



*LUCID's Land Use Change Analysis as an Approach
for Investigating Biodiversity Loss and Land Degradation Project*

**The Implications of Land Use Change on Forests and Biodiversity:
A Case of the "Half Mile Strip" on Mount Kilimanjaro, Tanzania**

LUCID Working Paper Series Number: 30

By

Christopher Mungo Peter William

Department of Geography
University of Dar es Salaam
P.O. Box 35049
Dar es Salaam, Tanzania

March 2003

Address Correspondence to:

LUCID Project
International Livestock Research Institute
P.O. Box 30709
Nairobi, Kenya
E-mail: lucid@cgiar.org
Tel. +254-20-630743
Fax. +254-20-631481/ 631499



The Implications of Land Use Change on Forests and Biodiversity:
A Case of the “Half Mile Strip” on Mount Kilimanjaro, Tanzania

The Land Use Change, Impacts and Dynamics Project
Working Paper Number: 30

By

Christopher Mungo Peter William

Department of Geography
University of Dar es Salaam
P.O. Box 35049
Dar es Salaam, Tanzania
Email: pmungo2000@yahoo.com

March 2003

Address Correspondence to:

LUCID Project
International Livestock Research Institute
P.O. Box 30709
Nairobi, Kenya
E-mail: lucid@cgiar.org
Tel. +254-20-630743
Fax. +254-20-631481/ 631499

Copyright © 2003 by the:
University of Dar es Salaam,
International Livestock Research Institute, and
United Nations Environment Programme/Division of Global Environment Facility
Coordination.
All rights reserved.

Reproduction of LUCID Working Papers for non-commercial purposes is encouraged.
Working papers may be quoted or reproduced free of charge provided the source is
acknowledged and cited.

Cite working paper as follows: Author. Year. Title. Land Use Change Impacts and Dynamics
(LUCID) Project Working Paper #. Nairobi, Kenya: International Livestock Research
Institute.

Working papers are available on www.lucideastafrica.org or by emailing lucid@cgiar.org.

TABLE OF CONTENTS

List of Tables	v
List of Figures	v
List of Maps and Plates	v
List of Boxes	v

ABSTRACT

1.0. INTRODUCTION	1
1.1. Background.....	1
1.2. Statement of the Problem.....	2
1.3. Study objectives.....	3
1.3.1. Specific objectives.....	3
1.4. Hypotheses.....	3
1.4. Conceptual and Theoretical Framework.....	3
2.0. THE STUDY AREA AND RESEARCH METHODOLOGY.....	6
2.1. Introduction.....	6
2.2. Selection of the study area.....	6
2.3. Description of the study Area.....	6
2.3.1. Location.....	6
2.3.2. Physiography and climatic conditions.....	7
2.3.3. Geology and soils.....	7
2.3.4. Vegetation.....	8
2.3.5. Population.....	9
2.4. Research Methodology.....	10
2.4.1. Sampling design.....	10
2.4.2. Sampling procedure and Sample size.....	10
2.4.3. Types and sources of data.....	11
2.4.4. Data collection techniques.....	11
2.4.4.1 Interpretation of Satellite images and Mapping.....	13
2.4.4.2. Structured interviews.....	13
2.4.4.3. In-depth interviews.....	14
2.4.4.4. Observations.....	14
2.5. Data processing and analysis.....	14
2.6. Presentation of findings.....	16
2.7. Limitations of the study.....	16
3.1 CHANGING LAND USE AND ITS IMPACTS ON FOREST COVER AND BIODIVERSITY.....	16
3.1 Introduction.....	16
3.2 Land use/cover patterns and change between 1952 and 2000.....	16
3.2.1 Types and extent of land use/cover and change, 1952-1982.....	16
3.2.2. Types and extent of land use/cover and change in 2000.....	19
3.3. Local peoples' perception of land use changes.....	20
3.4.1. Forest degradation and loss of biodiversity.....	22

3.4.1.1. Forest cover loss and degradation.....	22
3.4.1.2. Loss of plant species diversity	25
3.4.2. Forest products that have disappeared or not easily obtained.....	26
4.0. ROOT CAUSES OF LAND USE CHANGE AND LOSS OF DIVERSITY.....	26
4.1. People’s perception on causes of land use change.....	26
4.2. Immediate causes.....	26
4.2.1. Expansion of agriculture.....	27
4.2.2. Encroachment on HMFS.....	27
4.3. Root causes of land use/cover change, forest degradation and biodiversity loss.....	28
4.3.1. Demographic change	28
4.3.2. Policies.....	30
4.3.2.1. Colonial policies	30
4.3.2.2. Post independence policies	31
a) Villagization policy.....	31
b) Forestry policies	31
c) Agricultural Policies	32
4.3.3. Management of the HMFS and institutional change.....	32
4.3.3.1. The HMFS under the Chagga Council.....	32
4.3.3.2. Management under district councils and the central government.....	33
4.3.4. Economic factors	36
4.3.5. Social/cultural factors	37
4.3.6. Top-down Approach to forest management.....	39
5.0. SUMMARY, CONCLUSION AND RECOMMENDATIONS	40
5.1. Introduction	40
5.2. Summary of Main Findings	40
5.3. Conclusion	42
5.4. General Recommendations	42
5.5. Recommendations for further studies	43
6. REFERENCES	44

LIST OF TABLES

2.1. Population statistics in Moshi rural District 1967-2002	10
2.2. Sampling procedure and sample size	11
2.3. Types and data sources	12
3.1. Extent of Land use/cover of the study area in 1952 and 1982	17
3.2. Extent of Land use/cover of the study area in 2000.....	19
3.3. Status of the Half Mile Forest Strip over time.....	22
3.4. Status of the forest cover in the HMFS at different time periods	25
4.1. Causes of changes in land use.....	26
4.2. Population Data for Moshi Rural District 1967-2002.....	28
4.3. Tree species planted in the HMFS between 1941 and 1990	33

LIST OF FIGURES

1.1. Causes of loss of vegetation and biodiversity.....	4
3.1. Land use/cover change between 1952 and 1982.....	18
3.2. Land use/cover change between 1982 and 2000.....	21
4.1. Causes of encroachment	27

LIST OF MAPS AND PLATES

Map 2.1. Location of the Study Area.....	8
Plate 2.1. Mosaic of Landsat 7TM+ Satellite images	12
Plate 3.1. Degraded forest in Kitowo village.....	23
Plate 3.2. Exploitation of few remaining mature stands in Kitowo village	23
Plate 3.3. Livestock grazing in the HMFS at Kitowo village.....	24
Plate 3.4. Secondary vegetation growth at Olele sub-village, Mweka.....	24
Map 3.1. Land use/cover in 1952.....	47
Map 3.2. Land use/cover in 1982.....	48
Map 3.3. Land use/cover change 1952-1982	49
Map 3.4. Land use/cover in 2000.....	50

BOXES

4.1 Factors of land use changes	26
4.2. Resentment of the local people against forest management	35
4.3. Diversification of agriculture.....	38

ABSTRACT

This study examines land use changes in Mweka and Lyasomboro villages in Moshi Rural District and how these have affected resources use patterns and ultimately forest cover and biodiversity in the Half Mile Forest Strip (HMFS) on the southern slopes of Mount Kilimanjaro. Land use change was determined from interpretation of the 1952 and 1982 aerial photos and satellite imagery of 1999/2000 while the impacts were analysed from field survey data obtained through interviews, discussions, observations and secondary data.

