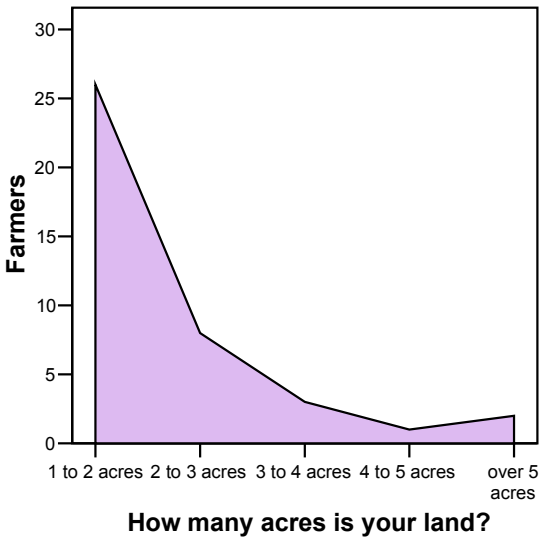
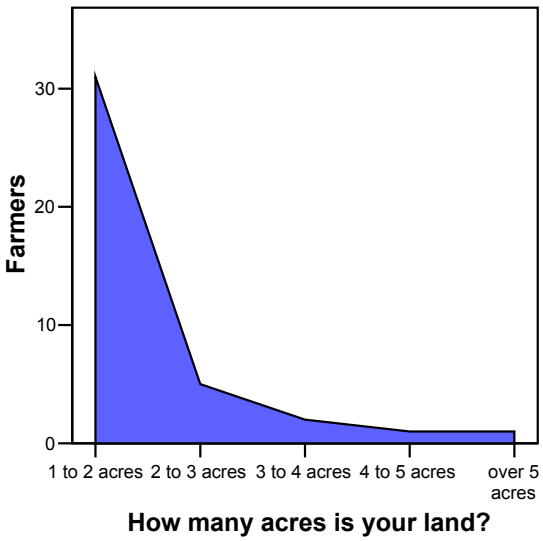


Figure 25: Imenti Forest region



Land sizes were slightly larger in the Mount Kenya Forest region (figures 27 and 28) whereby 27% of the farmers owned land that was 2 to 4 acres.

The farmers in the study area allocate their land for uses that will bring them the best benefits over time according to the land quality and capability, which is the suitability of their soil. In this case, the size of land is not a determining factor. Since the most farming is small scale, crop productivity is not as high. Both cash crop production and food crop production are mainly rain-dependent types of agriculture which makes the seasons and precipitation patterns very crucial. This further helps in understanding the significance of the risks faced with erratic and variable characteristics of rainfall in the region.

The farming system usually consists of seasonal routine activities through the year which involve ploughing and manure application, planting, weeding, harvesting and threshing. The majority of the food crops grown are consumed at household level and only the

surplus is then sold in the local markets. There is no specific pricing structure and the prices are controlled by the supply and demand of the type of crop.

5.10.3 Major land use on the farms

Farmers were asked to indicate the primary use of their land based on the largest agricultural practice carried out on their farms. The answers were necessary to obtain the major uses of land in each farm in the study area. Correlation tests showed no significant relationship between the farm size and the major land use. Horticultural vegetable and fruit crops that were grown on smaller areas of land were also cultivated as cash crops.

Imenti region

In the Imenti Forest region, over half of the respondents used their farms largely for subsistence farming, and only 10% of the respondents principally grew cash crops on their farms (figure 26). Livestock is more widely practised in the Imenti Forest region as compared to the Mount Kenya Forest region.

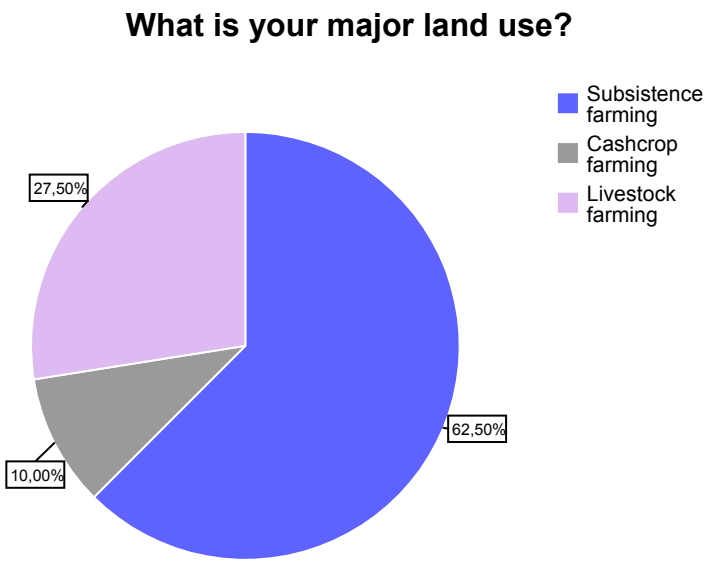


Figure 26: Major land use in the Imenti Forest region

Mount Kenya Forest region

In the Mount Kenya area, half of the farmers used their land for subsistence farming, while the other half stated that the major use of their land was for cash crop farming.

There were no farm areas left for livestock farming and the cattle were zero-grazed or grazed in the neighbouring forest reserve.

Main type of crops cultivated

The main traditional crops grown in the study area and some characteristics of favourable conditions for growth are as follows:

Crop	Requirements and Remarks
Maize (*Zea mays)*	Requires a temperature range of 14-30°C, and is sensitive to frost. Cool temperatures are a problem for the ripening. Rainfall of 600 – 1200 mm per year is needed, and this should be well distributed throughout the growing season (OTTICHILO et al. 1991).
Beans (*Phaseolus vulgaris)*	Beans are sensitive to frost, excessive rain, and require a daily mean temperature of 15-20°C (LANDON 1991:284).
Potatoes (*Solanum tuberosum*)	Require a daily mean temperature of 15 to 20°C; they are sensitive to frost and require well-drained, aerated and porous soils with a pH between 4 to 6 (LANDON 1991:285).
Groundnuts *(Arachis hypogaea)*	Groundnuts have medium drought resistance, pH range 5.0-7.0, and a medium level of nutrient need and require a mean daily temperature of 22-28°C. They are sensitive to frost, and require well-drained soils.
Miraa (*Catha edulis)*	Also widely known as "Khat" is popularly grown in Meru. It is a drought-tolerant evergreen shrub whose leaves contain *cathinone* and *cathine*. It tends to grow in relatively rocky soil, where the drainage is good. The miraa plant grows to about 10 feet high and its leaves are traditionally chewed by people of East Africa and the Middle East as a stimulant (EROWID 2004).
Arabica coffee *(Coffea arabica)*	Arabica coffee does well in temperatures between 15° to 25°C, with a rainfall range of 750 to 2,500 mm, and in Kenya in altitudes between 1,400 and 2,000m (LANDON 1991:285).
Bananas (*Musa spp)*	Bananas thrive in mean monthly temperatures between 25° to 28°C, and a well distributed average rainfall of 1500 to 2500mm (LANDON 1991:285).
Tea (*Camellia sinensis*)	Requires rainfall not less than 1125 mm annually that is well distributed with mean minimum temperature not below 13°C, and a maximum mean not above 29°C, grown best in tropical red earths (LANDON 1991:285).

Table 9: Traditional crops

Farmers were asked to state the crops grown on their farms to discover what crops were cultivated in the study area. Since the farmers are primarily small-scale farmers, a

diversity of crops that can increase the profitability of their farming is expected so that if one crop should be unsuccessful, then there is always an alternative to depend on. The farmers were asked to further indicate the major crop grown according to the largest farm area allocated for the crop.

Imenti Forest region

Maize, which every farmer in both regions in the study area grows, is a staple food. In both forest regions, farmers expressed that maize and beans are sometimes intercropped with other cash crops.

Photo 4: Intercropping

Intercropping of maize and beans in a farm in Giaki where the farmer grows food crops as well as cash crops to improve the family income (C. Mugo, July 2004).

Farmers around Kithoka and Ruiri in the Northern Imenti areas, stated that low grain yield in the maize has caused the farm areas in which maize is grown to be smaller in size, giving way to groundnuts and horticultural farming. Maize is mainly grown on half of the farms in the Imenti Forest region. The farmers in the Imenti Forest regions stated that as maize yields have been going down, they could only grow enough supply for their household use. Furthermore, the farmers have opted not to sell any surplus they might have as one could no longer rely on the rains and unpredictable circumstances like the destruction of their crops by wildlife.

Coffee, horticultural crops and beans are all under 20% of the major cultivated crops, while potatoes are not popularly mainly cultivated on the farms in the region. In the Imenti Forest region 17.5% of the farmers living near the Meru town region mainly cultivate coffee on their farms. The farmers usually integrated the perennial coffee crops with food crops that are grown throughout the year for consumption. The farmers argued that the growing of the crops continuously would suppress the growth of weeds. Moreover, enough food had to be grown to cater for their income needs; they totally depend on their farmlands for survival

Main type of crop cultivated

Imenti region		Frequency	Percent
Valid	Maize	20	50,0
	Beans	5	12,5
	Coffee	7	17,5
	Horticultural Crops	6	15,0
	Potatoes	2	5,0
	Total	40	100,0

Table 10: Main crops cultivated in the Imenti Forest region

On the adjacent forest areas of the Lower and Upper Imenti Forest areas, horticulture, groundnuts and recently, miraa are more widespread and grown as cash crops. The farmers expressed that besides miraa being a cash crop it is used for recreational purposes, and to dispel feelings of fatigue; it has been used for many years in a social context. However, more importantly, today the growing of miraa has become popular due to its growing market and the fact that it is a more reliable source of income (personal communication KWS Warden). Five percent of farmers (figure 27) who mainly cultivate potatoes mentioned the noticeably smaller tuber size of potatoes over the years. This they claimed to be because of degraded land and the lack of enough fertilizers. Farmers also expressed that they have decreased the space allocated for their potato and beans in order to create more space for livestock.

Nonetheless, the farmers who have begun to grow groundnuts stated that, unlike the other crops such as potatoes and beans, groundnuts prosper even in some of the soils where these other crops would not do well. The medium drought resistance requirement

according to LANDON (1991) explains why the growing of groundnuts is more widespread in the Northern areas around Kiirua in the Imenti region. The farmers expressed that the growth of horticultural crops is on the increase. Fifteen percent of the farmers in the Imenti region now choose to partly concentrate on horticultural farming partly on their farms where a mixture of vegetables and fruit trees are planted on small areas of the farm. However, due to water unavailability and irregular irrigation, the farmers in the region were sceptical about making any large investments at the time of research.

Mount Kenya region

Horticulture is however not popular in the Mount Kenya region, and none of the farmers interviewed practised horticulture as the main farming activity. Although 7.5% of the farmers in the Mount Kenya region cultivate potatoes as a main crop on their farms, about three quarters of the farmers in the region plant potatoes on smaller areas on their farms due to favourable market prices and the demand for potatoes. According to the farmers, increases have however been made in the areas allocated for the growing of potatoes due to market availability.

Unlike farmers in the Imenti region, farmers in the Mount Kenya region are sceptical about diversifying the crops grown on their fields and prefer to adhere to the traditional crops grown in the area. The cultivation of perennial crops, especially tea which is mainly cultivated by 42.5% of the farmers is largely represented on farms adjacent to the Mount Kenya Forest Reserve due to the favourable growing conditions (table 10).

Tea growing was stimulated during the 1970s by favourable prices and by a well organised marketing/processing organisation. Gross earning for tea went up, especially from 1984, when there was a boom in the tea price (STERKENBERG et al. 1986). Thirty-five percent of the farmers mainly cultivated beans, while maize, coffee and potatoes had lower representations on the farms. Therefore, more investments are made in the tea plantations which bring the farmers better income.

Main type of crop cultivated

Mount Kenya region		Frequency	Percent
Valid	Maize	2	5,0
	Beans	14	35,0
	Tea	17	42,5
	Coffee	4	10,0
	Potatoes	3	7,5
	Total	40	100,0

Table 10: Main crops cultivated in the Mount Kenya Forest region

Supplementary land use

Livestock keeping in the study area is important, both for income generation and as a cultural tradition, (NYAGA 1997, BERNARDI 1989). Most livestock is grazed in the protected areas or near major water sources within the region. Although the Meru area has potential for fish farming where species of tilapia, rainbow or trout can be found, (ROK 2001a) consumption of fish is not common in the Meru diet.

Marketing crops

Low commodity prices on particular crops or an increasing demand for food crops compels farmers to be a part of a rapidly expanding market. The crops cultivated provide information at the farmers' level about different socio-economic circumstances associated with successful production and market demands. The farmers in the study area save the best seeds from their harvest as the primary source with the hopes of getting better yield returns from their investments.

From the interview results carried out in the Mount Kenya Forest region, half of the respondents preferred to grow tea rather than coffee on their farm lands. Over the past 20 years, farming areas under tea plantations have increased. This change has taken place mainly because the purchase of coffee has gone down and its prices that are often subject to change have gone down with time. A decade ago, the coffee-growing farmers in the Mount Kenya region claimed that they could sell their coffee for about 20 Ksh (20 Cent) per kg, but today they do not receive more than 5Ksh (5 Cent) per kg. This factor has greatly affected interest in further expanding coffee plantations, and most of them have been abandoned. Most farmers also complained of coffee being an expensive crop to

maintain which is also subject to disease. Market prices thus also influence land use and land use change decisions in the study area.

5.10.4 Land use change

To discover the extent of land use change on the farms, the farmers were asked to indicate from choices of:

- No change in land use, if there has been absolutely no changes in the past 20 years
- Slight changes in land use for changes, for instance an increase of livestock numbers, or a decrease in crop farming areas, or a shift of farming area from one part of the farm to another
- Major changes in land use including a complete change, for instance from crop farming to subsistence farming, or a total change from livestock farming to crop farming, or from crop farming to horticultural farming and from NRC to private land farming

The majority of responses from the farmers towards the changes in soil quality is connected to the agricultural aspects like reduced yields and a difficulty in maintaining yields and also rocks, or a hardened surface that makes ploughing difficult. The farmers' perspective has thus been presented through how production has changed in the current yields compared to the farms historical trends. Taking these factors into consideration, they then result to making land use changes as a response to the weight of the matter at hand.

Increasing demand for food has resulted in continued agriculture intensification. Farming methods have changed and unlike the colonial times, the communities no longer grow just enough crops to sustain themselves. The farmers distinctly stated that there is a growing need to incorporate more cash crops or increase the number of food crops grown on their farms to maintain their livelihood.

Economic forces could thus trigger land use changes in the study area. The intensification further varies according to the market economy and the potential of the farms according to the eco-region. Furthermore, the land use patterns on the neighbouring farms in the region were greatly reflective of present land use changes.

Socially, the families in adjacent farm areas are sometimes related through the inherited land. The historical patterns of land use in the study area can easily be traced in certain locations as they are very similar.

On the drier sides of the Mount Kenya area, land use and agrarian production have seen fundamental changes since 1963, which are characterised by intensification, increase of the range of crops grown and reduction of the proportion of market production. In particular, the cultivation of maize has expanded enormously. Potatoes have increasingly become popular since the 1970's (PESTALOZZI 1986:113).

Imenti Forest region

Thirty-seven and a half percent of the farmers in the Imenti Forest region have experienced major changes of land use on their farms since the early 1980's (table 11). An additional change of land use in the Imenti region includes the change from cultivated cropland to horticultural farming. In the Northern areas around Ruiri, and to the east end of the study area in Giaki, farmers claim that increased temperatures and low precipitation have compelled them to adapt to planting drought-resistant crops on most parts of their of land. This ensures that they keep up farm production yields in order to meet soaring economic demands.

About 28% of these farmers had to continue their cultivation practices on their own land, following the governmental transition of NRC banning in 2000, which is the greatest change of land use in the study area. It is evident that there has been a farming shift from crop cultivation to the rearing of more livestock. This change however, the farmers did not regard as a major change, but a slight one, as mostly it was an increase in livestock, which did not influence the type of crops cultivated on their farms.

Extent of land use change since the early 1980's * Change of farming method Cross tabulation

Imenti Forest region		Change on farming method				
		No change	Crop farming to livestock farming	NRC to farm	Livestock farming to horticulture	Crop farming to horticulture
Extent of land use change since the early 1980s	no change	6	0	3	0	0
	slight change	1	8	5	0	2
	major change	1	1	11	2	0
Total		8	9	19	2	2

(n = 40 farmers)

Table 11: Extent of land use change in the Imenti Forest region

Farmers were now changing their vegetable garden areas from within the homestead area to the bottom valleys of the farms, where water from the rivers and streams was more readily available for irrigation. The vegetable gardens particularly need constant irrigation, and farmers cannot fully depend on rainfall. Along with the vegetable gardens, tree nurseries are also becoming popular along the bottom valleys of the farms.