The results show that cultivated land has expanded at the expense of grazing and forest land. Forest cover declined from 194.41Km² in 1952 to 155.8 Km² in 1982. Plant species such as *Embelia schimperi* (Ngetsi) and *Myrsine africana* (Ngetsi ndogo), have become rare in the HMFS while *Ocotea usambarensis* (Camphor) has almost disappeared in the HMFS

The land use/cover changes and changes in resource use patterns in the study area are attributed to encroachment and expansion of agriculture. The underlying causes, however, include adopted development and economic policies, changes in forest management responsibilities, changes in population characteristics and top-down approach in forest management. It is recommended that people-centred collaborative forest management be opted for, and out-migration supported.

1.0. INTRODUCTION¹

1.1. Background

Land use changes worldwide have become a global concern because of the negative impacts often associated with them. Land use changes are diverse and may be explained in terms of temporal and spatial aspects. They may involve the complete transformation of some land use type(s) into other land use type(s). Transformations may be in form of replacements of, for example, forestry by agriculture or grazing and agriculture by settlement. In other areas, land use changes involve partial transformation of land use types into other forms while retaining their primary status, such as rain fed agriculture to irrigated agriculture or natural to exotic vegetation.

Moreover, land use changes could entail such systems change as changes in cropping systems that may include mono-cropping to inter-cropping or vice versa. Again, land use changes may occur in the form of extensification and intensification in which case one or more land uses expand at the expense of other land use types or their uses intensified. Extensification of agriculture, for example, can be at the expense of grazing land, forestry, and settlement. Intensification of agriculture may be in the form of continuous use of the same piece of land without resting it. It may also include practices that conserve soil and replenish it.

Land use change from forestry to agriculture and livestock keeping is reported to have occurred in Ilha Grande, south of Rio de Janeiro state in Brazil (Wunder, 2000). This was also the case in the Sahel where agricultural land use and livestock keeping replaced some of the forested areas (Ahlcrona, 1986). In Tanzania, it is reported that in the 18th Century Kondoa Irangi Hills of central Tanzania were wooded when the *Rangi* reigned Irangi Hills of Kondoa District (Christiansson and Kikula, 1996). Valley bottoms were used for pastures. But with time, the pasture valley bottoms and fertile wooded hills were put under agriculture. Some of the wooded areas were turned into grazing lands.

Generally, changing land uses in a particular setting are known to impact on forest cover and species diversity in forest biomes. They reduce forest cover and alter species diversity particularly in forest biomes leading to land degradation in some places. In Australia, for example, a change of land use from forestry and woodland to agriculture resulted in one-third of the woodland and half

¹ This paper is derived from a M.A. thesis by the author from the Geography Department, University of Dar es Salaam

of the forest being cleared for agriculture (Campbell, 1994). In Brazil, Wunder (2000) reports that of the original forest extension of 1,000,000 Km² (12% of the Brazilian territory) only about 70,000 Km² (7% of the original area) remain today. Moreover, *Haematoxylum basiletta*, a plant species used as dye has been greatly reduced. In Tanzania, FAO (1993) estimated that natural forests decreased by about 12.7% from 1980 to 1990.

The root causes lurking behind changing land uses in various countries vary, although their impacts on forest cover and species diversity are almost similar. These root causes include demographic and institutional changes, adopted development policies, political and social-cultural forces, war, development of infrastructure and environmental change (Wood et al., 2000). In Australia, for example, the land use changes have been driven by the necessity to improve production in the agricultural sector that is being backed up by the complexities of political, economic and social dynamics to achieve improved standards of living of the people (Campbell, 1994).

In Ilha Grande, south of Rio de Janeiro State and the Brazilian Atlantic forest biome, land use changes from forestry to agriculture and livestock keeping were, on one hand, linked to government policies and on the other to agricultural practices of the local communities (Wunder, 2000). Agricultural policies encouraged plantation agriculture in forest areas while local slash and burn agriculture also expanded. The resettlement scheme, which substituted pioneer tribes with Tupi-Guaran Amerindians, spread the use of fire through slash and burn agriculture. As a result, currently only 30% of the primary forest is not heavily intervened while the rest consists of secondary vegetation of variable age (Wunder, 2000). Change of the use of the forest from purely economic to conservation, however, is encouraging contemporary regeneration of the forest in the area.

Changing land use in the Sahelian zone was partly an ecological response to recurring adverse weather and to a larger extent driven by socio-economic and political forces (Ahlcrona, 1986). As a result, vegetation cover changed and degradation and plants species diversity loss occurred in central Sudan. Besides, due to increasing aridity *Acacia nubica* and *Calotropis procera* species, which are unpalatable to livestock, replaced *Acacia senegal* species.

In Tanzania, rapid depletion of forests has been associated with increase in population, extensification of agricultural activities and increased demand for forest products (Misana and Nyaki 1993). A primary factor behind extensification of agricultural land has been the ongoing rapid population growth and the resultant pressure on land. Lurking behind these precursors, however, are development policies as well as a forestry and land policies (Salih and Tedla, 1999; Kikula, 1996; Bojang and Reeb, 1998). The dispersion of forestry activities or related responsibilities in different ministries and agencies with overlapping mandates, jurisdiction conflicts, and confusion etc. also have had negative effects on management of natural resources. Consequently, forests have been overexploited and degraded.

The thrust of this study is to underscore the extent and the impacts of land use changes on forest cover and plant species diversity. The study focuses on land use changes around the Half-Mile Forest Strip on the southern slopes of Mount Kilimanjaro.

1.2. Statement of the Problem

Mount Kilimanjaro plays important roles in socio-economic and ecological functioning. The mountain contributes to agriculture, forestry and tourism. Ecologically Mount Kilimanjaro constitutes the major watershed of northern Tanzania. It is a source of water for domestic use, irrigation agriculture, industrial activities, and for the generation of Hydroelectric Power (HEP). Moreover, the forest on this mountain keeps natural scenery of Mount Kilimanjaro, which attracts tourists from all-over the world. Forests are also habitats for a diversity of fauna and flora and are sources and sinks for most of biochemical and energy flows that sustain the biosphere and geosphere, including trace gas emissions and hydrological cycle.

Despite the value of Mount Kilimanjaro, changes in land resource use patterns resulting from pressure on land and forest resources pose a great threat to the sustainability of the forest as well as the socio-economic and ecological functioning of the ecosystem. Changes in land use are causing severe stress on forests and biodiversity. Agriculture and settlement in some areas have replaced forests. Certain species such as *Ocotea Usambarensis* (Camphor) are being threatened due to encroachment. Different parts of the forest reserve on the southern slopes of Mount Kilimanjaro, including the Half Mile Forest Strip (HMFS), experience different forms of encroachment (Yanda and Shishira, 2001). The encroachment stems mostly from the use of the forest areas for agriculture, charcoal making, settlement, livestock grazing, collection of fodder, setting of fires, lumbering and fuelwood search. Thus, the HMFS, which buffers Kilimanjaro Forest Reserve and Kilimanjaro National Park is experiencing severe stress than it can currently be estimated, given the pressure and trend of the changing land uses of the area.

Although land use changes on the slopes of Mount Kilimanjaro are not just a current phenomena, they date back to some 200 years ago (Sevaldsen, 1997), the severity of their impacts on both forest cover and plant species diversity is causing serious concern on the future functioning of this fragile mountain ecosystem. It is, therefore, the intention of this study to provide an in-depth understanding of the patterns of land use changes and how these impact on the forests and plant species diversity in the HMFS, so that ways will be sought to reverse this trend.

1.3. Study objectives

The major objective of this study is to examine the nature and extent of land use changes on the southern slopes of Mount Kilimanjaro and their impacts on the forest cover and plant species diversity in the HMFS.

1.3.1. Specific objectives

The specific objectives are:

- i) To determine the nature and extent of changes in land use that have occurred in the HMFS and surrounding areas between 1952-2000,
- ii) To establish the causes of these changes,
- iii) To assess the impacts of the changes in land uses on the forest cover and plant species in the HMFS.

1.4. Hypotheses

- i) Different types of land use changes have occurred in the area between 1952 and 2000.
- ii) Land use changes in the area have led to a decline in the forest cover and plant species diversity of the HMFS.

1.5. Conceptual and Theoretical Framework

Numerous studies have dealt with the Human-Environment-Development nexus, their thrust being the interrelationship among and between these components. Among authors that present a general outlook on how humans affect the natural environment and capital stock are Goudie (1992,1981), Thomas (1956), and Fisher (1992). Others are Gradwohl and Greenberg (1990), Anderson (1988), Lusigi (1992), Zaba and Clarke (1993), Whitmore (1993), UN, (1993), Mabblerley (1979), Wood et al. (2000) and Lindberg (1996).

The relationship between man and the environment has long been mutual and co-evolving. Over time, however, this relationship has changed as people's livelihood strategy responded to complex sets of environmental-societal dynamics, be it population pressure, policy changes and/or ecological changes (Maro, 1974; Larsson, 2001 and Sevaldsen, 1997). Consequently, land fragmentation, transformations and modifications have been concomitants of changing land and resources use patterns in given ecosystems.

Figure 1.1 Causes of loss of vegetation and biodiversity.

Source: Adopted from Wood et al. (2000:344)

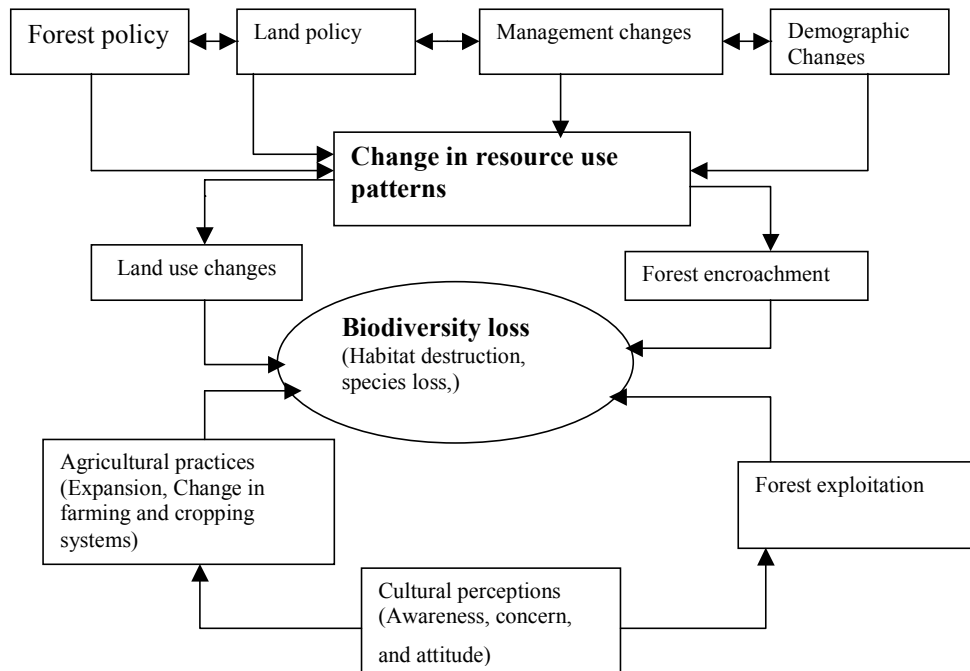


Figure 1.1 presents a synthetic framework, adopted from Wood et al. (2000), which illustrates interrelationships between processes and phenomena, whose combination culminate into change in resource use patterns and loss of biodiversity. The framework has been modified for this study because some of the components in Wood's framework are irrelevant.

According to Wood et al. (2000), habitat destruction and plant species diversity loss stem from a complex combination of direct and indirect driving forces. Direct driving forces are those associated with the exploitation of natural resources at a local scale. These include changing land use of a particular niche as replacement of natural vegetation by cultivated land; expansion of agriculture into areas used for grazing; settlement expansion at the expense of natural vegetation and changes in cropping systems. Preparation of agricultural land, for example, involves clearing of vegetation, which in turn may reduce vegetation cover and either change or lead to a complete loss of primary vegetation. Similarly, settlement expansion at the expense of agricultural and grazing lands may result into habitat reduction and vegetation cover loss. At the same time, when grazing land is encroached for agriculture, the grazing area is reduced; the carrying capacity of the land is decreased instigating pressure on the pastureland and alteration of species composition. All these causes, however, are regarded as precursors that are a result of the root causes.

According to Wood et al. (2000), the underlying factors for changing resource use patterns (and their ultimate habitat destruction and plant species loss) include cultural perception of the local communities on forests and biodiversity, adopted or existing forest and land policies, change in forest management responsibilities, demographic changes, macro-economic policies and structure, and poverty and inequality. These responses may result into either improved natural resources use and management or negative impacts with such results as degradation of a natural ecosystem and biodiversity loss.

In this study, it is assumed that land use changes and their impacts on the forest cover and species diversity in HMFS are influenced by government policy, change in management of the HMFS, cultural perception of the local communities of the forest resources and demographic changes in surrounding villages. For example, the Forestry Policy of 1957 and Forest Ordinance of 1959 may

have generated conditions unfavourable for sustainable use of the forests by the communities in adjacent areas. Section 15 (1) of the 1959 Forest Ordinance restricts consumptive utilization of forest produce without a license (NEMC, 2000).

The fact that the gazettement of Kilimanjaro Forest Reserve was done when the slopes of Mount Kilimanjaro had already been settled might have aroused resentment (Katigula, 1992) in these communities. As such their cultural perception (awareness, concern and attitude) towards the management of forest resources may have spontaneously or drastically changed. The resentment, for example, could have influenced changes in resource use patterns and land use leading to unsustainable exploitation of the forest products and even arson. Moreover, encroachment resulting from changes in resource use patterns and changing land uses could have impacted negatively on the forest and species diversity.

The features of land uses in a particular setting do not arise accidentally in a cultural system (Kikula, 1996). They are a result of long periods of “experimentation” culminating into well established cultural beliefs of what is right for both the people and the environment. The behaviour patterns and lifestyles embedded in cultural perceptions, therefore, are usually transmitted over successive generations (Fisher, 1992). Whenever these lifestyles and behavioural patterns embedded in cultural perceptions are altered by policy intervention and/or any other factor, they may break down and lead to changes in resource use patterns and the resultant habitat destruction and biodiversity loss.

Moreover, change in management of the forests in HMFS over time may have had negative or positive impacts on the use and management of the forest resources. Such changes may include, change in resource management responsibilities and, therefore, the way decisions on the use and management of the resources are made. The change in forest management could give room for mal-administration e.g. illegal licensing for forest resource harvesting, which could result in land use land/cover change and adverse impacts on biodiversity. Moreover, laxity on the part of the managing institution as a result of such changes in management when juxtaposed to poor or inadequate resources and facilities, may constrain implementation of land and forest policies in place. Poor implementation of these policies could culminate into habitat destruction and species loss.

A land policy on the other hand affects the way land tenure issues are handled as they define access to, ownership of and tenure to forest resources. The policy could deny the local community sense of ownership and, therefore, the community’s need to sustainably use the resources in vicinity. A land policy, however, cannot be regarded as a driving force on its own because it may reinforce or be reinforced by other policies. Speirs and Marcussen (1999), Tevera (1994) and Rugumamu (2000) assert that land and forest policies, in particular, have been promoting private investment and trade in the agricultural and forestry sectors. National strategies in relevant policies, however, rarely respond to the growing need for greater understanding of the links between policies’ development goals and the sustenance of the natural capital e.g. the forest. Ignoring the links amplified results in habitat destruction and loss of biodiversity.