Photo 5: Bottom valley farming

Tree nurseries, vegetable beds and sugarcane cultivation at the bottom valley of a coffee farm in Kithoka, Imenti Forest region. The farming takes place near the water sources, which simplifies irrigation which is vital in the dry periods. Other crops planted at the farm bottom valleys include arrowroots, yams, and bananas (C. Mugo, July 2004).

Mount Kenya region

In the Mount Kenya region, a change in agricultural farming patterns has not been widespread. Twenty-eight of the interviewed farmers in the Mount Kenya region had not changed their land use patterns in the last two decades, and 12 farmers reported a slight change of land use patterns which involved a decrease in livestock farming to more crop farming as the cross tabulation of the extent of land use change and the change in farming method shows (table 12). According to the farmers, there was a steadily growing preference for tea plantations which increased over the last decade. On the farms, maize is still popularly grown today both in the Mount Kenya and the Imenti Forest Reserve areas, and the farm area sizes allocated for the growth of maize have not changed.

Extent of land use change since the early 1980s * Change of farming method

Mount Kenya region		Change of farming method			Total
		No change	Livestock farming to crop farming	Crop farming to horticulture	No change
Extent of land use change since the early 1980s	no change	27	0	1	28
	slight change	0	12	0	12
Total		27	12	1	40

(n = 40 farmers)

Table 12: Extent of land use change in the Mount Kenya Forest region

5.10.4.1 Fragmentation of farms

As population densities expand, the access to resources such as land becomes more stringent as a result of the pressures which occur. The traditional development cycle - the more children in a household the more the labour - plainly results in the continual division of land. However, with no specific land tenure systems on the farm areas in the study area, the emerging scarcity of land may contribute to the inadequate and intensified use of land consequently leading to land degradation both on the farms lands and adjacent protected areas.

The farmers were asked to state the primary use of their land and indicate whether it was used as an income generator, was inherited and kept as family history, or was used for family space. The results can indicate the level of connection and attachment the farmers had to the land, which has an effect on the perception of its maintenance. About 80% of the farmers in the study area claimed that they had inherited the land they live on. The farms were valued and investments were made to nurture the areas. However, the land areas are no longer large enough for further division amongst all their children, which will in future cause a major problem. Furthermore, the population increase has also played a role in the intensification of crop production and livestock keeping on the farm areas whereby much smaller units of those areas of land would not be very practical.

5.10.4.2 Land degradation measures

The farmers were asked if they left land fallow, or if they only practised continuous farming without letting the land rest and regenerate, in order to discover what their understanding of the importance of allowing the soil to regenerate so as to sustain the soil nutrients and prevent land degradation was. Fallowing encourages a natural ecosystem and is more appropriate over the long term than continuous farming. If there are any fallow periods, the cultivation times are considerably shortened, which thereby contributes to land use changes.

Due to increasing land scarcity in the study area, over 78% of the farmers in both forest regions indicated that they no longer leave any of their land fallow. Some crops such as tea and coffee which are mostly grown in the Mount Kenya region are perennial and so fallowing practices are non-existent.

According to the farmers, about 20 years ago, fallowing was a more common practice, but with growing families and high standards of living, every part of the land has to be fully utilized at all seasons. This leaves no time for any living or dead plant matter, earthworms, insects, or microorganisms, to increase. Without the fallowing periods, the land gradually loses its suitability and its effectiveness for maintaining long-term productivity and soil fertility.

Correlations

Mount Kenya		Do you practise continuous farming or do you fallow?	How many acres is your land?
Do you practise continuous farming or do you fallow?	Pearson Correlation	1	,021
	Sig. (2-tailed)		,897
	N	40	40
How many acres is your land?	Pearson Correlation	,021	1
	Sig. (2-tailed)	,897	
	N	40	40

N=40 farmers

Table 13: Correlation: farm size and farming method

In a correlation test to find out if the farm sizes in the Mount Kenya region thus have any influence on the fallowing and continuous farming methods (table 13) there is strong evidence that the variables have a relationship between them, i.e. the significance level is close to 1 between the size of land and continuous or fallow farming. The farmers who had larger areas of land, would leave some areas of the land bare at least over one or two seasons to allow the soil to regenerate before the following cultivation.

Imenti Forest region

In the Imenti Forest region, 77.5% of the farmers do not leave the land to fallow, which means that no soil restoration take place in a natural setting. These farmers clearly stated that the acres of land available to them are not sufficient and all areas of the land have to be used at the same time to maintain their livelihoods.

However, the same farmers claimed that during the NRC in the protected forest regions in the Imenti area, the community is forced to consider a fallowing practice for a period so that the soil fertility can recover after a year or two of farming. In the long run, this is supposed to bring about recovered land, with regenerated secondary forest. However, this method has only led to deforestation and degradation as the ability of the forest to regenerate itself gradually diminishes.

5.10.5 Land use and degradation

Soil quality is one of the most important factors in sustaining agricultural land use practices. It is important to support and sustain crop productivity without degrading a region. The better the soil quality, the greater and more effective its function will be. Although land use methods largely influence the quality of the soils, the soils respond differently according to the way they are managed and depending on the existent properties of the soil and its landscape. Nevertheless, both Andosols and Nitosols that occur in the study area have a high potential for agricultural production, and their natural fertility is high (DRIESSON et.al 1991).

The history of farm use, combined with the basic soil characteristics which include the ecosystem, the agricultural use, farm yields and farmers' concerns are considered to assess the quality of the soil. The farmers were asked to describe the quality of their soils in the past 20 years. The farmers stated how well they thought their soil is doing

according to their expectations from it. A farmer's expression "been good" showed that they were content on the soils production over the years. A choice of "remained the same" expressed no particular improvement and no losses in production. When the farmers stated that the soils had "become worse" it signified that there was a degenerating trend over the years which had to constantly be improved by the use of fertilizers and/or manure, and "become very bad" had a negative impact on the yields. The farmers' perceptions were based mainly on the availability of soil fertility and nutrients in the soil that they regarded as influential on the yields. The ultimate purpose of assessing farmers' perceptions of soil quality is to provide the information necessary for a perception on the approximately 20 years of agricultural production.

Photo 6: Organic mulching

The available maize stalk residue in a farm North of Thimangiri is left on top of the soil so as to improve soil quality before the next planting season. Additionally, there is the planting of trees and fruit trees (avocado and mango trees) on the farm for food, and fodder purposes (C. Mugo, July 2004).

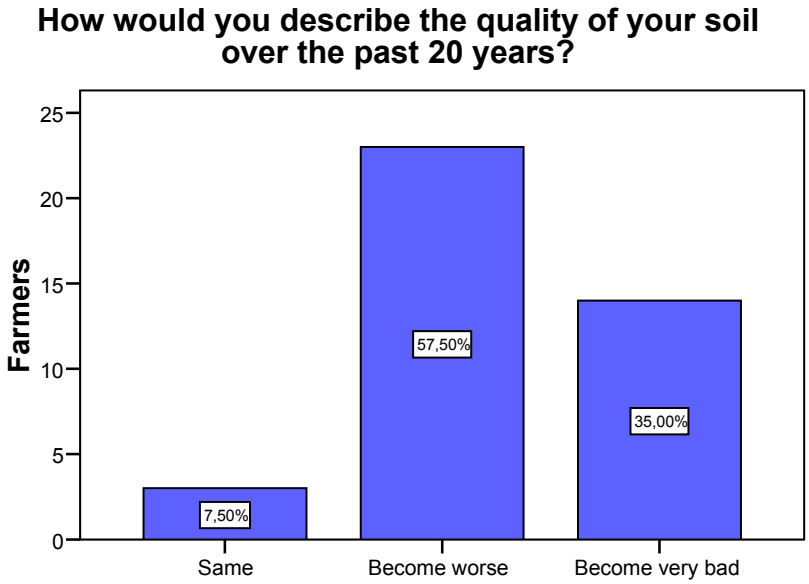


Figure 27: Soil quality change in the Imenti Forest region

There was no respondent to the choice of soil quality "been good" in the past 20 years in the Imenti Forest region, explaining that the farmers were not content on the production of the soils over the years

Imenti Forest region

Over 90% of the farmers adjacent to the Imenti Forest area described the condition of soil on their farms for the past 20 years as deteriorating as figure 28 implies. The quality of the soil has become worse or very bad. The soils in the Northern part of the study area in the Ruiru and Kianjai are relatively sandy/stony, which would cause them to naturally drain faster posing the issue of the possibility of rainfall being retained in the ground in that part of the region. The bar chart (figure 29) displays the change of land use as a result of the change in quality of the soils on the farms in the Imenti Forest region. Both slight changes of land use and major changes were made evidently when the soil quality had become worse.

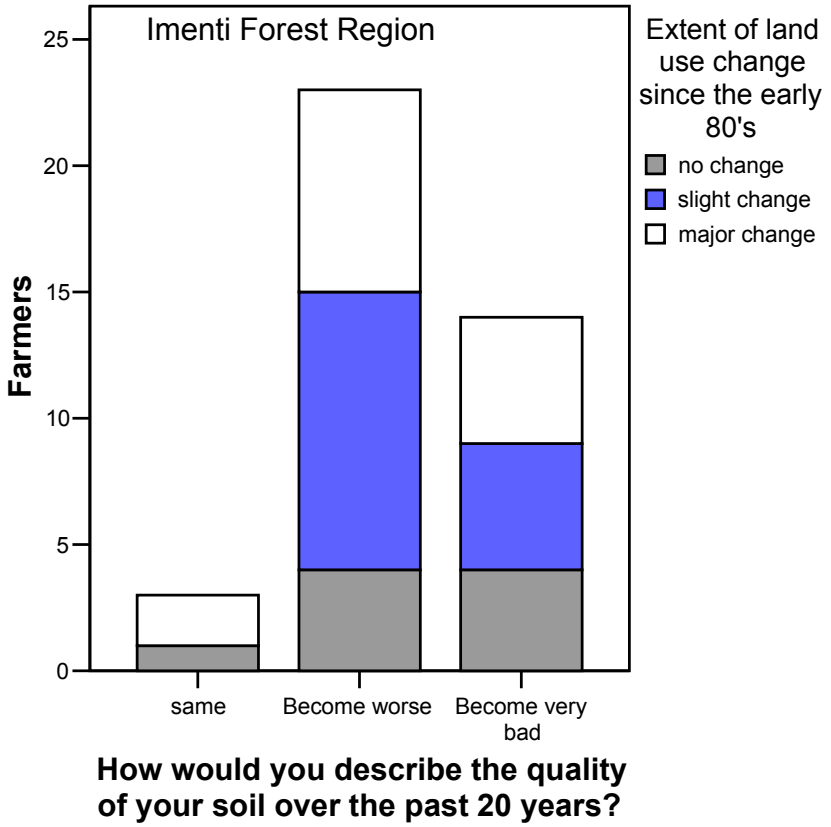


Figure 28: Soil quality and extent of land use change -Imenti region

The correlation table 14 illustrates that although it could be evident that there was some relation between the extent of land use change since the early 80's and the changes in farming method. This moderate correlation is a result of the .489 value and, the footnote clearly states that a significance level of .01 is required in order to be considered.

Correlations

Imenti		Extent of land use change since the early 1980s	Change on farming method
Extent of land use change since the early 1980s	Pearson Correlation	1	,489(**)
	Sig. (2-tailed)		,001
	N	40	40
Change in farming method	Pearson Correlation	,489(**)	1
	Sig. (2-tailed)	,001	
	N	40	40

** Correlation is significant at the 0.01 level (2-tailed).

Table 14: Land use change and farming methods in the Imenti Forest region

How would you describe the quality of your soil over the past 20 years? * Extent of land use change since the early 1980s Cross tabulation

Mount Kenya			Extent of land use change since the early 1980s	
			no change	slight change
How would you describe the quality of your soil over the past 20 years?	Been good	Count	5	3
		% within How would you describe the quality of your soil over the past 20 years?	62,5%	37,5%
		% within Extent of land use change since the early 1980s	17,9%	25,0%
		% of Total	12,5%	7,5%
	Same	Count	18	8
		% within How would you describe the quality of your soil over the past 20 years?	69,2%	30,8%
		% within Extent of land use change since the early 1980s	64,3%	66,7%
		% of Total	45,0%	20,0%
	Become worse	Count	5	1
		% within How would you describe the quality of your soil over the past 20 years?	83,3%	16,7%
		% within Extent of land use change since the early 1980s	17,9%	8,3%
		% of Total	12,5%	2,5%
Total		Count	28	12
		% within How would you describe the quality of your soil over the past 20 years?	70,0%	30,0%
		% within Extent of land use change since the early 1980s	100,0%	100,0%
		% of Total	70,0%	30,0%

Table 15: Soil quality and land use change -Mount Kenya region

Mount Kenya region

In the Mount Kenya area, 85% of the farmers assessed their soils as being good and remaining the same over the past 20 years. None of the farmers in the Mount Kenya Forest region stated that their soils had become "very bad" over the 20 years. In a cross tabulation with which the quality of soil and the land use in the Mount Kenya area were analysed (table 15), 62% of the total farmers who claimed that the quality of the soils over the past 20 years had been good had no changes of land use on their farms. The majority of farmers stated that the quality of their soils had remained the same whereby almost 70% of these farmers had no changes of land use on their farms. The bar chart (figure 30) clearly shows that the majority of farmers had no changes of land use largely because the quality of soil had remained the same since the early 80's.

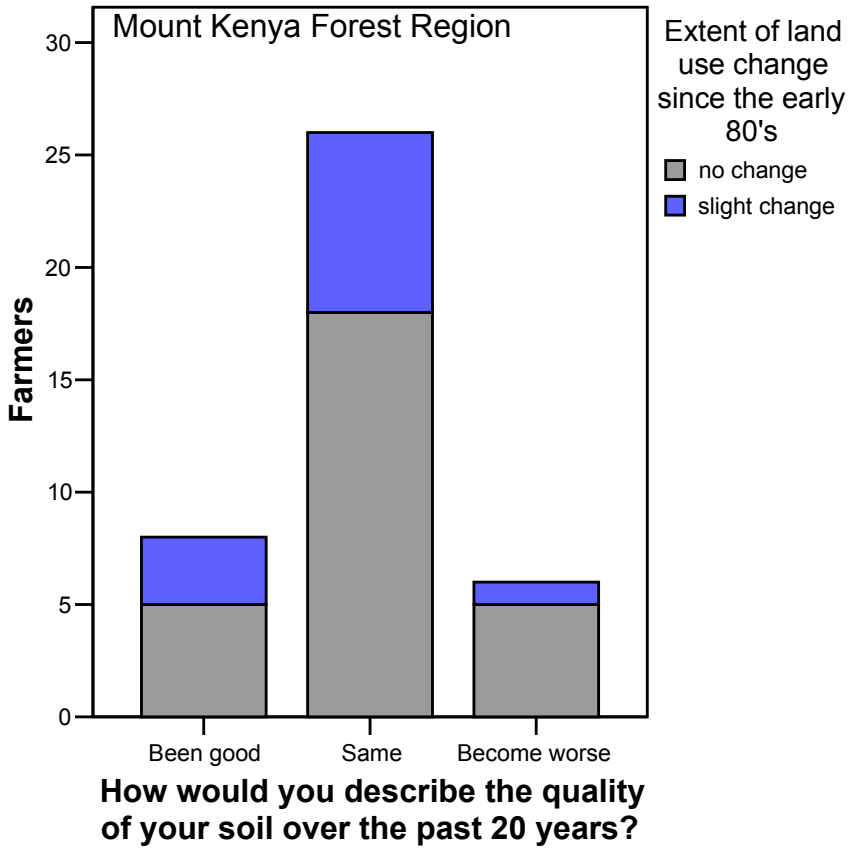


Figure 29: Soil quality and extent of land use change -Mount Kenya region

The choice "very bad" in relation to the quality of the soils in the Mount Kenya region over the past 20 years was not mentioned by any of the farmers. This signified that they were content with production of the soils.

Photo 7: Rill indicators of degradation

Rills deepening into small gullies in the Mount Kenya protected areas in Kibaranyeki. The loss of topsoil may be hastened due to the slopes present in the area, as well as rainwater in the rills on the soil surface (C. Mugo, August 2004).

5.10.5.1 Degradation indicators

Indicators of soil erosion observed in the study area consisted of root exposure, and the formation of rills and gullies. Erosion was evident in the downhill cultivated fields and farming on steep slopes. This process gradually contributes to the restriction of potential land use. Although the formation of rills which eventually develop into gullies may be the result of intense precipitation, cattle pads from grazing may also initiate the rills. The gully then widens with time.

The farmers in the study area were conscious of soil erosion as a result of the physical loss of soil and the decline in the fertility of the soils, which was related the problem to declining crop yield. About three quarters of the farmers expressed dissatisfaction with the yields on their farm areas over the years. The farmers in the Imenti Forest region stated that the continual loss of top soil on their farms had led to a decrease in the soil potential. Moreover, they claimed that the main reason for deteriorating soils was due to poor management of the farms, especially because of the high cost of fertilizers.