Socio-economic development policies may also have adverse impacts on the environment or on biodiversity, due to mistakes in implementation at different levels and limited knowledge of policy makers. In mid and late 1980s, Structural Adjustment Programs (SAPs) were adopted in sub-Saharan countries, including Tanzania (Tshibaka, 1998) as key reforms to getting economic growth process revamped. The concomitants of SAPs at sectoral level were liberalization of prices of agricultural inputs; removal of subsidies on agricultural inputs, commodities, and disengagement of government from agriculture and its support services. These may have altered resource use patterns and land use changes in the study area. Consequently, these changes may have driven changes in forest cover (Turner II et al., 1995) and species diversity (Wood et al., 2000). Also, overlapping mandates between different administrative systems and inaccurate reports may have adverse impacts on the forest cover and biodiversity

In general, policy and institutional failures in different circumstances must be addressed by micro level research of the likely impacts in the environment-development nexus. This experience can be helpful in establishing area specific factors (Wood et al. 2000).

Lastly but not least, demographic changes, particularly population growth, may be accompanied by changes in resource use patterns because of pressure on scarce resources in an area. Population growth is known to have an inverse relationship with, for example, the forest ecosystem (Fisher, 1992; Goudie, 1992; Lusigi, 1992; and Wood et al., 2000). Increasing population pressure together with scarcity of such resources as agricultural land, firewood, poles, timber and fodder may result into encroachment of forest reserves for agriculture, particularly when there is no more room for agricultural intensification, and for woody and non-woody products (Moyo et al., 1993). When exploitation of these resources reaches breakeven levels it gives way to habitat destruction and biodiversity loss. Due to pressure on resources, people tend to diversify their livelihood strategies. For example, they may resort to exploitation of forest resources in order to supplement on-farm income and food requirements, which was formerly not a priority.

This study will, therefore, attempt to explore how land and forest policies, demographic changes, economic forces, changes in forest management and people's cultural perceptions may have influenced land use changes and resource use patterns in the villages that surround the HMFS. Their subsequent impacts on forest cover and species diversity in HMFS will also be investigated.

2.0. THE STUDY AREA AND RESEARCH METHODOLOGY

2.1. Introduction

This section describes the study area in terms of physiographic and climatic conditions, geology, soils, vegetation and population characteristics. It also describes in detail the methods and techniques employed for data collection and analysis.

2.2. Selection of the study area

The Half Mile Forest Strip and its adjacent villages of Mweka (Kibosho east Ward) and Lyasomboro (Marangu east Ward)-Moshi Rural District on the southern slopes of Mount Kilimanjaro (Map 2.1) were selected as an area of study. This is because of easy accessibility as the two villages are reachable by vehicles. Secondly, the degradation of HMFS around these villages is quite significant.

The HMFS has for long been a social forest from which the Chagga could extract forest products. It is also one of the oldest buffer forest in East Africa (Kivumbi and Newmark, 1991); it buffers the Kilimanjaro Forest Reserve, which is a Catchment Forest, and Kilimanjaro National Park. Due to population growth, the population density of the area has been high such that pressure on the forest reserve has been high. Besides, the management of the HMFS since its establishment in 1941 has been changing over time, which may have impacted on the forest cover and biodiversity.

A study by Yanda and Shishira (2001) on the southern slopes of Mount Kilimanjaro showed that there is encroachment on forests on Mount Kilimanjaro. The extent to which this encroachment is related to changing land use in the vicinity is, however, not known. This, together with its implication on vegetation cover and plant species diversity of the HMFS, therefore, needed to be established.

2.3. Description of the study area

2.3.1. Location

The Half Mile Forest Strip (HMFS) is a narrow strip of forest located south of Mount Kilimanjaro. It is aligned west to east forming a buffer of the Kilimanjaro Forest Reserve. The forest is part of the Kilimanjaro Forest Reserve, and it stretches from Kikelelwa river on the northeast to Sanya river on the southwest, cutting across Hai, Moshi Rural and Rombo districts. Its width varies considerably from several hundred centimetres to several meters but averages

approximately 0.8 kilometres or one half mile, hence the name Half Mile Forest Strip. The area studied comprised of Mweka and Lyasomboro villages, which are located in Kibosho east and Marangu east wards, respectively, in Moshi Rural District. The villages are adjacent to the HMFS. Mweka village border villages of Sungu on the west and Uru on the east and southeast. Lyasomboro borders Mbahe village on the east and Mshiri village on the west while it borders Isari village on the south (Map 2.1).

2.3.2. Physiography and climatic conditions

Generally, the physiography of the area under study consists of an undulated terrain with a gentle slope (0° - 5°) at lower altitudes. Above 1200m on the south and above 1400m on the east, the slopes steepen greatly and often exceed 15° . Slopes in excess of 25° are mostly restricted to river valleys or to the steeply sloping ash cones (Ngana, 2001). The altitude varies between approximately 1890 meters above sea level at the forest edge and ≤ 1400 meters above sea level in the village. River valleys dissect the area in the two villages and in some areas, the rivers have cut deep forming very steep river valleys.

The rainfall pattern in Kilimanjaro region is bimodal with short rains from November to December and long rains from March to May. The average annual rainfall ranges from 1000-1700 mm and it varies up to 2500mm with elevation and aspect.

2.3.3. Geology and soils

The area is characterized by relatively shallow depth of volcanic rocks underlying the Archean Basement Complex. The oldest rocks with extensive exposure are the lavas from Mawenzi, which are characterized by different rock types (Ngana, 2001).

Rocks in the area are mostly Basic. These rocks are rich in calcium and magnesium-containing minerals such as andesine, labradorite, anorthite, olivine and augite.

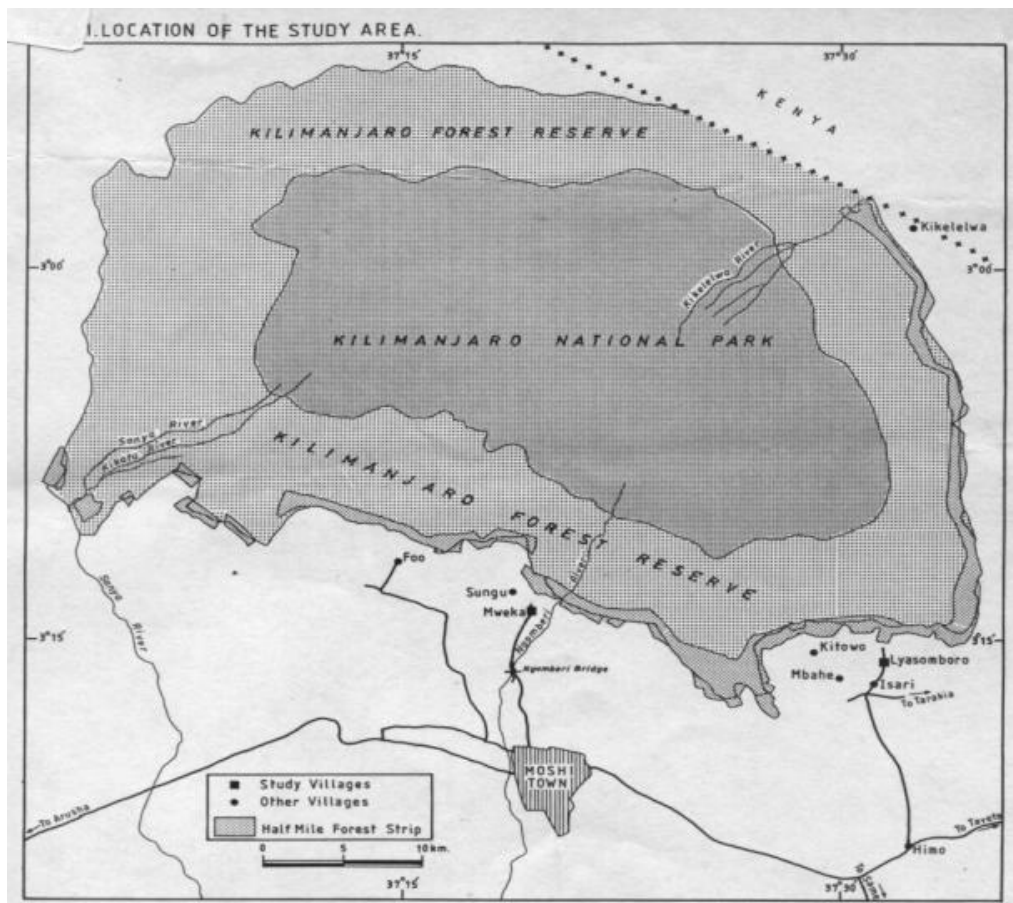
A wide range of parent materials have developed into soils of the area, which, in most cases, are shallow and rocky particularly in higher altitude. The soils on the southern slopes of Mount Kilimanjaro are, therefore, very varied, most of them having been derived from volcanic rocks. Anderson (1993) classifies the soils of Mweka village under three types: the upper part of the Mweka-Ngomberu Bridge transect that has been categorized as Umbwe complex, the middle part categorized as Mrawi series and the lower part as Msinga series. Umbwe complex and Msinga series consist of Ferruginous tropical ferrisols while Mrawi series is made up of Humic ferrisols.

According to Anderson (1993), Rhombporphyry or Trachyte parent materials underlie the soils in Umbwe complex as well as Mrawi and Msinga series. The topsoil in Umbwe complex is approximately 15cm and the depth often less than 100 variable. The surface soil texture is gritty humic loam and the subsoil moderately prismatic. The soil on the surface is very dark brown while the subsoil is brown. The structure of the soil on the surface comprises of a weak sub angular blocky and the subsoil moderately prismatic. The soil is friable.

In Mrawi series' the topsoil is approximately 15cm. Depth of top rock is usually over 100 variable, the surface soil texture being humic sandy loam. The subsoil soil texture is clay loam. The soil is dark brown on the surface to subsoil, the surface structure being characterized by a weak crumb and weak prismatic at subsoil, and it is very friable.

The topsoil in Msinga series is approximately 20cm, the top rock depth usually being over 150 variable. The surface soil texture is sandy clay loam while it is silty clay loam at subsoil. Surface soil colour is dark brown and it becomes dark red brown at subsoil. The soil is moderately crumb to sub angular blocky in structure at surface, whereas it is moderately prismatic at subsoil. Although the soil is friable, it has a slight tendency to cap.

Map 2.1. Location of the Study Area



The soils in Lyasomboro villages have been classified into two categories: Masia complex, which dominates the upper part of the Lyasomboro-Isari transect, and Marangu series, a Marangu variant (lower phase) covering the lower part. Olivine analcite or andesite or basalt parent material underlie the Masia complex whose top soil is approximately 10cm while its top rock depth is frequently less than 100 variable. The texture is humic loam for the surface soil and silty clay for subsoil. Soil colour ranges from very dark brown at the surface to brown at the subsoil. The soil is moderate fine crumb in structure at the surface and moderate sub angular blocky at the subsoil. Soils are generally very friable.

The Marangu variant (lower phase) consists of Olivine analcite parent material. The approximate topsoil depth is 12cm; depth of top rock usually over 120 variable, and surface and subsoil texture being sandy loam and gritty clay loam. The colour of the surface soil is dark brown while that of the subsoil is dark red brown and sometimes mottled. Soil structure at the surface is moderate to sub angular blocky and weak prismatic at subsoil. The soil is friable although the surface tends to cap (Anderson, 1993).

2.3.4. Vegetation

The vegetation of Kilimanjaro Forest Reserve (KFR) primarily varies with rainfall, temperature, soils and altitude. According to the Ministry of Natural Resources and Tourism (MNRT) (2001), the lower altitude dry montane forest occurs on the southern slopes below 1800m with submontane riverine forest in stream valleys from 1400-1600m. *Calodendrum capense*, *Croton macrostachyus*, *C. megalocarpus*, *Cussonia holstii*, *Olea capensis* and *Vepris simplicifolia* dominate the former while the later consists of *Albizia schimperiana* and *Newtonia buchananii*.

Montane forests occur from 1600 to 2700-2800m altitude. Below 2000m, these forests are often secondary, having been logged for camphor (*Ocotea usambarensis*). The lower altitude secondary forests comprise of *Albizia gummifera*, *Macaranga kilimandscharica*, and *Polyscias fulva*. At altitudes above 2400-2500m up to the forest line at 2900-3000m occurs the upper montane forest. Undisturbed montane forests at higher altitudes (2000-2500m) are dominated by *Ocotea usambarensis* with *Podocarpus latifolius* and *Rapanea melanophloeos*, the upper limit of *Ocotea usambarensis* being 2750m. *Hagenia abyssinica* becomes more dominant above 2600m altitude. In the cloud forest belt there is a rich epiphytic cover with mosses and liverworts covering tree trunks.

Subalpine heath is dominated by *Erica arborea*, which forms either pure stands with an open canopy or mixed stands with *Podocarpus sp.* and *Hagenia abyssinica*. In both types, a rich moss layer covers trees and the ground (MNRT, 2001).

The HMFS on Mount Kilimanjaro was established in 1941 with a prime objective of providing the local people with wood and wood products. In many areas, however, humans have greatly altered the vegetation through such activities as slash and burn farming, grazing of livestock, felling of trees and harvesting of grass. Only remnants are found in some of the areas (Misana, 1991). Thus, most parts of the forest reserve consist of secondary vegetation, with a few stands of and/ or regeneration of camphor (*Ocotea usambarensis*), *Albizia gummifera*, *Macaranga kilimandscharica* and *Polyiscias fulva* (Ministry of Natural Resources and Tourism, 2001). Other tree species include *Juniperus procera*, *Olea africana*, *Syzygium guineense*, some *Podocarpus latifolius*, *Erica sp.* and some *Cassiporea malosana* (Katigula, 1992; Hermansen et al., 1985). Various fern sp. and other grasses mixed with bushes dominate in the degraded areas, particularly along the edges of the HMFS and the surrounding villages.

The area below the HMFS, particularly in the middle zone (700-1400m) and high zone 1400-2000m, is dominated by tree-crop vegetation. Crops such as coffee (*Coffea sp.*) and bananas (*Mussa sp.*) are predominant. Other vegetation types include fodder grass characterized by *Setaria splendida*, Guatemala grass, Elephant grass, and Guinea grass (O'king'ati and Kessy, 1991). Moreover, there are such food crops as maize, beans, and Yams. Also, fruit trees, such as pears and plum peaches, are found in the area.