The farmer approach reveals the problems that they face which are also linked to the indicators acquired from them. In three farms, farmers had abandoned farm regions adjacent to the protected areas due to the wildlife (especially elephants) trampling over the land whereby this caused the soil to become very compact and difficult to till. This occurrence may lead to a change in the soil structure resulting in the decrease of water infiltration into the soil, or even the proper penetration by plant roots. The issue can be especially questionable in the dry seasons when plant roots are unable to penetrate the compacted soils. The same case applies to the proper germination of seeds. Irrigation water cannot penetrate the changed soil structure and compacted roots, causing more evaporation to take place. The farmers stressed that such soils were difficult to cultivate, and even after the soils have been broken down into large clods, these do not break down any further even after the rain falls.

Land degradation threats could also be observed in the field farm areas where the large areas of gently sloping farmland in the relatively low lying regions in the Imenti Forest have not been effectively contoured as opposed to the very steep regions, in the Mount Kenya Forest region, where no land had been abandoned. In the greater majority of the farms, there is an absence of trees which would assist in decreasing the strong impact of rain or wind causing soil erosion on farm that is not cultivated.

Photo 8: Wildlife migration corridor
Degraded areas at the borders of the protected Imenti Forest regions (C. Mugo, July 2004).

5.10.5.2 Degradation and grazing

Livestock keeping is practiced as a source of income as well as the provision of food. However, where crop cultivation is also involved, no large areas of land can be allocated for grazing. All the farmers interviewed in the study area kept livestock species with the most popular being cattle and chicken. Domestic animal products that the farmers mainly obtain include milk and eggs and they keep the manure for their own use. The farmers were asked to state the animals kept on the farms to assess land use practices. The farmers indicated the main species of livestock breed.

Imenti Forest region

In the Imenti Forest region the popular types of livestock kept in the study area include goats, cattle, sheep, and poultry (figure 31). It is also common that each farm keeps a dairy animal or two for the provision of milk in the household. Farmers in the Imenti region expressed that their numbers of cattle and goats had increased within the last 5 years. The keeping of beef cattle is common both as subsistence and as an income earner. Goats and chicken accounted for 20% and 22.5% respectively of the main livestock kept on the farms in the Imenti Forest region.

Main type of animals kept on the farm?

Imenti		Frequency	Percent
Valid	Cattle	19	47,5
	Sheep	4	10,0
	Chicken	9	22,5
	Goats	8	20,0
	Total	40	100,0

(N=40 farmers)

Figure 30: Main animals kept on farm -Imenti Forest region

Main type of animals kept on the farm?

Mount Kenya		Frequency	Percent
Valid	Cattle	20	50,0
	Sheep	3	7,5
	Chicken	14	35,0
	Goats	3	7,5
	Total	40	100,0

(n = 40 farmers)

Table 16: Main animals kept on farm -Mount Kenya region

Cattle and goats are most popular within the Northern parts of the study area around the Lake Nkunga, Ruiri and the Upper Igoki areas. Although livestock keeping is more popular in the Imenti Forest areas, farmers stated that the initial capital investment was too high, and unfortunately the farmers have no guarantee that the payment of loans can be met.

Mount Kenya region

Dairy cattle in the Mount Kenya Forest areas are kept both as a source of income and for subsistence purposes. Fifty percent of the respondents kept cattle as the major domestic animal on the farms (table 16). Goats and sheep were not so popular in the Mount Kenya area whereby there were only 7.5 of each. The cattle are kept under a zero-grazing system, with an average of two cows per homestead.

Fodder crops like Napier grass are grown along the terraces in the farms. The farmers could harvest the Napier grass every month, making it an optimal fodder for the animals in the small scale farming areas. Principally, the cattle are zero grazed, and the chickens if not very large in number are free range, and chiefly maize grains are provided for their

feed. Cattle are the main farmyard manure generators. The manure is removed from the stall and heaped for decomposition in a pile before it is utilized on the crops.

5.10.5.3 Grazing impacts

The farmers in the study area customarily make use of the forest reserve areas to graze the livestock. Over-grazing is however a major factor contributing to land degradation in parts of the study area, especially within the protected regions.

Over-grazing has resulted in degradation in large areas which are now open lands especially in the Imenti Forest region. The farmers explained that this is as a result of an increase in livestock populations as an alternative to the cultivation of crops in the region. The trampling and over utilization of animal paths has also led to the degradation of land especially along the Lake Nkunga, where both cattle and livestock graze. These areas reveal eroded grounds where loose topsoil masses have been transported downhill by gravity forces. On such grounds, rainwater runs off instead of being absorbed. Moreover, the livestock also feed on, and destroy the young trees in the protected areas

Photo 9: Lake Nkunga path

Visible soil erosion along livestock tracks through excessive trampling of livestock to and from the Lake Nkunga (C. Mugo, July 2004).

Farmers in the study area experience the absence of enough grazing land due to small farming plots. The recent restriction and banning of free access into the reserves has resulted in a great struggle with less pasture. With this element of the added pressure of grazing of livestock on the same pastures for many years, the farmers perceive that land degradation will occur.

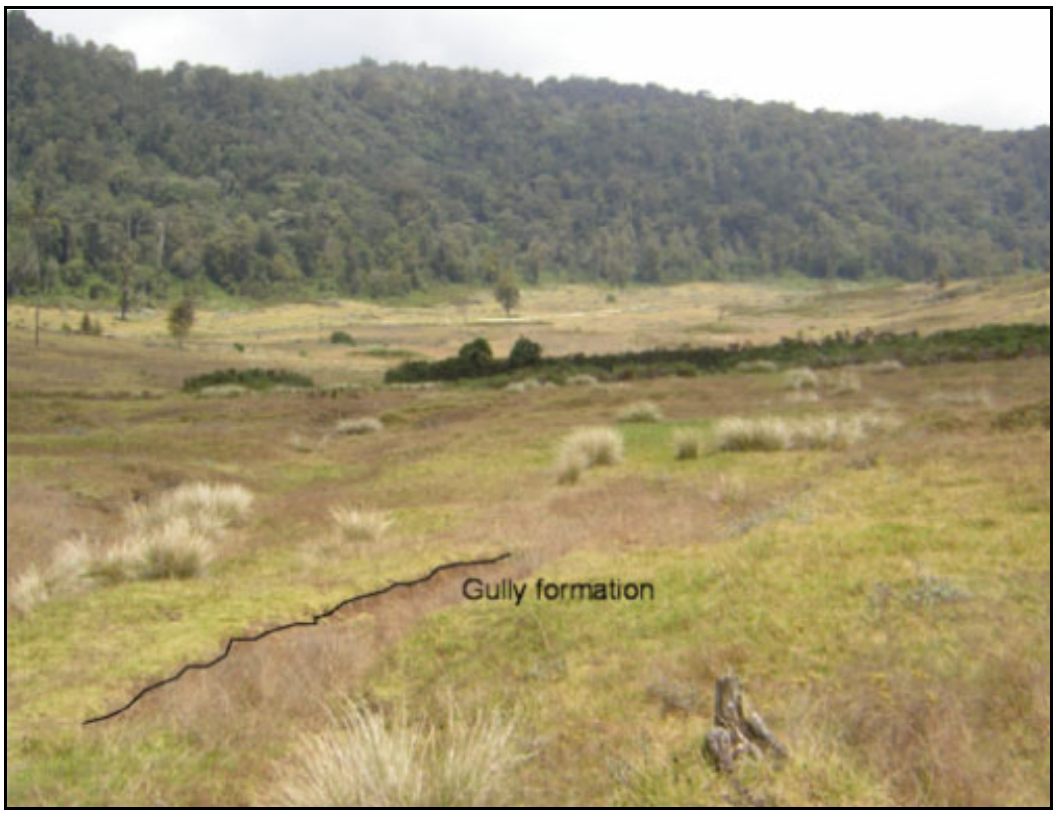


Photo 10: Gully formation

Accelerated erosion from overgrazing in Kibaranyeki (Mount Kenya Forest region). The formations of gullies are indicators of degradation. .This is an example of an area that was once forested, then used for the NRC and is now open to grazing with permits (C. Mugo August 2004).

5.10.6 Managing land to prevent degradation

The study area subject to land degradation especially with the intensification of land use and state altered land use policies has resulted in more vulnerability and insecurity characteristics of the farmers. The lack of stability would only reflect an improper management of the land degradation issues.

Farmers were therefore asked to state how they manage and maintain their farmland concerning soil quality, to determine their perception on how well the soil does after the

application of measures. This approach helps ascertain the level of farmer knowledge and the extent of farmer engagement and involvement in maintaining the quality of the soils in relation to land degradation.

The use of terraces is the most popular method to halt the erosion process in the study area as this decreases the slope on which the crops are planted. The more the top soils become vulnerable to erosion, the more care is needed to prevent land degradation by practicing suitable land uses to conserve the soil. The farmers used terraces, and grass strips irrespective of the steepness of the slope as that is the method they had used from one generation to another to prevent soil erosion.

In the Mount Kenya region, zero grazing is more widely practised and cattle is not usually grazed along the banks of streams or rivers and in the protected forest regions as is common with farmers in the Imenti Forest region. This practice ensures that none of the manure is wasted. Apart from that, there is also the use of grass heaps or legume stover that is used as trash lines. The trash lines act as a barrier to runoff and this later develops into a terrace. This method could also increase the organic matter in the soil if the trash lines are distributed to all parts of the farm. Nevertheless, in recent years, the farmers claim to never have abundant stover from their harvests for this use. Farmers in the Mount Kenya area also stated that land continually degrades in areas where fertile soils have been over utilized.

About a third of the farmers however expressed that the soils in the bottom valleys were more fertile than the soils on other parts of their land, which has resulted in relocating of the vegetable gardens from near the homestead to the bottom valleys as the yields were higher. Soil fertility was thus a criterion that was used to determine what part of the farm was best suited for their land use, i.e. the type of crops, and livestock keeping areas.

As the yields decrease on their farms, the farmers began to be keener on the use of additional fertilizers or manure on their farms to improve the exhausted soils. Soil tests are however expensive, therefore leaving the crop yield, and the successful maturity of fruit trees, and abundant growth of napier grass strips for the farmers to evaluate the nutrients of their soils. This requires that the farmers habitually apply their observational skills to the nutrient cycle on their farms.

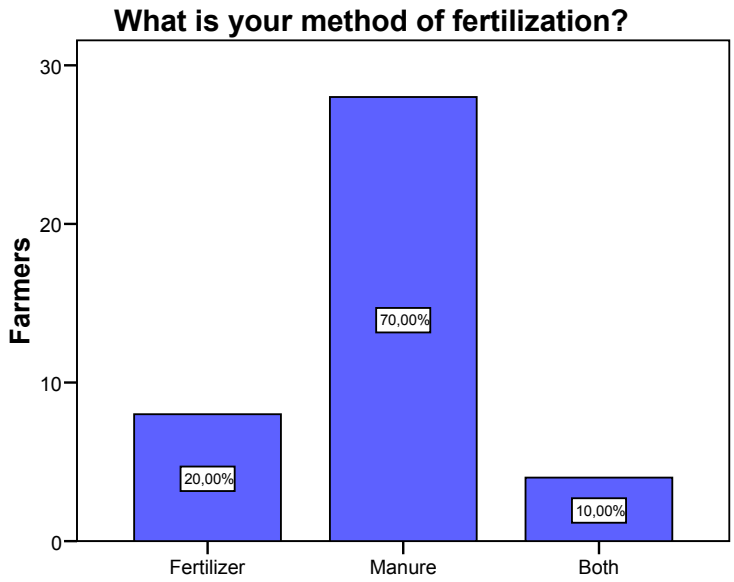


Figure 31: Fertilization methods - Imenti Forest region

After each harvest, significant quantities of soil nutrients are lost and these nutrients are components of the exported biomass. These decreases in the soil's nutrients require the replacement of the soluble minerals at regular intervals through the addition of fertilizers. When supplemental fertilizers are not added, eventually fertility decreases and the soil resource begin to degrade (JOHNSON and LEWIS 1995:100). The use of chemical fertilisers is beyond the economic means for the small-scale farmers which engage in continuous cropping without the addition of any nutrients.

Farmers in the study area were aware of the use, and importance of fertilizer to improve the fertility of the soil. The farmers showed awareness of the decline in the organic matter of their soil which results in less plant nutrients being available in the soil which consequently degrades the soils physically. The farmers in the Imenti area (70%) largely depended on organic fertilizer, mainly animal manures and crop residues in the attempt to maintain soil fertility (figure 32). In the Mount Kenya Forest area, 35% of the respondents used chemical fertilizer, and 22% of the farmers used both organic and chemical fertilizers. The collected manure is piled up in a composite pile and then used when they have a considerable amount, in this procedure, it is important to properly manage the manure so that nutrients are kept intact prior to use.

Chemically, the farmers in the study area mainly use fertilizers containing phosphorous DAP (Diammonimum Phosphate fertilizers) on their farms while nitrogen providing

fertilizer CAN (Calcium Ammonium Nitrate) was used by 20% of the respondents. NPK (Nitrogen, Phosphorous, Potassium) was also used in the study area. In the Ruuiri areas of the Imenti Forest where soils are shallow and sandy, a probable increase in the use of organic matter content of the soil by use of the manure would help enhance the water holding capacity. Because of continuous cultivation, apart from soil organic matter, the soils may thus lack elements like nitrogen and phosphorous because of their non-replenishment. However, overall in the study area, there was a decline in the use of inorganic fertilizers because of socio-economic constraints.

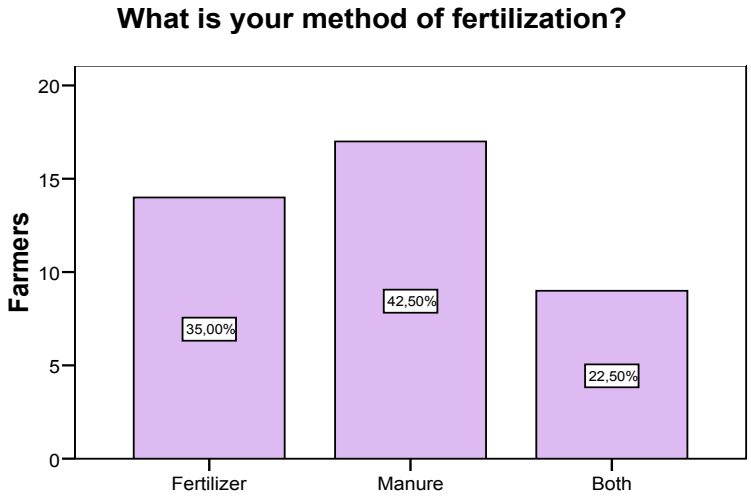


Table 17: Fertilization methods -Mount Kenya Forest region

The results in the cross tabulation (table 18) indicate that 67.5% farmers in the Imenti Forest region practice continuous farming while principally applying manure. Since the cattle are mostly grazed in the protected areas, the availability of manure is then not easily accessible.

Cross tabulation

Do you practice continuous farming or do you leave land fallow? * Do you use manure or fertilizer?

Imenti Forest Region		Do you use manure or fertilizer?			Total
		Fertilizer	Manure	Both	
Do you practice continuous farming or do you fallow?	Continuous	7	27	4	38
	Fallow	1	1	0	2
Total		8	28	4	40

Table 18: Fallowing and fertilization method -Imenti Forest region

The continuous growing of one crop usually results in the degradation of soil while an appropriate rotation of crops assists in putting back the nutrients lost. This is because the amount of nutrient used up by certain plants is not necessarily the same nutrients that would be taken up by a different type of crop. This makes a seasonal rotation of the crops beneficial. The majority of the farmers in the study area however practiced crop rotation, whereby they replaced parts of the maize fields with beans.

Continuous farming is however not practised in the neighbouring forest areas, and the areas are thus considered high agricultural potential areas. The soils have not been over utilized and exposed to degradation. Therefore, a growing scarcity of potential farming land or grazing areas leads to encroachment of the protected areas. As a result, farms are partially deserted or turned into grazing areas. Farm areas that have been abandoned only become more degraded. JOHNSON and LEWIS (1995) agree that when much of the soil is bare, a moderate rainfall event can result in greater soil losses than a more intense storm when plant cover is high.

5.10.7 Household income

The amount of income a household has, and relative assets greatly influence a livelihood by either elevating it or reducing it. It was thus significant to find out if the farmers in the study area derived their income from their farms, which would explain their perception in choice of land use and changes that are prompted for income purposes. Subsistence farming is an important feature in the study area accounting for 84% of all the total income.

Agriculture therefore plays an important role in jobs and livelihood dependency. Eighty-two and a half percent of the farmers in the Mount Kenya area derived all their income from their land. A total of 85% of the respondents in the Imenti Forest area also derived all their income from their land (table 19). The cross tabulation shows that these households also had the majority of land use changes since the early 80's. Since household income was closely linked to farm production, food security strongly accounts for the decisions and methods of land use to ensure that daily requirements are met.