Important tree species in Mweka and Lyasomboro villages include *Dracaena usambarensis* (Isale or Masale), *Croton macrostachyus* (Mfurufuru), *Newtonia buchananii* (Mkufi), *Psidium guajava* (Mpera mwitu), *Cordia africana* (*Abyssinica*) (Mringaranga), *Albizia schimperiana* (Mfuranje). Other tree species found in the home gardens include, *Rauwolfia caffra* (Msesewe), *Margaritaria discoidea* (Mshamana), *Cupressus lusitanica* (Mtarakwa), *Ficus sp.* (Mtembwe), *Grevillea robusta* (Mueresi/Mweresi), *Erythrina abyssinica* (Muididi, Mriri) *Milicia excelsa* (Mvule) and *Persea americana* (Parachichi). These indigenous and exotic tree species in the home gardens (*Kihamba*) serve multiple uses. Not all trees that are found in the home gardens, however, have been planted. According to Misana (1999), some trees, such as *Milicia excelsa*, *Albizia schimperiana*, and *Rauwolfia caffra* are indigenous, which had been left standing at the time of clearing the farms.

2.3.5. Population

Humans have continuously occupied the slopes of Mount Kilimanjaro for the last 2000 years (Newmark 1991). Attraction of the various agricultural people was due to relatively abundant precipitation and fertile soils. A dramatic increase in the human population, however, is a phenomenon of the last 60 to 90 years. According to Mbonile (1999) and <http://www.tanzania.go.tz/population.html>, the population in Moshi Rural District has been increasing over time since 1967 and so has been the population density of the district (Table 2.1). While in 1967 the population was 241,490, it has reached 504,287 by the year 2002.

Table 2.1 Population statistics in Moshi Rural District 1967-2002.

Years	1967	1978	1988	2000	2001	2002
Population	241,490	311,600	342,760	474,562	489,199	504,287
Area (Km ²)	1,558	1,558	1,558	1,558	1,558	1,558
Population density/Km ²	155	200	220	305	314	324

Source: Population data for 1967,1978, and 1988 are based on Population census whereas 2000,2001 and 2002 is based on Population projection (Source: <http://www.tanzania.go.tz/population.html>).

The population of Moshi Rural district has been increasing at an average rate of 2.8% per year over the past 35 years. According to Maro (1974), several reasons explained this trend in population increase. These include the evolution of agriculture from subsistence to coffee cash crop economy that resulted into supra carrying capacity of population. Other factors include change from traditional cash crops such as coffee to dairy farming and market gardening, improved use of irrigation furrow system that enables farmers to grow crops several times a year, and improved social services like medical services, schools, etc. Others include the development of commuting to the lowlands to cultivate cereal crops but retaining residence in the core areas in the highlands, and in-migration from other parts of the country during the boom of plantation economy.

2.4. Research Methodology

2.4.1. Sampling design

Fieldwork was carried out along transects around the HMFS in Moshi Rural District. Two transects of the HMFS were selected on the basis of accessibility, levels of degradation and prevailing land uses. These were forest areas around Mweka and Lyasomboro villages in Kibosho east and Marangu east Wards, respectively. The former formed Ngomberi-Mweka transect while the later constituted Isari-Lyasomboro transect. Both Mweka and Lyasomboro villages border the HMFS. Location of the villages was geo-referenced by using Geographical Positioning System (GPS) GARMIN GPS 12XL Software 4.00. A household formed the sampling unit. This composed of a husband, wife, children and family dependants living in the family. A household also composed of single fathers and mothers, unmarried or widowed.

2.4.2. Sampling procedure and Sample size

A stratified simple random sampling procedure was employed to obtain a sample of fifty respondents from each village. The total sample size was one hundred respondents. The number of people in each village register was divided into strata based on sex and respective sub-villages. There were seven strata in Mweka village and four in Lyasomboro village. An almost equal number of females and males comprised the sample (n) (Table 2.2)

A table of 5-Digit random numbers generated in the computer software LIMDEP version 5.1, developed by Green (1988), was used in picking a random sample from the village registers. A sample size (n) in each stratum was picked on the basis of its proportion to a sampling frame (N). The criterion was that If $N < 10$ one digit was picked from the random numbers' table and two digits if $N > 10 < 100$. The rule, however, was that a zero, any number greater than N or a repeated number in the table of random numbers was discarded. The random number picked in the table was corresponded to the name of the bearer of that number on the register for each stratum. The total number of the sample (n) constituted a gross proportionate number of selected individuals in each stratum (Table 2.2).

Table 2.2 Sampling procedure and sample size

Village	Sub-village	Households	Sample	Female	Male	Percentage
MWEKA	Kichao	176	13	6	7	1.78
	Kifura	128	9	5	4	1.23
	Orera	86	6	3	3	0.82
	Olele	66	5	2	3	0.68
	Mweka juu	81	6	3	3	0.82
	Mweka chini	103	7	4	3	0.95
	Omi	51	4	2	2	0.54
	Omissions	39	-	-	-	-
TOTAL (1)		730	50	25	25	6.84
LYASOMBORO	Marawe	-	12	6	6	1.70
	Lefuri	-	12	6	6	1.70
	Koteete	-	13	7	6	1.85
	Rongi	-	13	6	7	1.85
TOTAL(2)		702	50	25	25	7.10
GRAND TOTAL (1&2)		1432	100	50	50	13.94

Source: Field Survey (2001)

This type of sampling procedure aimed at minimizing bias and increasing the validity so that inference could be drawn for the whole population. The selected sample size was regarded sufficient because according to Boyde and Stasch (1981) for a random sample to be representative of that population it should at least constitute 5% of the total population. The sample (n=50) was 6.8% of 730 households in Mweka village whereas it formed 7.1% of approximately ± 702 households in Lyasomboro Village (Table 2.2).

2.4.3. Types and sources of data

Both primary and secondary data were collected for the study. Primary data included land use cover patterns and changes, socio-economic characteristics, population, perceptions, status of the forest, and management of the HMFS (Table 2.3). Secondary data comprised of management history of the HMFS, socio-economic characteristics, population dynamics, and experiences on land use changes and their impacts. Primary data were derived from structured interviews using questionnaires, in-depth interviews of key informants, discussions, field observation and a mosaic of Landsat 7TM+ Satellite images for October 1999 and February 2000 (Plate 2.1). Secondary data were obtained from literature survey, 1952 and 1982 land use/cover maps of the southern slopes of the mountain (Yanda and Shishira, 2001), reports, files and documents (Table 2.3). A literature survey was undertaken at the University of Dar es Salaam, District Administrative Secretary's Office in Moshi and the Catchment Forestry office–Moshi.