Farmers in both forest regions further stated that unemployment rates were high, making production on the farms of great significance. This had not hindered changes of migration by male family members from the rural village areas to the urban centres in search of employment to increase the household income. From the total farmers interviewed, only 4% lived on and owned property that was 4 acres and more which was all their property. Land has continuously been subdivided leading to agricultural intensification.

Is all your household income derived from your land? * Extent of land use change since the early 1980s Cross tabulation

Imenti Forest Region		Extent of land use change since the early 1980s			Total
		no change	slight change	major change	no change
Is all your household income derived from your land?	No	1	3	2	6
	Yes	8	13	13	34
Total		9	16	15	40

Table 19: Income and land use change -Imenti Forest region

5.10.8 Major problems faced by farmers

An analysis of farmer problems was significant to identify constraints according to the ranking and priorities as seen by the farmers. This could lead to an establishment of land use change causes and effects criteria list that influences land use. Farmers were asked to indicate the types of problems that the farmers in the study area were facing during the

time of research. Although the farmers were keen on giving a list of problems they face, they had to state one.

What problems do you face as a farmer today?

Imenti region		Frequency	Percent
Valid	Lack of water	13	32,5
	Unreliable rainfall	8	20,0
	Wildlife conflicts	14	35,0
	Low fertile soils	4	10,0
	High labour costs	1	2,5
	Total	40	100,0

N=40

Figure 32: Farmer problems- Imenti Forest region

In the Imenti Forest region, 35% of the farmers indicated wildlife conflicts as a major problem (figure 33). The lack of water (32.5%) and the unreliable rainfall (20%) were also stated as major problems the farmers were facing at the time of research. The unreliable rainfall is frequently mentioned in the Imenti Forest region, the farmers expressed that the unreliability of rainfall was due to a change in rainfall patterns in the Imenti Forest area over the past decade. The farmers perceived that the destruction of the Imenti Forest also has impact on the increase of temperature and precipitation loss in the region. The available historical climatic data does not verify the issue.

There has also been an increase for the demand of water especially for the farmers that are now trying to promote their irrigated horticultural farming, the vegetable gardens, as well as the traditional beans crop fields. Ten percent of the farmers in the Imenti Forest area regarded the low fertility soils as their greatest concern, while the high labour costs were not regarded a major problem.

However, problems of high labour costs seemed to largely apply to the farmers in the Mount Kenya Forest area. This is due to the larger farm areas with the coffee and tea plantations where the crops are more labour intensive. Unreliability of rain and low fertility soils were not mentioned as major issues by the farmers in the Mount Kenya Forest region. In addition, most Andosols have excellent drainage because of their high porosity and their occurrence in high terrain regions (DRIESSON et al. 61:1991).

Problems of wildlife conflicts were mentioned as major problems in both forest regions (see also table 20). It is important to note that since it was a very actual problem at the

time of research, the farmers could have regarded other problems that they face as secondary at the time.

What problems do you face as a farmer today?

Mount Kenya region		Frequency	Percent
Valid	Lack of water	18	45,0
	Wildlife conflicts	13	32,5
	High labour costs	9	22,5
	Total	40	100,0

N=40

Table 20: Farmer problems- Mount Kenya Forest region

5.10.9 Wildlife conflicts

Problems like wildlife conflicts that the farmers faced were raised because the farmers' crops were destroyed, they lost their livestock, property, and the conflicts and endangered their lives. The wildlife are threatened by the farmers or killed to avoid future conflicts. When crops are destroyed consecutively over the seasons, then it also compels the farmers to adapt to different methods of land use especially if there are no crop-protection initiatives offered for them. The small-scale farmers who are already economically vulnerable develop negative attitudes towards the wildlife. These continued wildlife human conflicts have an effect on the farmers' perception of the forest reserve areas, which can also be regarded by the farmers as 'wildlife habitats'.

Population growth generates a demand for land in areas traditionally reserved for wildlife. Human populations and wildlife are increasingly competing for natural resources (land and food) so naturally both interests come into conflict over land, space and food. As a result, cultivation extends into ecologically marginal zones where new farms encroach on game controlled areas. Ultimately, humans and animals clash (YEAGER and MILLER 1986:71). This is a conflict that 35% of the farmers within the Imenti Forest region (figure 33) and 32.5% of the farmers in the Mount Kenya region aired as one of the worst problems they face as farmers today in the study area. The animal species causing destruction include elephants, vervet monkeys and bush pigs monkeys.

Imenti Forest region

A destruction of the wildlife habitat forest reserve, has led to the destruction of property, crops and livestock losses, and the killing or injury of humans. Night after night, farmers have to stand in watch of their farmlands to drive away elephants that destroy their crops. In parts of the study area where there is no electric fence especially around the Ruiru and Kanjai areas, the cases of wildlife conflicts are common. Farmers in those areas, expressed concerns specifying that the elephants usually migrate around the months of July and August, from the North Isiolo region, including the Meru National Park, through a corridor near Ruiri, and then again between December and January in search of vegetation in the Mount Kenya Forest. In addition, since the fencing has been done in only some areas of the forest reserve, it causes wildlife to move towards their farms in search of exit areas.

The farmers in the Imenti Forest area further stated that they do not get the security they are entitled to receive from the KWS when the elephants raid their crops and they do not receive any compensation. An instance of a very bitter farmer claimed that since her husband had been killed trying to fight off elephants, she had not received any form of compensation whatsoever for over a year. Elephants destroy their whole farms overnight and the land is left bare.

The farmers express that the elephants do not find enough to feed on in the degraded forest ranges because of rampant illegal logging and corruption, and therefore seek the food crops on their farms. The elephants and other wild animals like baboons and vervet monkeys also destroy tree plantations by uprooting or simply trampling over them. The wildlife (especially elephants) however also causes destruction of the forests as well.

Farmers in the study area also expressed the conviction that there was no use of them planting any crops on their farms or even tree seedlings, as they have been destroyed several times, and the only solution would be to fence off the reserve area. Furthermore, they receive no compensation for the destruction of their farms.

Nevertheless, according to the farmers, in cases where their crops have been destructed by wildlife, the authority (Forest Department and KWS) would be more lenient on them with regard to the utilization of the forest resources thereafter.

5.10.10 Farmer perceptions of the protected areas

The farmers were also interrogated on their perception of the protected areas with regards to the benefits and any conflicting land use issues. The long term interaction and use of the forest reserve resources requires the support of the adjacent communities making it necessary to understand their values and perceptions of the areas. The understanding of the relationship between the adjacent farmers and the protected forest regions can better explain occurring threats like deforestation and degradation impacts that occur.

Eighty-seven and a half percent of the farmers in the study area had not visited the neighbouring protected areas mostly because of the lack of money. Three farmers claimed they had not time and 15 farmers stated that they had no interest. The adjacent communities were aware of the forest reserves designated purpose and any legal entitlements they had to the protected areas.

In the study area, about 44% of the farmers admitted to benefiting from the forest reserve with the collection of firewood being highest in both regions. The farmers however reported that there was more forest cover 2 decades ago, as more deforestation than afforestation has been taking place. Certain tree species like *Prunus africana* and *Fragoropsis angolensis* are still widely accepted in traditional healing, making traditional health care still an important aspect. In this, the farmers stated the decrease of the medicinal plant species although there was an increasing demand on herbal medicine. 97.5% of the farmers in the Imenti Forest region directly benefited from the neighbouring forest for firewood, building material, fodder and grazing as well as fruits, herbs and honey collection.

Seventeen point five percent of the farmers adjacent to the Mount Kenya Forest region, stated that they did not directly benefit form the forest areas (figure 34). These are mainly the farmers in the fenced, forest regions where a 100m belt of tea exists which made it more difficult to penetrate into the protected regions. These farmers may moreover not practice any grazing activities in the protected areas.

Although farmers in the study area greatly value the forest regions because of its products for domestic use, the farmers also argue that the protected areas are selfishly manipulated by government and tourism oriented organisations that make profit. The profit is not used to improve the livelihood of the communities adjacent to the forest, who are in turn held responsible for the reserves utilization.

Forest destruction is unfortunately then censured on them. Relationship between park rangers has also not been one of the best because mostly, decisions are made without farmer consultancy which is a forceful means of resolving the problem related issues. This contributes to the negative attitudes and perceptions of the farmers and communities towards the importance of the protected areas.

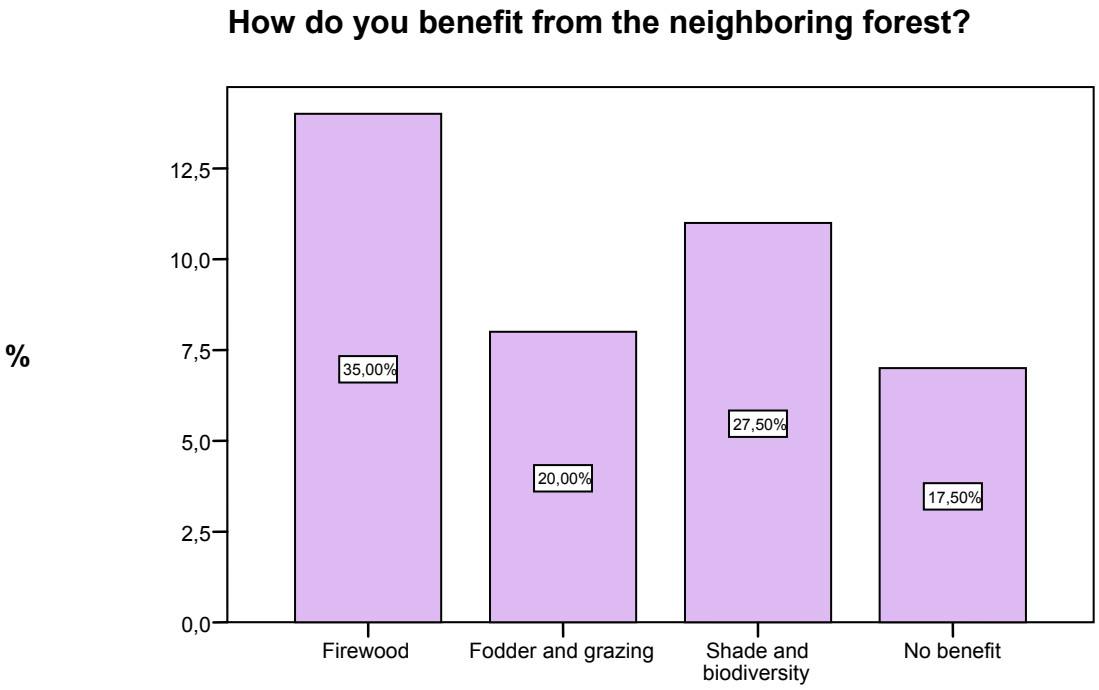


Figure 33: Farmer benefits of adjacent forest areas

Firewood and fodder collection

Almost all households interviewed in both forest areas use firewood for the preparation of their meals. It is usually acquired from the neighbouring forests, and trees on the farms that are cut and used in form of twigs and branches. The use of charcoal in the study area has also been on the increase.

The collection of firewood is mostly done by women who mainly prune the trees in the protected areas. There is a significant amount of firewood required daily as it is the main source of energy. Since the principal meal in the study area consists of beans and maize, the farmers expressed that food takes a long time to prepare so using charcoal or even kerosene both of which are on the expensive side are never an alternative.

Where do you get your firewood from?

Imenti region		Frequency	Percent
Valid	On my farm	6	15,0
	From reserve	30	75,0
	Other	1	2,5
	Total	37	92,5
Missing	No response	3	7,5
Total		40	100,0

Table 21: Acquisition of firewood- Imenti Forest Region

In the Imenti Forest region 75% of the farmers collected twigs and wood pieces from the forest reserve, (table 21) 2.4% of the farmers have enough trees on their farm whereby they can collect firewood on a daily basis. In the Mount Kenya region, 30% of the farmers got their firewood directly from the forest reserve, while the other 70% acquired firewood from their farms.

In addition, whenever possible, the farmers collect their firewood even with expired permits in the forest reserves as the graph above indicates. Many of the farmers in the study area use wood to construct their homes and to fence their compounds. However today, more and more homes are planting trees on border lines other than using wooden planks/poles.

5.10.11 Farming in the protected areas

In the protected areas, forest department reports state that the Non-Residential Cultivation (NRC) was mostly accompanied by the distraction of original indigenous tree species, with the establishment of faster growing tree plantations with exotic trees, especially from South Africa (personal communication with DFO Meru station -Abuto).

Photo 11: Regenerating forest area

A regenerating forest area with pine plantations in Marania (Imenti Forest region) after the banning of the NRC. Evidence of maize stalks from a harvest in the year 2002 (C. Mugo August 2004).

Afforestation is included in the NRC farming method as tree seedlings from the forest department nurseries are planted within the forest reserve areas. Farming is also incorporated and while the farmers cater for their crops, they assure that the young tree plantations are free from weeds. About 5 of the farmers however admitted that this was not always the case as the uprooting of tree seedlings, so as to extend the time allocated on the shambas was a common practice. It consequently happens that the forested areas are not replaced by any form of vegetation, and the land hence takes into a process of degrading.

5.10.11.1 Banning of the forest utilization

Due to rising corruption and mismanagement of the forest reserve areas, the NRC failed to successfully establish tree plantations and contributed to the destruction of natural forests. In the early 80's, there was the possibility of families residing within the protected areas, to cultivate and tend their crops. However, the ban of the NRC was put into place in the late 80's and the families were driven out of the forest regions because of the destruction of the forest. According to farmers, the NRC nevertheless continued, especially through the bribing of officials and forest guards.

Reports from farmers living in the Upper Imenti Forest area which is still much degraded are convinced that extensive forest destruction that was happening a few years ago was purely as a result of corruption as they witnessed large trucks that were loaded with illegally logged trees which could not have belonged to any of them.

After the recognition of the vast destruction of the Mount Kenya Forests as a major environmental problem, strict measures towards the protection and management of the forest reserves has led to the prohibition and restriction of utilizing the forest resources without a permit. Permits have to be issued for the cutting down of trees, including on farm trees, and permits have to be issued for selling trees (personal communication with Meru forest warden -Mburia).

Although this question not only applied to farmers who have been living within the areas where no electric fence (Imenti) or no tea zone is present, restrictions to use the neighbouring forest has caused great concern. The use of the forest solely to graze wildlife or collect firewood only with a licence has increased farmer expenses and minimized benefits of the protected region. Extra costs imposed on the utilization of the protected areas will leave the adjacent communities more impoverished. By formerly being allowed to farm and graze in the forest, they had more space which they today petition.

About three quarters of the farmers in the Imenti Forest area claimed that due to the ban of forest utilization, they would have to implement new land use methods as the partially neglected soils on their farms are no longer fertile, and they cannot rely on them. Furthermore, the farmers stated that a ban for them to use the forest because of forest destruction reasons that were not caused by them was very biased. Since the decision was made without consulting the local community, they claimed that the measures were bound not to succeed, as they too should be involved in management issues of the neighbouring protected areas.

5.10.12 Tree plantation

Trees are important as they not only provide ecological advantages, but also social and economic benefits. The tree roots not only anchor the trees but also the topsoil increases its resistance to erosion. The farmers were hence asked if they had recently (within the past 2 years) planted any trees to obtain their perception of the importance of trees on

their farm areas. The farmers were also asked if they would plant more trees on their farm areas if seedlings were provided from the government so as to rule out the seedling cost factor for not planting trees.

In the study area, the farmers perceived the importance of trees as a factor that plays a role in the land use practice. The farmers also possessed a wide knowledge of the tree species in their environment. Notably was the importance of knowledge in the medicinal plant species that were available in their surroundings.

Sixty-five percent of the farmers in the Imenti Forest region had planted trees recently on their land, and 77.5% of the farmers in the Mount Kenya region had recently planted trees on their farms. Tree species that were commonly planted by the farmers in their home gardens include *Grevillea robusta*, *Eucalyptus globulus, Vitex keniensis, Croton macrostachyus*, and *Olea africana.*

Although all the farmers had planted trees within the past 10 years, the major constraint was that the seedlings are too costly. Secondly, the farmers claimed that there was also little or no available space on the small acres of their farms to plant any trees. In spite of that, if seedlings were to be provided by the government, 90% of the farmers agreed that they would plant trees mainly at the borders of their land. With the restrictions of access to the forest reserves, small self-help groups like the "Weru" are now actively involved in the planting of nurseries and eventually selling the seedlings.

Photo 12:"WERU" conservation initiation signboard

Farmers self help-community project "Weru" in the Imenti Forest region, where preserving the forest reserve regions and the wildlife is of great significance. The majority are composed of registered groups committed to improving the environment and their livelihoods (C. Mugo, July 2004).

Most of the nurseries are owned and initiated by community based women's organisations that form a team with members ranging from five to twenty people and have various social projects. The community groups require a lot of commitment for their success, as members are expected to fully participate in the activities. The women are also convinced that with the organisation of such groups, it would be easier to obtain support from the local government for their projects. Besides, they also share ideas and offer advice amongst themselves on better farm methods and soil degradation measures.

The DFO also encourages individuals to take responsibility of the tree nurseries and supervise tree-planting activities in the region as a measure of involving the local communities in forest management. At the time of research, the Japanese International Cooperation Agency had donated seedbeds to the District forest office at Meru. The nurseries are mainly Meru oak (*Vintex keniensis*) which the elephants do not feed on. The farmers get permission to collect firewood and fodder from the forest reserve as remuneration (personal communication DFO Meru station -Abuto).

Photo 13: Women initiatives

Women from the community inspecting the tree nurseries at the DFO station in Meru (C. Mugo July 2004).

5.10.12.1 Reasons for planting trees

According to the farmers, the most important reasons for planting trees in the study area include firewood, fruit and fodder, fencing and shade and soil conservation (whereby the leaves are sometimes also used for mulching). The farmers expressed that as the numbers of livestock and populations increased, so did the requirement of more trees. Other reasons the farmers planted trees were for construction, and medicinal purposes which are important to the livelihood of the community, and to provide a habitat for beehives. About 10% percent of the farmers interviewed also have beehives in the protected areas. Honey is used mainly for economical purposes and also for brewing purposes. Honey has long been used in traditional ceremonies and celebrations like initiations and marriages among the Meru (see BERNARDI 1989, NYAGA 1997). The farmers have man made wooden beehives in the forest, where it is easily accessible.

5.10.13 Endangered plant or animal species

The loss of vegetation through land use in the study area has had an effect on the animal species, as the ecological balance has been disturbed. Trees consist of the principal factor on which other species in the forest are subject for their existence. To further perceive what the farmers knew about changes in their immediate surroundings, they were asked to mention if they were aware of any endangered animal or plant species that were present 20 years ago, and are scarce or nonexistent today. The farmers are aware that there is a disappearance of plant and animal species. When asked to mention animal and plant species that are endangered or have disappeared within the areas, the farmers stated: warthogs, lions, cheetahs, baboons, buffalos, antelopes, monkeys, and bushbucks. Plant species included cider, African plum tree, Cyprus, Elgon teak, fruit trees, Parastol tree, Elgon Olive, Cape mahogany, that are mainly trees whose primary use is timber.

The farmers connected the loss of plant biodiversity (trees in the forest reserve area) to the reduction of wildlife dispersal land, which consequently increases human wildlife conflicts.

5.10.14 Government and agricultural support

Mostly small scale farmers do not have land areas that are large enough to measure up to the yield productions in large farm areas and are thus never considered significant in a market oriented farming system. Agricultural extension services are necessary to assist in advising the small scale farmers in decision making between the crops cultivated according to the amount of land area available, soil conservation measures, irrigation options, livestock development to overcome challenges the farmers face like low yields, lack of finance, land management and also marketing issues. Since the Mount Kenya region is an area where farming is intensified, a lack of proper farming techniques will result in further land degradation and possible deforestation.

The farmers were thus asked if they received any support from the government, NGOs or farmer associations. This was to find out if any support would also influence land use changes that take place within the study area.

Imenti Forest region

About 82% of the farmers in the Imenti Forest region expressed that they did not receive any support whatsoever from the government NGOs or farmer associations. The visits and support must have not been recent since the farmers barely remembered holding talks with agricultural educationists who had come to give them advice on proper or improved farm management techniques. In the Imenti Forest region, the farmers expressed that help was needed to enhance their livelihood, especially because they presently do not have total access to the protected areas and fertilizers are too expensive. However, inadequate funding has led to the lack of personnel and thus the less frequent or non-existent farm visits that were more popular in the 80's (personal communication with Meru central District DFO -Abuto).

Mount Kenya Forest region

Indeed, it is evident that the majority of the agricultural attention and policies have shown preference to the farm areas in the Mount Kenya region where the majority of the farms produce crops (tea and coffee) for the market. These farmers hence directly benefited from governmental strategic land management advice.

In the Mount Kenya Forest region over half of the farmers received support mostly for farmer associations on farming methods whereby they were advised on improved farming methods, soil fertility and fertilizers, preventing soil erosion, reducing harvest losses, tree planting etc. As expected in the cross tabulation (table 22) in the Mount Kenya Forest region, 4 out of 22 farmers had a slight change of land use despite receiving support from the Government, NGOs, or farmers associations on farming methods and/or conservation. On the other hand, from the 7 farmers in the Imenti Forest region who received support, all had a change of land use irregardless.

Do you get support from the government, NGOs, farmers associations etc on farming methods and/or conservation?
*** Extent of land use change since the early 1980s Cross tabulation**

Mount Kenya Region		Extent of land use change since the early 1980s		Total
		no change	slight change	
Do you get support from the government, NGO's, farmers associations etc on farming methods and/or conservation?	No	10	8	18
	Yes	18	4	22
Total		28	12	40

Table 22: Farmer support and land use change-Mount Kenya Forest region

5.10.15 Crop irrigation and water sources

Farmers in the study area have the possibility of obtaining water for domestic use or irrigation from the streams and rivers. The lack of water in the areas is however one of the major problems farmers experience. The unreliability of water can be related to water shortages which have an effect on land use for instance farmers practicing horticultural farming need sufficient water supply in order for the crops to thrive. A long interval without water to irrigate crops presents risks to productivity. Water for domestic use is also put under strain. The farmers were thus asked to state the availability of water and irrigation methods in relation to land use, and possible effects on land use change.

Mainly, water sources are concentrated along the Kathita and its tributaries in the Imenti region, and Thingithu towards the Mount Kenya Forest in the study area. In the Northern

regions, in particular the dry seasons, the farmers stated that they have to walk long distances of over 1.5 km in search of water in this part of the region. Women are particularly put under a disadvantage because they fetch the water. This can also explain the shift of the vegetable gardens to the bottom valleys of the farms.

Imenti Forest region

Seventy-seven and a half percent of the farmers did not irrigate their crops, and relied fully on rainfall. However, 77% of the farmers had water sources near their land. Twelve and a half percent of the farmers irrigated their crops. Farmers in the Northern part of the study area expressed that water availability is very limited. Water for their vegetable gardens is also very scarce, as most of the acquired water is principally utilized for domestic and livestock consumption. The usage of water for agriculture on the farms is not regulated which causes conflict of water availability in regions further away from the mountain source.

In the areas around Ruiri, the farmers complained that people pumped water from the rivers, with or without necessary permits. Informal irrigation methods in the study area do not clearly define the rights of access to the water for the different farm uses. This has resulted in conflict as the little flow of water they usually have in the rivers has greatly decreased, and the rivers are almost dry. Unfortunately, no account is taken of long-term hydrological records to determine the water resource availability (UNEP and GEF 2002). Irrigated farming also poses conflict between the river water users. A farmer in Amwari stated that farmers are consuming most water on the slopes, and therefore conflicts could occur if water does not reach the downstream communities.

The use of the bucket for irrigation is most widespread in the study area. This method is very popular in irrigating fruit trees, banana plants and the vegetable gardens. The use of self-constructed sprinklers, which is a method where the water is perforated through nozzles that are operated under pressure forming a spray pattern, was observed on 2 farms in the Mount Kenya region. In the Mount Kenya Forest region 12.5% of the farmers irrigated their crops, and tap water was never used for irrigation because it is rationed and was not always readily available. However all the respondents in the Mount Kenya region has water sources near their land.

Photo 14: Giaki-Bean plantation on an irrigated farm

The use of buckets, sprinklers and drip irrigation is the most common method of irrigation in the study area. In the drip irrigation the water flows through hosepipes with openings that discharge water in different intervals. The irrigation method largely depends on the availability of water and the size of the farms being irrigated (C. Mugo, July 2004).

5.11 Discussion

The objectives of this research was to document land use changes so as to note action programs that can prevent degradation in a well planned foreseeable period. The approach was to obtain:

- Farmers' perceptions of the impacts of land use, land use change and degradation on their farms and in the protected areas in the past 20 years in the NE Mount Kenya
- Socio-economic factors that influence land use change in the region
- The indicators of land degradation

The application of the satellite images and GIS data further demonstrates the land use changes in the study area on a larger scale. This allowed for vegetation cover changes in the forest regions to be mapped. With the available GIS data, the satellite images and the responses from the interviews, land use changes within the NE Mount Kenya area were satisfactory as they include both human and natural factors. The analysis of the two forest regions separately was also an important approach due to the differing AEZ regions within short distances.

5.11.1 Farmer perceptions of degradation

From the interviews, participants who were mainly the heads of households, in this case being the men, willingly offered to participate in the interviews, which were conducted in the local language, Kimeru. Even though it is the women who have the most access to conditions in both the farms and the protected areas, decisions of land use changes were solely made by the men, who customarily inherit land.

Land degradation has manifested itself in several ways in the study area. Forest vegetation in the reserves which provides wood and fodder, has become scarce. The farmers claim that the soils in the Imenti forest region have become stony. Amongst other changes, this has resulted to a change of crops grown for instance in the Imenti region, whereby a more widespread addition of drought tolerant crops like peanuts and mirraa have been introduced. Footpaths are being destroyed and it is visible that the soil has moved along the surface down the slopes, into the lake Nkunga. These factors have

negative impacts for land users who largely rely on the forest reserves and the production of their farms for a living.

As mentioned, farm areas in North Imenti were more prone to degradation than other areas. Vegetation cover is scarce and the plains to the north are composed of the Nyambeni lava volcanics, which are low lying and with particularly shallow and rocky soils (BAKER 1967). Potential and quality of the farms is deteriorating, as indicated by the farmers. This was because of declined soil fertility due to nutrient deficiencies and crop productivity, which result in constraints on farming on the lands. Farmers attributed low crop yields to potential land degradation. Degraded fields were perceived to be unyielding, and thus poorly managed.

Over 90% of the farmers adjacent to the Imenti Forest area described the condition of the soil on their farms for the past 20 years as deteriorating, which also explains the tentative land use changes in the region. The degradation of farmlands compels the farmers to introduce improved practices that prevent further degradation and maintain soil fertility, particularly to sustain crop production. Twenty-five percent of farmers in the Imenti Forest region have opted to cultivate more groundnuts, which have medium drought resistance, but still require well-drained soils. Nonetheless, the availability of Nitosols in the Imenti Forest region, which according to DRIESSON et al. (1991) are used for moderate to high production under a wide range of crops, allows farmers to diversify their choice of food crops.

Although the Mount Kenya area and the Imenti Forest area have differing ecological settings, intensified land use is present in both areas, and farmers from both regions stated that the potential of their farmlands was deteriorating. Farms in both the Mount Kenya area and the Imenti Forest areas were susceptible to land degradation. JOHNSON and LEWIS (1995) agree that land degradation is neither limited to fragile environmental settings nor to rural activities. Nevertheless, farmers in the Mount Kenya region concentrated on improving the quality of their soils and farming methods, rather than changing their historical patterns of land use.

The steep relief features that are predominant in the Mount Kenya region combined with the region's higher precipitation makes the soils more susceptible to erosion. Overgrazing and the expansion of open areas in the forest in the Mount Kenya region has led to the formation of visible degradation indicators like rills and gullies, making the

Mount Kenya region even more vulnerable. Continual loss of top-soil diminishes the potential of the soil to store nutrients and retain water.

The farmers in the study area however largely exhibited profound knowledge of the natural environment and arising degradation problems. Farmers perceive that land degradation is accelerated due to loss of vegetation cover, especially the destruction of indigenous tree species.

OGALLO notes that drastic climate changes that have been observed over many high tropical mountains are closely associated with global climatic changes like those connected to global warming induced by an increasing release of greenhouse gases (GHG) (OGALLO 1990: 139). The farmers in the Imenti Forest Reserve linked the destruction of forest vegetation cover with the increasing unreliability of rainfall in the regions. The satellite images (TM and ETM) also show a clear loss of vegetation cover within the forest reserves in the Imenti region. None the less, according to the meteorological (WORLD CLIMATE 2006), rainfall data remained constant in the same range in the Meru weather station. However, precipitation data in specific weather stations on the Eastern side of the study area where there is a change in the AEZ (JAETZOLD et al 1982) is not available.

All farmers interviewed were aware of suitable land use methods that can prevent land degradation. The farmers had specific perceptions of farm management including the planting of trees, use of terraces, planting of napier grass and covering bare soil with mulch. However, the farmers' perceptions on appropriate land use methods were largely related to generating income to meet basic needs. Consequently, in both forest regions, maize and beans are increasingly intercropped, a method which increases effective utilization of nutrients, water, land and light (MWARIRI 2005). However, in some cases within the Imenti region, the farms are in a poor state due to the lack of proper maintenance, especially by farmers who believed that the government should intervene and offer more financial support. Although the farmers perspective of degradation was expressed in accordance to deterioration of forest vegetation, also essential to the farmers regarding land degradation is the a decrease of production and lower yields; which is a vital factor for them. Subsequently, the farmers resolve for a change of land use, which can include the intensification of farming: for instance intercropping or a complete change of crops grown. These decisions that the farmers make are usually on a short term approach to improve their standard lives, or fulfill their requirements in the particular

given period. This is mostly as a result of financial constraints where land use options are reduced. As a result, the farmers only focus on their immediate needs. Nevertheless BLAIKE (1989:23) argues that there is virtually no land which produces economically useful products such as crops livestock or trees, which cannot be managed to maintain yields indefinitely. Even for the least resilient ecosystems, there are techniques of land management providing protection form degradation.

5.11.2 Farmers' perceptions of land use change

Land use changes in the study area are triggered by economic forces and farmers' perceptions on profitability and increased income. The farmers adopt changes of land use when crop yields decline and alternative crops are in market demand. Farmers also adopt land use changes if there are prospects of higher returns. An example of a notable change in land use practices due to economic factors was the change from cash crop farming to horticultural farming. Farmers were willing to change to horticultural farming if they could obtain water for irrigation regularly. Also the planting of more drought resistant cash crops like groundnuts and miraa also increased in the Imenti Forest region.

Thirty percent of the farmers in the Imenti Forest region have gone through major land use changes, which largely consist of the shift from the NRC. The areas used for farming on private lands need to now cater for all the subsistence farming which also includes the keeping of livestock. This means that the farming area is reduced in size, and accordingly decreased yields resulting from an intensification of land use could cause food shortages.

Although the NRC was not necessarily successful in the reforesting of degraded areas in the forest, the farmers around the Imenti Forest were convinced that if they were still allowed to plant crops in the forest as well as tend the young trees, it would alleviate some of their constraints, especially that of farming space. Since the family land has been continuously subdivided over the years, it can prove difficult for a farmer to competently manage the farm as an income generator without much yield from it. He would need to provide cash crops and subsistence crops as well as sustain soil nutrients, for example by the use of fertilizers to prevent further degradation.

As a result of declining crop yields, there has also been a preference for increased livestock farming over the cultivation of crops. This is largely evident in the North-Western area of the Imenti Forest region. Livestock farming however is not a common

practice with the small-scale farmers in the study area, which would impede a total adoption of dairy farming for instance.

The change of land use to horticultural farming seems to be a better option as land sizes are mostly between one and two acres in the Imenti Forest region. The farmers tend to favour the horticultural garden, which can improve the soil quality and the yield of the plants. In the Mount Kenya region, the farmers are content with the profits and income from perennial crops, tea and coffee and the traditional crops, maize, beans and potatoes; with these crops abrupt land use changes seldom occur. The slower the land use change, the more likely people can adapt without catastrophic harm (JOHNSON and LEWIS 1999:52) For the farmers in the Mount Kenya region, their short-term objective is to yield a profit, while their long-term objective is to sustain their soils. The perceptions of sustaining their soils consequently influenced their decisions to apply chemical fertilizers, which 35% of the farmers use despite the cost constraints.

5.11.3 Land use change and the protected areas

The main reason for a lack of interest in the neighbouring protected areas could be connected to the number of wildlife conflicts (34%) and additionally, the banning of the NRC, resulting in changes in the access rights to the protected areas. There had been reluctance in the Imenti Forest region to adopt practices that could reverse the land degradation processes on their farms. These were to a large extent the farmers who concentrated on the farming areas within the protected areas. In the protected areas however, the cultivation of the traditional crops like maize and beans was vital economically, as the farmers profited from the practice. There was a particular preference for the soils in the protected areas, due to the fertility and satisfactory yield levels.

This perception of the protected areas could have come about as a result of the deteriorating soils on their farms, whereby over 90% of the farmers claimed that their soils had become worse over the past 20 years. These farmers could have also become content with the allocation of the farming spaces in the protected areas, and partly neglected their own farms. As a result of neglecting the farms, a decline in the productive capacity resulted in low yields, which in most cases led to a substitution of other crops.

In the Mount Kenya area, where the reserve had been fenced off, and no shamba system (NRC) was practised even shortly prior to the research, the farmers were inclined to

appropriately manage the farm areas that were available to them. The farmers also had opinions and alternatives that were related to degradation prevention measures for land use in the protected areas, based on their past and present experiences. In this instance, the construction of an electric fence, originally thought to protect the farmers' crops from the wildlife, also acts as a boundary between the farms and the protected regions which then prevents encroachment. The fence also makes it difficult for illegal logging to take place, especially where the transportation of the wood involves large trucks, as these would have to use the entrances, which are easily patrolled.