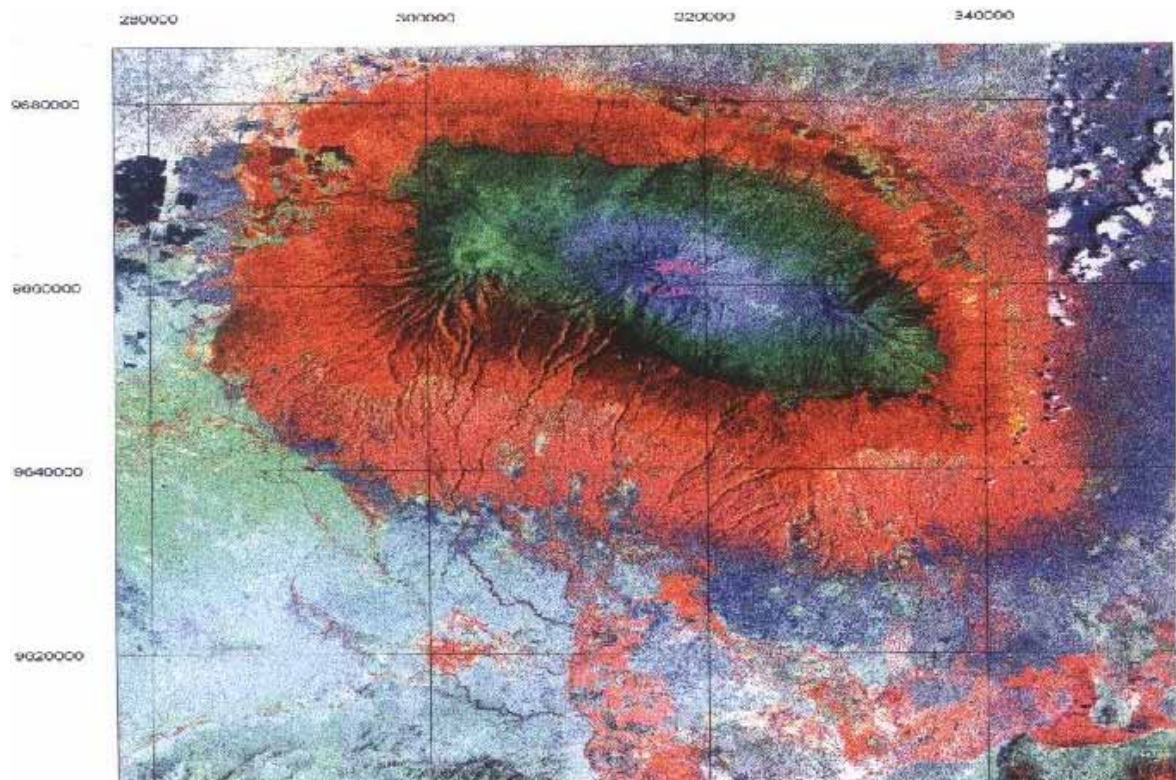
2.4.4. Data collection techniques

Data collection was done through a methodological triangulation; this entailed the use of multiple methods to study a phenomenon or a single problem. Triangulation is a process of data collection, which involves looking at an object from more than one standpoint (Mwanje, 2001) The methods used included interpretation of satellite imagery, questionnaire interviews, field observations, in-depth interviews and discussions. As a strategy, these methods were put to play to gather information and allow for the crosschecking of facts.

Table 2.3. Types and data sources

Types of data	Sources
Primary	➤
Land use/cover	➤ Digital Landsat 7ETM+ satellite Imagery for October 1999 and February 2000.
<ul style="list-style-type: none"> ➤ Temporal land use changes, ➤ Socio-economic characteristics, ➤ Population characteristics, ➤ Perceptions, ➤ Status of the forest, and ➤ Management of the HMFS. 	<ul style="list-style-type: none"> ➤ Structured questionnaire interviews ➤ In-depth interviews of key informants ➤ Discussions ➤ Field observation
Secondary	
Land use patterns and changes	➤ 1952 and 1982 land use/cover maps
<ul style="list-style-type: none"> ➤ Management history of the HMFS, ➤ Socio-economic characteristics, ➤ Population dynamics, ➤ Experiences on land use changes and their impacts elsewhere. 	<ul style="list-style-type: none"> ➤ Files ➤ Documents ➤ Reports ➤ Quarterly and annual reports from the Kilimanjaro Catchment Forestry Moshi office.

Plate 2.1 Mosaic of Landsat 7TM+ Satellite images for October 1999 and February 2000



The major advantage of triangulation in this respect is that, comprehensive information on the study theme could be adduced by eliminating over-reliance on one single source of data. It is also attainable under a qualitative paradigm. The disadvantage, however, is that triangulation can be costly.

2.4.4.1. Interpretation of Satellite images and Mapping

In an East African context three fundamentally different approaches have for long been used in the description of vegetation cover. These include the hierarchical, physiognomic and ecological approaches According to United Republic of Tanzania (URT) (1997), each approach has its strength and shortcomings as all have historically been rationalized to cater for East African diverse vegetation types.

In this study, the physiognomic approach was preferred to others because the main purpose of the study was to provide a premise of land cover and land use from which the analysis of temporal changes and their implication on species diversity could be made. The physiognomic approach involves the categorization of vegetation into a series of physiognomic types according to visible (or physical) attributes, notably the height and canopy cover (or density) of the dominant life forms of those plant associations which actually occur (URT, 1997). Special consideration is given to the relative contributions of woody plants and grass, with sub-types being defined by species composition of the dominant life form, and grassland type (URT, 1997).

Classification of land use in order to facilitate its analysis is always contentious as it collates consideration of present land use and/or potential land use; that is, the land capability (URT, 1997). This study, however, focused on how land is being used at present compared to use of the same land in the past. This was so because land use changes in the HMFS between 1952, 1982 and 2000 had to be established and described.

Digital Landsat 7ETM+ satellite images of October 1999 and February 2000 were first radiometrically and geometrically corrected and geo-referenced to Transverse Mercator geographic projection, using modified Clarke (1880) spheroid. The two images were then patched and a sub-scene clipped from the full image on the basis of a frame covering the study area. The sub-scene was also used to clip same areas of study on the 1952 and 1982 digital maps.

A visual interpretation of a colour composite mosaic of Landsat 7ETM+ of October 1999 and February 2000 at a scale 1:150,000 (plate 3.1) was done. Generally, the interpretation of the various land use/cover types on the satellite image were based on an evaluation of image characteristics such as tone, texture, size, pattern, location and association. The land covered by green woody vegetation, for example, forests, was easily recognized on the satellite image by the reddish shade.

After image interpretation, polygons were digitised and 1999/2000 mosaic land use/cover map was produced at a scale of 1:150,000. The map provided an understanding of the present land use/cover in the study area. The 1952 and 1982 maps generated from the interpretation of aerial photographs (Yanda and Shishira, 2001) showed the past land use/cover in the same area.

2.4.4.2. Structured interviews

Structured interviews involved the use of a questionnaire that was administered to respondents. A total of 100 respondents, fifty males and fifty females were interviewed. Data collected included land use history, the year the land was brought under current use, the previous land use/cover and the year it was put under that use/cover and underlying causes for the change in land use. Other aspects in the questionnaire included: impacts of the land use changes on the forest cover and plant species diversity, plant species that have disappeared and/or whose abundance or distribution have been reduced and the reasons for the phenomenon, people's perception of the land use changes and their impacts on forest and plant species diversity, the role of the central government in managing the HMFS and whether the management has been a success or failure.

Besides, involvement of the adjacent local communities in the management of the HMFS and their input was also sought.

2.4.4.3. In-depth interviews

In-depth interviews were conducted to key informants who consisted of foresters in Moshi Rural District, officials from the Catchment forestry office–Moshi, honey gatherers and herbalists. Others included government administrators at village and district levels. Separate checklists for guiding the interviews were used for administrators, honey gatherers and herbalists, and forest officials.

The administrators' checklist and forest officials' checklist were meant to capture information on population dynamics, land use changes, encroachment on the HMFS and participation of the local people in the management of the HMFS. Moreover, the administrators' checklist sought information on village socio-economic activities, village attempts in managing the HMFS, benefits that accrued to the village from forest management, and village socio-economic activities. Additionally, the forest officials' checklist captured information on the status of the HMFS' plant species diversity, the role of the government in managing the forest reserve and economic diversification of the local people. The honey gatherers and herbalists checklist sought information on medicinal, bee plants, and plants for income and artisan use that were disappearing.

2.4.4.4. Observations

Whereas interviews allowed for a large sample, may have suffered loss of details and accuracy. To minimize these effects this study combined advantages of interviews and field observations.

Observations were made on the type and status of vegetation cover and land use types both in the villages and the HMFS. Accessible areas of the forest tract between Mweka and Lyasomboro villages were visited and the status of the vegetation cover in the HMFS and that of the villages was captured by the use of a YASHICA M-2 DX camera. This was intended to provide pictorial evidence of the degraded parts of the forest, on one hand and village land use/cover, on the other.