Impacts on the protected areas

As figure 35 displays, land degradation in the protected areas has resulted through the interaction of the expanding community and the protected areas. The major town in the study has a population density of 1,306 people per km² (CBS 2005). Consequently there has been a decrease of forest vegetation, possibly due to the demand for forest products. This has been an ongoing historical process whereby also in the colonial times, deforestation took place in the protected areas. This includes the destruction of vegetation by clearing land for agriculture. The clearing was no longer thoroughly monitored and controlled, and there was no continuation of tree planting in the allowed farming regions.

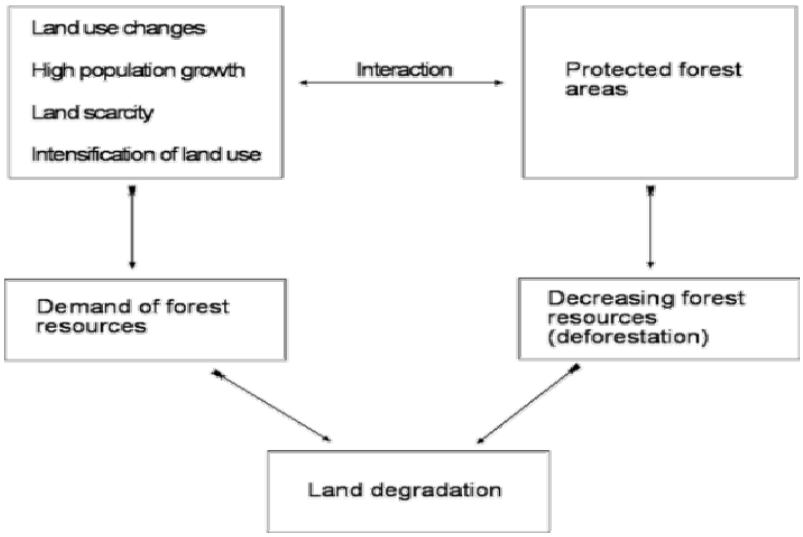


Figure 34: Interaction of land use factors resulting in land degradation in the study area

From the analysis of the TM and the ETM satellite data, the unsupervised classification clearly illustrates a decrease in forest vegetation cover, and an intensification of land use and settlement in the study area. There is an intensification of arable lands in adjacent regions of both forest areas. The mixed hardwood tree species, which are mainly found in the Imenti Forest region, could be a probable cause of the vast forest destruction, due to the high demands for hardwood both locally and nationally (WASS 1995). The impact of the immense loss of forest reserve areas however, has challenged the farmers especially in the Mount Kenya Forest region to adopt initiatives like the planting of tree nurseries, to reverse land degradation both on their farms and in the protected areas. Governmental support for committed self-help groups enables them to profit from the supply of tree seedlings to promote the afforestation measures that combat land degradation.

Despite the awareness of the degradation that is taking place in the Imenti Forest region, the farmers perceive that newly imposed reserve laws and regulations do not integrate their priorities and interests, especially in reference to their needs for farming land. Historical patterns of land use in the protected areas however reveal that monitoring of the NRC has not been successful.

Although some households agreed that they do exceed their licence quotas for firewood collection in the protected areas, they stated that the firewood was used for domestic use purposes only. With the significant destruction of the forest, some tree species have disappeared, and although these areas are being replanted with exotic tree species, especially pines and cypresses, these species are not resistant to termites. Even though they can be treated with preservatives, they do not match the resistance of indigenous species such as the pencil cedar (*Juniperus procera*) (KOHLER 1986:100). However, as the satellite images indicate, forest regions North of Meru increased which is a result of the afforestation initiatives of the women in the area.

Unfortunately, the negative impacts of land degradation and the value of the protected forest regions are realised long after the full effects have occurred. Since at the time of research, the wildlife conflicts were the most current existing problems the farmers faced, other issues like the degrading of land could have easily been overseen. Encroachment and human impact which is already evident in the adjacent protected areas, could continue to occur unless proper reserve management practices and governmental intervention provide for the communities' livelihood and development chances.

Present restrictions on the utilization of protected areas placed upon the farmers causes even more pressure on their land, which is already perceived as degraded. The conflict between short-term economic gain and the long-term environmental deterioration has presented a complicated issue in the region especially when the communities consider that they don't benefit from the neighbouring reserves.

5.11.4 Forest reserve management policies

Tackling the land degradation issue will generally entail addressing two separate questions: (1) How is land degradation brought about? and (2) Why does land management fail to be effective? (BLAIKIE and BROOKFIELD, (1987) quoted in UNPOPIN et al. 1995). Besides the political factors that are involved in the dynamics of land use stability, poor economic conditions and an underdeveloped infrastructure contribute to the heavy dependency on the farmlands. This eventually leads to a competition for resources, especially in the neighbouring protected areas, adding to ineffectiveness in management. The shortage of agricultural land results in lower yields, leading to food insecurity and a lagging economy. This factor increases the threats to the protected area through illegal practices that are still happening. This conflict is exacerbated by wildlife crop raiding, which further adds to the feelings of resentment towards the wild animals in the reserves, creating a general negative attitude towards the protected regions. The ban of the NRC (shamba system) is an added challenge to the conservation of the forest ranges, especially where households strongly relied on the "fertile" parts of the forest to grow their subsistence crops and graze animals. The adaptation or allocation of farming plots into the reserve, combined with a high rate of population growth, would mean that the government would have to enforce conservation policies and management regulations for the forest so as to avoid conflicts.

Farmers perceived that in an earlier generation the use of medicinal trees and plants was very common, but with tighter restrictions on the utilization of the forest, and the disappearance of medicinal tree species, most households now visit modern dispensaries or public hospitals when they are ill. This factor indicates that there has been a decline in species like prunes Africana which has been exploited for medical use. (personal communication with Meru forest warden- Gichuru). When the use of wood exceeds the sustainable yield of wooded areas, forests and woodlands are gradually destroyed. This in

turn triggers or accelerates soil erosion. As a result of the new reserve regulations, forest products such as firewood, fruits and fodder are no longer easily accessible.

The government should look into supporting the community interaction with the protected areas by imposing acceptable forms of policies and governance by agreeing locally with the forest management (KWS and FD) It is important that the farmers get an impartial share of the social and developmental benefits of the protected areas, including access to forest resources. An abrupt change of rules governing protected areas will only lead to abrupt changes in land use in the adjacent farm areas, which will in turn lead to degradation. A target to resolve how the expanding adjacent populations at the local level can make use of their farmlands without degrading the soils can assist in keeping the household income continuous. At the same time, farmers can have access to the protected areas without degrading the forest resources. The forest reserves are intended to be conserved for their intrinsic value, as a resource for the livelihoods of adjacent populations and ultimately as a national resource.

5.11.5 Population growth discussion

Although no data is available on the human carrying capacity of the study area, population pressure is a major constraint**.** The Kenyan highlands have historically attracted, and continue to attract, populations. Overall, population pressure is determinant in vegetation loss, especially in areas with limited land reserves (UNPOPIN et al. 1995). High population densities play a role in the changes of the natural ecosystem. The GIS population data displays a continued increase in populations from 1979 to 1999, with the latest statistics representing densities of over 300 people per km² in the study area. Population pressure and the fragmentation of land through the traditional inheritance laws lead to smaller farm areas, forcing the farmers to intensify the use of their land areas. Due to the frequent division of the farms, the land also loses its efficiency in crop production where for instance, cash crops require larger farm areas for optimal profit. The farmers become drawn to a subsistence economic system, where the small areas of land have to be utilized to their full potential. In addition, after land has been inherited, fragmentation of land spaces can further waste space because of the need to construct roads, paths and fences. Fragmentation also usually results in a change of land use in order to adapt to the new area of available land. Population growth is most likely to result in land degradation when land is held in common without rules governing its access

(JOLLY and TORREY (1993) quoted in UNPOPIN et al. 1995). Between 1987 and 2000 there has been an increase in cultivated and plantation areas along both forest reserves distinctly in the Githongo, Katheri, Githirune, Upper Abothuguchi and Nkuene regions whereby farmers in this region stated to have increased their tea plantations.

In addition, a growing need for food production to cater for the expanding population results in intensified land use. With more people, the increased demand for food results in increased competition for arable land, tending to change land prices. In the common situation in which farmers with small plots have much less access to credit and new technology than those with large plots, this may result over time in a smaller proportion of the rural population owning land (UNPOPIN et al. 1995). Land use intensification has given rise to competition for space, especially by overexploiting the neighbouring protected areas with the collection of wood, fodder, grazing etc to meet their household requirements. This is also evident in the expansion of the Kibarayeki open forest areas in the Mount Kenya region, as the TM and ETM images illustrate. The population growth in the study area is connected to agricultural land use, which involves the accessible fertile Andosols and Nitisols that have a high potential for agricultural production (DRIESSON et al. 1991) and also the availability of forest products from the protected areas. Continued pressure depletes land, and this only exacerbates land degradation issues in the area. This situation creates uncertainty for the future trends, especially where the social governance is not actively involved. Sixty-four percent of the respondents did not get any support or agricultural advice from the government or any agricultural extensions.

In the study area, the lower midland areas that have higher temperatures and lower rainfall effectively have the lower population densities. Population in these areas however continues to increase, which could mean that people migrating from the highly populated areas to the marginal areas could carry on or adopt land use methods that are not suitable for the lower midland areas, thus causing land to degrade.

It is widely accepted that the greater density of the human population, the greater are its impacts on the surrounding environment (JOHNSON and LEWIS 1995). Using satellite images, it is possible to relate the distribution and development of population densities from the GIS data, to the intensification of land use and settlement. For instance an increase of population in the Meru town area (urbanization) from a population density of 980 people per km² in 1979 to a density of 1306 people per km² (1999) in a decreased

area of land could possibly result in the increases cultivation areas that are apparent in the Lower Imenti Forest region, as the year 2000 ETM images indicate. Continued pressures on the neighbouring rural villages from the rapidly growing population and low returns from agriculture can contribute to the rural-urban migration phenomenon. With increasing population pressures, there is a need to improve land use methods, while increasing land productivity without degrading the land.

5.11.6 Agriculture

Climate is an important factor in the study area, because it greatly dictates the type of land use that is practised. Precipitation plays the largest role. When considering the methods in which land will be used and managed, the farmers assess the productivity of the land, by looking at the yields and the amount of rainfall available in an area. This then determines the type of crop to be grown. The GIS data reveal the variability of precipitation between the different AEZ in the study area which clearly distinguishes land use potentials. Humidity decreases eastwards and northwards, and there is a close correlation with the alignment of the natural vegetation, which varies from dense forest to more scattered vegetation. The lower rainfall and probably low humus content of the soils in the Northern part of the Imenti Forest transitional areas (semi-humid, semi-arid transitional zones) make the area ecologically sensitive and more prone to degradation and land use changes. The high evapo-transpiration in the Northern regions of the study area also limits biomass from establishing a good basis for compost that helps increase soil fertility. This climatic component also influences farmers' perceptions of soil quality in the Northern Imenti Forest region and the preferred increase in livestock farming (23%), as well as changes to horticultural farming, where 15% of the farmers in the region preferred to concentrate on horticultural farming.

The farmers in the Mount Kenya region had the added advantage of being able to manage their soils better due to favourable AEZ climatic conditions that influence crop yields, and an abundance of forest cover. This factor has made the Mount Kenya region particularly appreciated by the farmers in that region. The climatic conditions make provision for the cultivation of perennial crops like tea that requires rainfall not less than 1125mm (LANDON 1991:285), and 18°C as the optimum mean annual temperature (REHM and EPSIG (1991) quoted in RUNGE 2005). In the ETM satellite image, there is

a clear increase of tea plantation zones along the Mount Kenya Forest Reserve border. The perennial crops; tea and coffee slow down the negative impacts of land degradation. However, in the Imenti Forest region, after decreasing crop yields the farm areas are considered to be unfertile, and are converted into grazing areas. Nevertheless, with the necessary attention, the soils could still be improved. These bare patches just contribute to accelerated soil erosion and the condition cannot be reversed.

The low agricultural input, which includes the ineffective use of manure or fertilizers due to the high price of chemical fertilizers, and the intensified land use under continuous cultivation (over 78% of the farmers in the study area do not fallow) result in the degradation of soil. The intensification of crop farming and the discontinuance of fallow periods have contributed to low crop yields as a result of loss of nutrients and organic matter in the soil. Since subsoils generally contain fewer nutrients than topsoils, more fertilizer is needed to maintain crop yields. This, in turn, increases production costs. Moreover, the addition of fertilizer alone cannot compensate for all the nutrients lost when topsoil erodes (FAO (1983) quoted in UNPOPIN et al. 1995).

In the Imenti Forest region most of the changes in land use took place when the quality of the soils was deteriorating, and once the soils had become very poor, fewer changes took place at that level. There has also been a shift from having the vegetable gardens near the homestead at the uplands of the farms, to the bottom of the valleys, which could have been as a result of the erosion of soils on the sloping fields. Crop performance in bottom of the valleys was considered by the farmers more satisfactory. The changes include the growth of crops that can withstand the low level of nutrients in the soils as well as lower precipitation. GACHENE (2003:45) notes that with a better understanding of the soil it becomes possible to plan the most cost-effective measures that target specific problems that limit production. In the study area, it is necessary to match crop requirement to the available AEZ.

5.11.6.1 Livestock keeping

While livestock do not necessarily cause environmental problems, overgrazing can be a major factor in land degradation (UNPOPIN et al. 1995). Fifty percent of the respondents keep cattle as the major domestic animal on the farms in the Mount Kenya region. Cattle are popular in both forest regions and the reason for this could be that goats and sheep are for the most part free rangers and prefer to browse than to be kept in

a stall. Nevertheless, the numbers of cattle and goats have increased within the last 5 years in the Imenti Forest region with 23% of the farmers changing from crop farming to more livestock farming. This increase could be as a result of the exhausted soils that have lost their nutrients. Yields are low, and fertilizer prices are high, which impacts on the maintenance and quality of the farms. However, with good management of the manure from livestock, which is a good source of organic matter, the farmers in the study area could maintain the soil nutrient levels.

The increase in livestock may also be due to the interest in the specialization of dairy farming as opposed to the cultivation of subsistence crops, in cases of declining yields. The pastures are intensively grazed, and time is no longer allocated for the regeneration of pastures due to limited space on the farms. This situation results in the search for better grazing pasture in the protected forest areas, where continuous grazing restricts the regeneration of the original vegetation cover.

5.11.6.2 Market policies

The main source of income for the households in the study area is agriculture, whereby 95% of the households interviewed relied on agriculture for their income. The cultivation of subsistence crops is important, especially maize and beans, which are essential, regardless of the cash crops grown on the farms. Also the population density is relevant to the level of direct pressure on resources; population growth and urbanization affect the volume of market demands; urbanization absorbs land, and is conducive to biased pricing policies (UNPOPIN et al. 1995).

Horticulture has almost doubled its Gross Market Production in Kenya from 1999 at 21 million Ksh (210,000€) to 37 million Ksh (370,000€ provisional quote) in 2004 (ROK 2005). The gradual change to horticulture can play a very important role in developing the small-scale farming regions in the study area. An increase in the cultivation of tea is evident due to better market offers, whereas in contrast, coffee prices have dropped. Factors like commodity prices and market availability therefore play a role in the way the land is used in the study area.

Farmers in the Kiirua in the Imenti region adapted to the cultivation of more groundnuts on their farms due to the degradation of the soils. However the soils must have still retained their ability to drain well in order for the groundnuts to prosper. The same

applies to the miraa which also requires well drained soils and which moreover has a growing market and is thus a more reliable source of income.

5.11.7 Poverty

From site observations in the study area, the degradation of soils and the degradation of the vegetation cover are both factors are correlated. With the intensification of land use, changes in, and even the destruction of, the natural system are inevitable. The soils have become poorer, which leads to an even poorer community. The extent of land degradation on a farm depends in part on how intensively the land is exploited, and in part on the holder's ability and willingness to undertake conservation measures. Small holdings may be "mined" in order to extract enough for family subsistence; their holders cannot afford to leave a large portion of the farm fallow; the output does not enable long-term investment in soil conservation or amelioration, or productivity-raising implements (UNPOPIN et al. 1995). The lack of resources and finance can thus be seen as the main factor that hinders the successful management of the farms. Increased constraints on farmers reveal worsening poverty in the study area, which has resulted from the unsuitable fragmentation and distribution of farmlands, which has in turn led to intensified use of the few acres of land.

The low yields on the farms not only lead to a lack of food security, but also greatly contribute to a lag in economic development in the area, leading to poverty. Appropriate enhancement of land use patterns that prevent land degradation increase crop productivity, thereby ensuring better food security and ultimately agricultural economic development. The farmers in need of support should have financial assistance from the private or public sectors to adopt improved methods of farming. Such resources could positively reduce negative farming practices that lead to degradation. However, as the farmers are already suffering from financial constraints, it would be not very useful to introduce improved farming methods such as the use of chemical fertilizers that would significantly increase.

Nevertheless, a clear link between poverty and land degradation is manifested as a result of the continuation of the traditional land tenure system and the growing population who require more food, firewood, construction material that are all obtained form the surrounding environment has also caused land users to move past the boundaries into the

forest protected regions. The degradation of land thus has adverse effects regarding the way that the families maintain their livelihoods.

5.12 Perspectives

In the absence of sound land use policies, growing population pressures, poverty, agriculture, market policies, and forest reserve management are factors for accelerated land degradation in the NE Mount Kenya region. The farmers in the adjacent protected regions in the study cannot be held solely responsible for the mass destruction of the forest regions.

The government needs to respond more effectively to the land use problems that are decelerating development in the region. For instance, an improved infrastructure will increase the availability of market access. Measures such as paying compensation for wildlife destruction, providing a reliable water supply, the provision of tree seedlings, education projects or farm visits should be implemented. These measures would reduce farmers' feelings of insecurity and the resulting abrupt land use changes.

Clearly there is no immediate fix of the land tenure issue, however the government has to positively respond and intervene by developing the areas within the major towns thus creating other job opportunities. That way, even family businesses could be inherited instead of small farming areas on the already intensely fragmented land. The government can also address issues of the changing demographics to encourage smaller families. These initiatives can support and encourage the farmers in the study area not to be exclusively dependant on their farmlands for an income.

However, when making land use plans for the study area it is important to take into consideration the AEZ differences of the District which define the land potential. It is important to fully understand the underlying factors that have led to degradation on a local scale both within the protected areas and in the adjacent regions.

Although it is not straightforward for communities to master a new system of land use altogether, it would be beneficial to encourage the farmers by giving them the support and security to achieve the first steps in the process successfully. The government should encourage farmers to seek advice concerning appropriate land use methods with regard to the market demands while reducing the risks of land degradation. This can entail

experimenting with a variety of crops on an alternating basis or intercropping with fruit trees and leguminous crops, which encourage nitrogen fixation. These experiments could even be carried out on small areas of their farms to begin with where yield processes could be observed to present alternative farming methods over the range of soil types and the precipitation availability.

The practice of agro-forestry, the cultivation of both agricultural and forest products, like it should be in the NRC in the reserves should also be encouraged (especially the plantation of non-timber tree farms and fruit trees) on the private farmlands. The planting fodder shrubs on the private farm lands can also be beneficial to the farmers. Governmental agriculturalists should assist in data-keeping and taking note of the changes and yields in the farms in relation to rainfall patterns on a specified crop rotation plan. This would also provide a historical record of land use to avoid the lack of long-term data.

More area-specific research should be carried out in the region, especially the identification of soil fertility or decline, so as to maximize and improve fertility of the accessible land. Farm monitoring should be encouraged as this could eventually indicate how crop production can be increased on the individual farms. That way it might be possible to improve land use at the household and farm level before combining regional interdisciplinary alternative agricultural approaches which the farmers would have to adapt to. It might be of great practical interest to assess the demands for wood from all the neighbouring communities with regards to the protected areas, to work out a concept as to how the utilization of the forest can be accomplished in a more sustainable manner.

Community participation is vital for effective and successful management strategies within the forest protected areas. This calls for more communication and better co-ordination as the communities should benefit from the existing neighbouring reserves from generated revenues.

The government should aim at integrating development projects that are directly beneficial to communities adjacent to the park. Promoting alternative income-generating activities, besides livestock and crop farming, can reduce pressures on the forest ecosystem. Moreover, there is a need to assess the impacts of new regulations and reserve management policies in relation to the land users, who are in this case the farmers. This will increase awareness of the land degradation factors and at the same time promote the benefits of the protected areas.

Furthermore, since it is mainly women who gather the forest resources, and also have most initiatives when it comes to tree planting, or managing group tree nurseries, tree nurseries on private land and at the forest stations, it would be advisable that gender issues are integrated in the protected areas management. Females should actively participate in decision-making processes pertaining to land use which would require more communication and better co-ordination. The transfer to the younger generations of knowledge gained and lessons learnt from land use change should be encouraged, mainly because the younger generations tend to adopt the practices of the older generations.

6 Conclusion

Linked socio-economic and ecological forces on land use and land use changes leading to land degradation in the past two decades were investigated in the NE Mount Kenya area. This area consists of the Imenti Forest Reserve, the Mount Kenya Forest Reserve and the adjacent farm areas in the region. Farmers living directly adjacent to the forest reserve protected areas were interviewed about present land use and land use change. In addition the interpretation of GIS data, satellite images, and field observations were used to assess the extent to which land use techniques were contributing to land degradation. The qualitative information from the interviews allowed for an approach that examined directly the needs of the land users, while the quantitative analysis showed the results of land use in the geographic area covered.

From the results, the actual socio-economic factors that influence the land users' decisions on farming methods in the study area include:

1. **Population pressure**: leading to more land fragmentation, no fallow periods, no use of fertilizers, loss of soil nutrients
2. **Reserve management policies**: restricted use of protected areas, reduction of farming and grazing land, farmers' changed perception of protected areas, human-wildlife conflicts, changes in land use, illegal use of forest areas, deforestation
3. **Economic changes**: demand for agricultural products, agricultural intensification, increase of livestock densities, demand for forest products
4. **Ineffective land tenure system**: customary land fragmentation, agricultural intensification
5. **Poverty:** lagged economy, poor infrastructure, smaller farm areas, decreased crop yields, intensified land use

These factors lead to land use changes, which then cause ecological impacts that consequently lead to additional land use changes.

The GIS data and the satellite images cover a wide area and allow for a comparison of present and past vegetation cover in the study area. The satellite images and GIS data provided a sufficient basis for land cover mapping where forest vegetation cover was the

dominant element. The use of images alone cannot serve as an optimal method to perceive the intricacies of land use and land use change impacts. Instead, the combination of the mapping and interview approaches appeared suitable. Observations focused on the land users to find out their concerns on how degradation impacts livelihood, and field investigations better explained the extent and causes of the problem by concentrating on local area impacts. A land productivity assessment focusing on loss of soil fertility (e.g. due to a lack of fertilizer use), erosion and physical degradation such as the compaction of soil, was made from a land users' point of view to emphasise land degradation impacts in the study area.

Since the benefits of the forest protected areas have both ecological and socio-economic significance, the evaluation of the ecological issues as well as the socio-economic factors offer a good basis for the investigation. Ecologically, deforestation (decline of vegetation) increases soil erosion, which affects an area's natural potential. Socio-economically, the total dependency on land from a growing population to earn a sustainable income increases the threat of land degradation. Although this approach is extensive, the main emphasis was placed on the participation of farmers because ethnographic research of this type has not been done before. The results in the research confirm the importance of socio-economic incentives in relation to land use impacts. These can provide lessons to be learnt that lead to a more favourable reception of profitable land use practices.

The study area is characterised by intensive land use on soils of volcanic origin. It is inhabited by the Meru who are primarily small-scale farmers. The farmers possess full landowner usage rights and rely heavily on agricultural production for their income. The region is characterised by a bimodal rainfall distribution with relatively reliable precipitation. Land use is related to differences in altitude, relief, humidity and temperatures.

The Mount Kenya Forest Reserve is distinguished by high elevation (between 1,500 and 2,500m asl) and a humid and sub-humid climate, while the Imenti Forest region lies lower and is characterised by semi-humid and transitional zones. The agro-ecological zones (AEZ) are defined by the differences in altitude, rainfall and temperature. The type of land use is determined by the AEZ. Accordingly, the Western part of the study area

(the Mount Kenya Forest region) experiences higher precipitation and is more humid. Land use in this region is mainly perennial thus eliminating seasonal land use changes. The analysis of the two forest regions separately was also an important approach due to the differing AEZ regions within short distances in the study area.

The analysis of the TM and ETM satellite images from 1987 and 2000 clearly indicates the degeneration of forest vegetation cover in the protected areas regions over the 13 years. The largest change is evidently the diminishing of the Lower Imenti Forest which consists of hardwood species like *Ocotea usambarensis* and *Vintex keniensis* which are used for timber. The loss of vegetation as an indicator of degradation is displayed by increased open areas in both the forest reserves. Cases of encroachment into the forest and the intensification of cultivated areas and settlement are evident in the far Eastern region of the Imenti Forest. The land users' decisions and approaches regarding the degraded regions in the Imenti Forest area (including the forest regions) became more and more confused as their main focus became survival in the deteriorating environment due to the changes in soil quality. Areas in the North Imenti regions, where the soils were perceived by the farmers to be of less value for agriculture because of decreased yields, are more susceptible to land degradation from land use changes. These changes include changes from crop farming to more intensive livestock farming, or intercropping which is intensified cultivation. Additional land use changes are also dependent on market demands and market availability. For instance, the farmers stated that there has been an increase in the cultivation of tea in the Mount Kenya area due to better market offers for tea, which is also evident in the ETM satellite image.

Continued population pressure combined with the lack of a lawful and effective system of land tenure in the study area has made land utilization issues complex and more difficult to accomplish. The growing population whereby GIS data indicate population densities of over 300 people per km² in both forest regions in the study area, exerts pressure on the protected area due to an increased demand for settlement areas, farmlands, grazing areas and firewood. The ETM satellite image displays a decrease of forest vegetation through encroachment whereby settlements and open regions are evident between Kithirune and Nkuene. There has also been an increase in plantation areas along the Mount Kenya Forest region, which can be explained by the growing population in that region. Population increase within the last two decades has

consequently led to decreased sizes of farm plots due to the customary fragmentation of land through inheritance. Consequently, farmers stated that intensified land use without the application of fertilizers and with no fallow periods, reduces the soil's nutrient value and lessens its optimal potential. This leads to poor yields, and thus food insecurity.

However, the major constraint mentioned by the farmers was the unavailability of water. This has led to cultivation increases near streams and rivers at the bottom valleys of the farms in both forest regions. Consequently, there is a growing conflict, as water used for irrigation is confined to particular outlets which hinder its flow. Additional constraints like the human-wildlife conflicts also play a role in the land use changes, whereby the destruction of crops by wildlife or the physical degradation of soil from the trampling wildlife influence efforts made by farmers to maintain their farms successfully. Particular cases in Giaki show that initiatives made by the farmers like the planting of tree seedlings would be unsuccessful as the seedlings are destroyed by elephants in the unfenced zones in the region. When initiatives do not work, there is then the danger that a cycle is set where land degradation features, including a change in soil structure and the loss of nutrients, lead to decreased yields and thus increased poverty for the population that is dependent on agriculture.

The availability of water sources determines favourable livestock grazing areas in the study area. However the grazing of large numbers of livestock, especially near the Lake Nkunga area, has led to soil erosion through constant trampling. The increase in livestock numbers in the Western area of the Imenti Forest has led to a need for more grazing areas, which has resulting in the formation of rills and gullies, which are indicators of degradation, in the protected areas. The soils in the transitional areas in the north, between Kiirua and Ruiri are stony and have lower water storage capacities, and are thus more susceptible to erosion. Such soils that have been termed by the farmers as "unsuitable" for crop cultivation are on the increase and are left open or used for livestock grazing which further intensifies degradation from the loss of vegetation cover on the vulnerable soils. In such regions farmers stated that there has been an increase of livestock numbers, which then impacts on loss of forest vegetation cover near the Lake Nkunga as the ETM image shows.

Farmers' perceptions of the protected areas revealed that conserving their farmlands as well as the adjacent protected areas is considered vital. Although the farmers perceived the importance of preserving the adjacent forest reserves, they still illegally use forest

products by collecting fodder and grazing their animals in the reserves. The farmers admitted playing a role in the extraction of forest resources without permits, which would include the collection of fodder. This however was not perceived as a major concern, as the practice has been carried out from generation to generation.

The appropriate planting of a tea belt in the Mount Kenya Forest region together with the electric fence acts as a buffer between the adjacent farmers and the protected forest regions. With no buffer zone and the NRC in the Imenti Forest region, land use change trends have been exceedingly rapid. The banning of access into the forest reserve areas in the Imenti Forest region, of which the farmers disapprove, has greatly reduced their grazing and cultivation areas, making this the biggest land use change in the study area.

Results from the two forest regions in the study area indicate that both forest ecosystems respond similarly to influences of the natural ecosystem and disturbances from human impact. The ETM images nevertheless show increases in forest vegetation cover in the Mount Kenya Forest region. Areas in North Abothuguchi that were plantation and cultivated regions in 1987 have forest cover in 2000 as a result of the afforestation initiative and the NRC ban. According to the farmers, the regeneration of forest cover north of Meru was also due to their afforestation initiative groups with various tree nurseries.

The farmers in the study area are aware of the negative impacts of degradation, and of appropriate measures to prevent degradation. There is widespread use of terraces on the farms to prevent erosion. Other measures like the use of fertilizers are however not readily available due to financial constraints. It is important to inaugurate appropriate farming methods that increase the rejuvenation of the soil to maximize the agricultural practices and yields on the land. An improved condition in agricultural economics and market orientation can encourage farmers to focus on producing profitable crops and at the same time adapt to better methods of land use.

The government needs to respond more effectively to the land use problems that are decelerating development in the region. Promoting the keeping of records of land use in order to avoid the long-term lack of data would be advisable. Furthermore, reliable water supply, the provision of tree seedlings to farmers, farmer protection from the wildlife and regular farm visits can reduce the farmers' feelings of insecurity and the abrupt land use changes that consequently arise. Also intercropping with fruit trees and leguminous crops

and planting fodder shrubs on the private farm lands can be beneficial to the farmers in the study area.

Land degradation in the study area has not occurred purely as a result of intensified agricultural land use practices. Interlinked socio-economic factors, including population pressure, reserve management policies, economic changes, an ineffective land tenure system and poverty, have contributed to the problem, making it difficult to identify one specific factor**.** Like in the Imenti Forest Region, the more degraded a particular region is, the more insecure the farmers are, and the more abruptly the land use methods undergo alteration. Therefore land use changes driven by the socio-economic factors in relation to the varying AEZ should be continually investigated and monitored to aid in controlling land degradation in the study area.

Deutsche Zusammenfassung

Im Rahmen der vorliegenden Arbeit wurden Landnutzung und Landnutzungswandel untersucht, die während der letzten 20 Jahre im NE des Mount Kenia Gebietes (Imenti Forest Reserve, Mount Kenya Forest Reserve sowie in den benachbarten Farmländern) zu Landdegradation geführt haben. Interviews zu Fragen aktueller Landnutzung und Veränderungen im Anbauverhalten, die mit den Besitzern der an die Reservate angrenzenden Felder geführt wurden, und die Interpretation von GIS-Daten und Satellitenbildern sowie Geländebeobachtungen bilden die Basis für die Beurteilung der Auswirkungen, die unterschiedliche Methoden der Landnutzung auf die Landdegradation haben. Die qualitativen Informationen aus den Interviews ließen eine detaillierte Vorgehensweise zu und ermöglichten so, besser auf die Gesprächspartner einzugehen, während die quantitativen Informationen Geländebefunde zur aktuellen Landnutzung und zum Landnutzungswandel belegen halfen.

Die Ergebnisse der Arbeit zeigen, dass die sozioökonomischen Faktoren, die die Entscheidung eines Landnutzers für eine Agrarmethode im Untersuchungsgebiet beeinflussen, die folgenden sind:

1. **Bevölkerungsdruck:** führt zu vermehrter Fragmentierung von Land durch Realerbteilung, keine Brachzeiten, kein Einsatz von Dünger, Verlust von Bodenfruchtbarkeit
2. **Parkrichtlinien:** beschränkte Nutzung von Naturschutzgebieten, Reduktion von Agrar- und Weideflächen, veränderte Ansicht der Bauern zu geschützten Gebieten, Konflikte zwischen Tieren und Menschen, Landnutzungswandel, illegale Nutzung von geschützten Waldgebieten, Entwaldung
3. **Marktwirtschaftliche Veränderungen:** Nachfrage von Agrarprodukten, Intensivierung landwirtschaftlicher Produktion, Zunahme von Viehdichte, Nachfrage von Waldprodukten
4. **Realerbteilung**: ineffiziente und traditionelle Flächenaufteilung, Intensivierung der agrarischen Produktion
5. **Armut:** verzögerte Wirtschaft, vernachlässigte Infrastruktur, kleinere Felder, geringere Ernte, Landnutzungsintensivierung

Diese Faktoren führen zu einem Landnutzungswandel, der infolgedessen ökologische Auswirkungen verursacht, die konsequenterweise zusätzliche Landnutzungsänderungen nach sich ziehen.

Der GIS-Ansatz und die Auswertung von Satellitendaten ermöglichten einen ersten Überblick über die natur- und kulturräumlichen Gegebenheiten vor Ort und erlaubten darüber hinaus einen multitemporalen Vergleich der Vegetationsgegebenheiten im Untersuchungsgebiet. Die Satellitenbildszenen und GIS-Daten bilden deshalb die Grundlage für die Landnutzungskartierungen, bei denen die Vegetation als dominantes Landschaftselement interpretiert wurde. Da die Verwendung dieser Daten alleine nicht ausreicht, die Zusammenhänge zwischen landwirtschaftlichem Druck, Veränderungen in der Nutzung und der zunehmenden Landdegradation zu verstehen, wurden die individuellen Wahrnehmungen der Landnutzer sowie eigene Geländeuntersuchungen herangezogen, um das Ausmaß und die Auswirkungen des Problems zu erklären. Gebietstypische Besonderheiten des Untersuchungsgebietes fanden so besondere Aufmerksamkeit.

Da der Nutzen der geschützten Waldgebiete sowohl in seiner ökologischen als auch in seiner sozioökonomischen Bedeutung liegt, stellten die Evaluation der ökologischen wie auch der sozioökonomischen Aspekte eine wichtige Grundlage für die Untersuchung dar. Obwohl die Vorgehensweise komplex ist, wurde die Landnutzungswahrnehmung der betroffenen Bevölkerung im untersuchten Gebiet analysiert und hier besonders berücksichtigt, da eine solche ethnographische Fragestellung bisher nicht in die wissenschaftliche Forschung zu Landnutzungsfragen integriert worden war. Die Forschungsergebnisse bestätigen die Bedeutung der sozioökonomischen Impulse für den Landnutzungswandel, aus denen sich Erkenntnisse für die Anwendung besser angepasster Landnutzungspraktiken ableiten lassen.

Das Untersuchungsgebiet ist der Siedlungsraum der Meru, die als Kleinbauern in einer fruchtbaren Landschaft mit Böden vulkanischen Ursprungs Ackerbau betreiben. Die Bauern haben volle Besitzrechte und die agrarische Produktion stellt ihre Haupterwerbsquelle dar. Die ganze Region hat eine bimodale Niederschlagsverteilung mit zuverlässigen Niederschlägen. Die Art der Landnutzung ist abhängig von Höhenlage, Relief, Niederschlägen und Temperaturen.

Die Mount Kenya Forest Region ist geprägt durch eine Höhenlage zwischen 1500 und 2500 m ü.M und humides bis subhumides Klima, während sich die tiefer liegende Imenti Forest Region durch ein semihumides Klima und einer Übergangszone auszeichnet. Die *agro-ecological zones* (AEZ) werden durch Höhenlage, Temperatur und Niederschläge definiert. Die Zugehörigkeit zu einer AEZ bestimmt die Art der Landnutzung. Aufgrund

der durchschnittlich höheren Niederschlagsmengen ist die Mount Kenya Forest Region humider. Deshalb ist die Landnutzung hier gekennzeichnet durch Dauerkulturen, wodurch saisonal bedingte Änderungen der Landnutzung hier nicht auftreten. Entsprechend wichtig war es, im Rahmen der Untersuchung den Verlauf der AEZ zu berücksichtigen, da sie sich innerhalb kurzer Distanzen im Arbeitsgebiet ändern.

Die Analyse von Landsat TM und ETM Satellitenbilddaten von 1987 und 2000 zeigt eine deutliche Abnahme der Waldfläche in den Waldschutzgebieten des Untersuchungsgebietes innerhalb von 13 Jahren. Die größte Vernichtung an Waldbestand weist dabei klar das Lower Imenti Forest Gebiet auf, wo vorwiegend Nutzholz wie *Ocotea usambarensis*, und *Vintex keniensis* Baumarten zu finden sind. Der Verlust der Vegetation als Anzeichen von Degradation zeigt sich durch eine Zunahme offener Gebiete in beiden Waldreservaten. Das Vordringen von intensiver Landwirtschaft und Siedlungsaktivitäten in die Waldgebiete wird vor allem im äußersten Osten der Imenti Forest Region deutlich. Die Gebiete in der Imenti Region, die nach Wahrnehmung der dortigen Kleinbauern aufgrund von Bodeneigenschaften unfruchtbarer sind (durch fehlende Aufbringung von Dünger), sind offenkundig auch anfälliger für Landdegradation, die durch Landnutzungswandel hervorgerufen wird. Böden, die unfruchtbar geworden sind und die weniger Ertrag erzielen, werden von den Bauern in der North Imenti Region geringer geschätzt, weshalb sie diese anders nutzen. Die Böden sind nun anfälliger für Degradation durch Landnutzungsänderungen, wie z.B. von Agrarwirtschaft zu einer zunehmenden Weidewirtschaft, oder dem Zwischenfruchtbau, der eine Intensivierung der Bewirtschaftung darstellt. Zusätzliche Landnutzungsänderungen sind auch von den Marktnachfragen und Marktverwendbarkeit abhängig so dass z.B. die Bauern in der Mount Kenya Region eine Zunahme an Teeplantagen wegen der besseren Marktangebote für Tee angegeben haben.

Fortgesetzter Bevölkerungsdruck und stetige Verkleinerung der Äcker durch die praktizierte Realabteilung verstärken die Komplexität des Themengebietes der Landnutzung im Arbeitsgebiet. Das Bevölkerungswachstum der letzten 20 Jahre hatte aufgrund dessen konsequent eine stetige Verkleinerung der ackerbaulichen Nutzflächen zur Folge. Die wachsende Bevölkerung in beiden Waldregionen, GIS- Daten zeigen über 300 Ew./km², übt aufgrund des dadurch zunehmenden Bedarfs an Siedlungsflächen, Ackerflächen, Weideflächen und Feuerholzes einen steigenden Druck auf die Schutzzonen im Untersuchungsgebiet aus. Siedlungen und offene Flächen, die innerhalb

der geschützten Gebiete zwischen Kithirune und Nkuene in den Wald eingedrungen sind, sind auf dem Landsat ETM Bild zu erkennen. Die Zunahme von Plantagen entlang der Mount Kenya Waldregion ist ebenfalls deutlich sichtbar und lässt sich im Zusammenhang der wachsenden Bevölkerung in dieser Region erklären. Die Bauern äußerten, dass trotz intensivierter Landnutzung Ernterückgänge und zunehmende Unsicherheit in der Ernährungssituation die Folge waren. Brachzeiten wurden nicht eingehalten, was ohne den Einsatz von Dünger die natürliche Tragfähigkeit der Böden überstieg.

Andere, dem Anbau abträgliche Hemmnisse wie die Wasserarmut bestimmter Teilräume haben zur Folge, dass im Untersuchungsgebiet der Anbau in der Nähe von Fließgewässern und besonders auf den Talböden zugenommen hat. Dadurch entsteht zunehmend ein Konfliktpotential, da das für die Bewässerungslandwirtschaft genutzte Wasser durch die dammartige Bewässerungsanlage auf bestimmte Zapfstellen beschränkt ist, die den Abfluss behindern. Zusätzliche Schwierigkeiten wie die Konflikte zwischen den Siedlern und den Wildtieren spielen hinsichtlich des Landnutzungswandels ebenfalls eine Rolle, wobei die Zerstörung der Bodenstruktur die ertragreiche Nutzung ihrer Ländereien maßgeblich beeinflusst. Besondere Fälle in Giaki zeigen, dass Initiativen wie das Pflanzen von Baumsetzlingen durch die Landwirte erfolglos sind, weil sie ständig durch Elefanten in den Regionen ohne Zaun zerstört werden. Durch die Entwicklungen in den letzten Jahren besteht die Gefahr, dass ein Prozess in Gang gekommen ist, bei dem zunehmende Landdegradation, messbar im Verlust fruchtbaren Bodens, zu rückläufigen Ernteeinnahmen führt, was eine Verarmung der von der Agrarwirtschaft abhängigen Landbevölkerung nach sich zieht.

Gebiete, die über eine Wasserquelle verfügen, werden im Untersuchungsgebiet bevorzugt und als Viehweide genutzt. Jedoch haben große Viehherden besonders in der Nähe des Lake Nkunga wegen des verstärkten Viehtritts und der daraus resultierenden Zerstörung der Grasnarbe zu Degradationserscheinungen beigetragen. Mit einer Zunahme im Hinblick auf den Viehbesatz wurde auch der Flächenanspruch bezüglich neuen Weidelandes größer, was einen zunehmenden Druck auch auf beide Waldschutzgebiete und die Bildung linearer Erosionsmuster (Rillen, Gullies) zur Folge hatte. Im Norden des Untersuchungsgebietes, zwischen Kiirua und Ruiri, sind die Böden steinig, besitzen eine geringe Wasserspeicherkapazität und sind erosionsanfälliger. Diese Böden werden von den Bauern als ungeeignet für Ackerbau betrachtet und bleiben deshalb zunehmend

ungenutzt oder dienen als Viehweiden, wodurch die Degradation der ohnehin erodierten Böden verstärkt wird.

Die Schutzzonen spielen in der Wahrnehmung der Kleinbauern trotz der eingeschränkten Nutzung neben ihren eigenen Feldern auch in Zukunft eine wichtige Rolle, weil sie weiterhin Waldprodukte (z.B. Feuerholz) nutzen und ihr Vieh in den Reservaten weiden lassen. Sie gaben im Rahmen der Befragungen zu, diese Waldressourcen illegal zu nutzen, weil es aus ihrer Sicht nicht von maßgeblichem Interesse sei, und da es traditionell über Generationen hinweg gängige Praxis ohne negative Auswirkungen auf die heute geschützten Gebiete gewesen ist.

Die zweckmäßige Anlage eines saumartig die Mount Kenya Region umgebenden „Tee-Plantagen-Gürtels“ sowie die Errichtung eines elektrischen Zaunes fungiert als Puffer zwischen den Waldschutzgebieten und den Ländereien der sie umgebenden Siedlungen. Ohne diese Pufferzone und durch die Non Residential Cultivation (NRC) in der Imenti Forest Region hat sich der Landnutzungswandel dort viel rascher vollzogen. Das Zugangsverbot für die Schutzgebiete in der Imenti Forest Region hat die traditionell als Weide- und Ackerland nutzbare Fläche der ansässigen Bauern stark reduziert. Hier dokumentiert sich der größte Landnutzungswandel im Untersuchungsgebiet.

Die Ergebnisse aus beiden Waldgebieten verdeutlichen, dass die Waldökosysteme ähnlich sowohl auf natürliche als auch menschliche Eingriffe in das naturräumliche Gleichgewicht reagieren. Die ETM Bilder zeigen dennoch in der Mount Kenya Waldregion an verschiedenen Stellen zunehmende Waldbedeckung an. Wie die Umfragen ergaben, weisen die Bereiche in Nord Abothuguchi, wo 1987 Plantagen und ackerbaulich genutzte Flächen vorhanden waren, bedingt durch die Aufforstungsinitiative der Bauern und das NRC Verbot, im Jahr 2000 Waldbedeckung auf.

Die Kleinbauern im Arbeitsgebiet sind sich gleichwohl der negativen Einflüsse der durch Vegetationsverlust hervorgerufenen Degradation bewusst und wissen um angepasste Maßnahmen der Bewirtschaftung, die der Degradation Einhalt gebieten können. Eine weit verbreitete Maßnahme gegen den erosionsbedingten Bodenverlust ist die Anlage von Terrassen. Andere Möglichkeiten wie die Nutzung von Dünger sind aufgrund fehlender finanzieller Grundlagen bislang nicht umsetzbar. In Gebieten wie diesen kommt es darauf an, angemessene Anbaustrategien zu adaptieren, die eine Verbesserung der Bodeneigenschaften bedingen und so zu einer Maximierung des Anbaus und der

Ernte führen. Verbesserte Bedingungen der Vermarktung agrarischer Produkte können ebenfalls dazu beitragen, die Bauern durch ihre Marktorientierung zu einem angepassteren Anbau zu ermutigen.

Obwohl das Konzept von Schutzgebieten eine positive Rolle bei der Entwicklung im Untersuchungsgebiet spielen kann, wird sein Erfolg im Kontext der aufgezeigten Landnutzungskonflikte in maßgeblicher Weise davon abhängen, ob sich gangbare Managementpläne erarbeiten lassen, die Flora, Fauna und menschliche Aktivitäten in Einklang bringen, um kontraproduktive Bemühungen in Zukunft zu verhindern. Die Kooperation von Forest Department (FD), Kenya Wildlife Service (KWS) und den ortsansässigen Gemeinschaften sind dabei von grundlegender Bedeutung, wobei Parkrichtlinien mit den Interessen der Kleinbauern abgestimmt werden müssen, wenn gangbare Lösungsansätze implementiert werden sollen.

Die Regierung sollte effektiver auf die Landnutzungsprobleme, die die Entwicklung in der Region verlangsamen, reagieren. Eine zuverlässige Kartierung der Landnutzung sollte gefördert werden, um einen langfristigen Mangel an Daten zu vermeiden. Außerdem sollten eine effiziente Wasserversorgung, die Verteilung von Baumsetzlingen und eine Beratung der Bauern dazu beitragen, plötzliche Landnutzungsänderungen zu verringern. Der Zwischenfruchtbau mit Obstbäumen, Leguminosen und Futterpflanzen auf den privaten Ackerflächen könnte den Landwirten im Arbeitsgebiet Vorteile bringen.

Die Landdegradation im Untersuchungsgebiet ist also, wie die Untersuchung zeigt, nicht allein die Folge intensivierter Landnutzungspraxis, sondern Folge einer Kette sozioökonomischer Faktoren wie Bevölkerungsdruck, Parkrichtlinien, marktwirtschaftlicher Veränderungen, Realerbteilung und Armut, die es als Teilaspekte erschweren einen bestimmten Faktor unabhängig zu spezifizieren und zu identifizieren. Je degradierter eine bestimmte Region ist und je unsicherer die Lebensgrundlagen für die dort ansässigen Kleinbauern sind, desto abrupter stellen sich Veränderungen in den Anbaumethoden ein, wie das Beispiel der Imenti Forest Region zeigt. Durch sozioökonomische Faktoren hervorgerufene Landnutzungsänderungen, vor allem eine Intensivierung der Nutzung in den nicht für die Landwirtschaft freigegebenen Schutzzonen, sollte aus diesem Grund kontinuierlich untersucht und überwacht werden, insbesondere in Beziehung zu den unterschiedlichen *agro-ecological zones* (AEZ), um eine weitere Landdegradation im Untersuchungsgebiet zu kontrollieren und zu verhindern.

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8 Appendix

Questionnaire

Location/Sub location: _____

Forest Region: _____ Date: _____

Name: _____ Gender: Male/female

1. How would you describe the quality of your soil over the past 20 years?
   Been good Same Become worse Become very bad
2. What is your major land use?
   Subsistence farming Cash crop farming Livestock farming
3. Main type of animals kept on the farm?
   Cattle Sheep Chicken Goats Other_____
4. Main type of crop cultivated
   Maize Beans Tea Coffee Horticultural crops
   Potatoes Other_____
5. How much of your land is allocated for the main use
   15% 25% 50% 75% 100%
6. Extent of land use change since the early 80's
   No Change Slight Change Major Change
7. Change on farming method
   No change Livestock to crop farming Crop to Livestock farming
   NRC to farm Livestock to Horticulture Crop farming to Horticulture
8. Do you use manure or fertilizer? Fertilizer Manure Both
9. Do you irrigate your crops? No Yes
10. Do you have any water sources near your land? No Yes
11. Do you practice continuous farming or do you fallow? Continuous Fallow
12. What are your measures against soil erosion?
    Terracing Tree cover crops Contour ploughing
    Mulching Other_____
13. Where do you get your firewood from?
    On my farm Forest Reserve No response Other_____
14. Is all your household income derived from your land? No Yes

15. What problems do you face as a farmer today?

    Lack of Water Unreliable rainfall Wildlife conflicts

    Low fertile soils High labour costs

16. How do you benefit from the neighbouring forest?

    Firewood Building material Shade and biodiversity

    Fodder/grazing Fruits/herbs/honey No benefit

17. Have you ever visited the neighbouring National Park/reserve?

    No Yes

18. Why have you never visited the protected area?

    Lack of time Lack of Money Lack of Interest Other_____

19. Does wildlife raid your crops? No Yes

20. How do you help preserve the forest reserve?

    Use of licences Plant seedlings No response

21. Can you name any endangered animal or plant species in this area?

22. Have you recently planted any trees? No Yes

23. If the government provided seedlings, would you consider planting more trees on your farm? No Yes

24. Is there any reason that keeps you from doing more to preserve the forest?

    Time Finances Knowledge Lack of land security

    Other_____ No reason

25. Do you get support from the government, Ngo's, farmers associations etc on farming methods and/or conservation? No Yes No response

26. What is the primary use of your land?

    Income generator Family space and recreation

    Family history Other_____

27. Are you the owner of this land? No Yes

28. How many acres is your land?

    1-2 acres 2-3 acres 3-4 acres 4-5 acres over 5 acres

29. How old are you? _____