2.5. Data processing and analysis

This study used three levels of analysis: the positivist, where quantifiable and verifiable data were used, phenomenology or humanist, where theories were employed to convey meaning to behaviour and attitudes and Geographical Information Systems.

In the positivist approach, all data from the questionnaires were coded into specific categories and tabulated in Microsoft Excel spreadsheet where different analyses were performed. The two hypotheses were then tested through descriptive analysis and testing of associations using a Chi-square Test. According to Croxton et al. (1979) a Chi-square Test is computed as follows:

$$\chi^2 = \sum (f - f_c)^2 / f_c \quad \text{Where:}$$

f = observed frequency, f_c = associated or computed frequency and
 χ^2 = Chi square test.

The first hypothesis stated that “Different types of land use changes have occurred in the area between 1952 and 2000”. A Chi-square Test was used to test association between ‘location’ (Mweka and Lyasomboro villages) and ‘land use changes’ at a calculated degree of freedom and 5% level of significance. This, according to Clarke and Hosking (1986), is the best way of testing binary, nominally or ordinal classified variables.

The second hypothesis was tested against quantifiable field findings through descriptive analysis and testing of associations using a Chi-square Test (χ^2). The hypothesis stated that ‘Land use changes in the area have led to a decline in forest cover and plant species diversity of the HMFS’.

A Chi-square Test was used to test association between the declines in forest cover and plant species diversity between two time periods: 1980-1990 and 1990-2000 at 3 degrees of freedom and 5% level of significance. This was done in conjunction with analysis of the land use/cover map derived from a mosaic of Landsat 7ETM+ images of October 1999 and February 2000 together with 1952 and 1982 land use cover maps. This facilitated comparison between the 1952-1982 and 1999/2000 land use/cover maps in order to observe changes that have taken place.

In the second approach, the analysis was linked to the conceptual framework, that is inter-relationships and intra-relationships between different processes and phenomena as they ultimately culminate into land use/cover change and loss of plant species diversity in a particular area. The first hypothesis, which stated that 'Different types of land use changes have occurred in the area over time', was again tested through this approach. Moreover the second hypothesis that stated 'land use changes in the area have led to a decline in the forest cover and plant species diversity of the HMFS' was also tested. The data from interviews, discussions and observations formed the bottom line for analysis in the approach.

Unlike in quantitative enquiry, for a qualitative enquiry it is often problematic to have a clear distinction between data gathering and data analysis (Mwanje, 2001). As such the analysis of qualitative data followed a hermeneutic perspective, which is an approach to human understanding as it provides the philosophical grounding for interpretivism. Hermeneutic is primarily concerned with the meaning of a text or a text-analogue such as the community (Mwanje, 2001).

There were incidences when respondents deliberately provided false information. Under such circumstances a hermeneutic perspective fostered a researcher to probe even further as to why they should do so and what would that mean in terms of forest resources utilization and management in their area. For example, data on household use of forest resources from the HMFS had to be managed in that perspective as most respondents denied to have been exploiting forest resources. No sooner had the researcher observed individuals (women, men, and children), some with axes, sickles and machetes, either cutting trees for poles and firewood or carrying firewood, and/or fodder, which included tree twigs than a hermeneutic analytical approach had to be concocted.

The last level of analysis was the use of Geographical Information Systems (GIS). This assisted in inputting, processing and analysing data from the satellite image. Data from a colour composite mosaic of Landsat 7ETM+ of October 1999 and February 2000 were analysed by using various modules of Geographical Information Systems (GIS) Ilwis 3.0 Academic and was displayed in Arc View Version 3.1 software. GIS also aided processing and analysing digital data from the interpretation of the 1952 and 1982 aerial photographs.

The changes in various land use/cover categories for 1952 and 1982 were detected by overlaying the two maps. Similarly, through this tool of analysis land use/cover categories for 2000 were also detected. Overlay analysis of the 1952 or 1982 and 1999/2000 maps, however, could not be done because the map sources were different and so were their scales. The 1952 and 1982 maps were derived from aerial photographs and were at a scale of 1:400,000 while the latter was from satellite imageries and at a scale of 1:150,000.

Through the approach the first hypothesis was partly tested as the extent of land use/cover changes, particularly for the 1952-1982 period, were detected and calculated. Again, the hypothesis that 'land use changes in the area have led to a decline in forest cover and plant species diversity of the HMFS' was tested as the extents of the various land use/cover categories could be created and the area coverage calculated. Land use/cover change (replacement by secondary vegetation, decrease or increase in area coverage), in this respect, was related to decrease, increase or loss of plant species diversity.

2.6. Presentation of findings

Qualitative information, such as perceptions of the local community on the management of the forest reserve, history of land use changes, villages' typology as well as farming systems and patterns, is presented in descriptive form. Data obtained from questionnaires are presented in the form of pie charts, tables and graphs. In addition, maps derived from satellite images constitute another form of data presentation. Maps and tables have been used to present the land use/cover patterns for 1952, 1982, and 2000.

2.7. Limitations of the study

The limitations the researcher encountered during the field survey included the following:

In-depth interviews with herbalists and honey gatherers were not very effective, as their turn up for the interviews were poor despite the fact that they were informed prior to the researcher's visit. Therefore, information provided by these groups was based on very few individuals some of whom were leaders of their respective groups. As such it can be assumed that the data obtained from these groups were inadequate and that might have influenced the findings in one way or the other.

Secondly, during questionnaire interviews questions that related to extraction of forest resources from the HMFS were deliberately wrongly answered as some of the respondents had already been caught in the forest reserve by forest guards. Such individuals were suspicious of the recurrence of the incident despite the assurance by the researcher that the research was purely academic. It is under such grounds that a methodological triangulation of data collection techniques and analysis provided strength of the findings for this study.

3.1 CHANGING LAND USE AND ITS IMPACTS ON FOREST COVER AND BIODIVERSITY

3.1 Introduction

The study area harbours different land use types whose patterns have been influenced by socio-economic impulses. Ideally, the land uses are not static as they change with time, scale and space (Wood et al., 2000). These changing land uses in the study area and their impacts on the HMFS are the focus of discussion in this section. It is hypothesized that land use changes in the study area have led to a decline in forest cover and biodiversity in the HMFS. The differences between the types and sources of data could not allow for statistical tests. The hypothesis was tested using land use change maps of 1952, 1982 and 2000. The 1952 and 1982 land use/cover change maps were derived from aerial photographs and were at a scale 1:400,000 while the 2000 land use/cover change map was derived from a satellite imagery of 1999/2000 and at a scale 1:50,000.

3.2 Land use/cover patterns and change between 1952 and 2000

Accurate information on land use/cover changes and the forces and processes behind them is essential for designing a sound environmental management plan. Thus, land cover analysis provides baseline data required for proper understanding of how land was used in the past, current changes and what changes are expected in the future. This section discusses the land use/cover changes in the study area during the last fifty years.

3.2.1 Types and extent of land use/cover and change, 1952-1982

The spatial distribution of the various land use/cover types in 1952 and 1982 are shown in Maps 3.1 and 3.2 in the Appendix (pages 47 and 48). Table 3.1 shows the extent of land use/cover during the two time periods.

Seven major categories and fifteen sub-categories of land use/cover types were identified on the 1952 and 1982 aerial photographs (Table 3.1). The major land use/cover category in 1952 was cultivation with herbaceous crops which covered 260.43 Km² or 34.5%. Natural forest covered 194.41 Km² or 25.8%. The natural forest was confined to the HMFS, KFR and river valleys.

Other major land use/cover categories in 1952 were mixed cropping (22.02%) and bushland with scattered cultivation (2.7%) and plantation 14.3%.

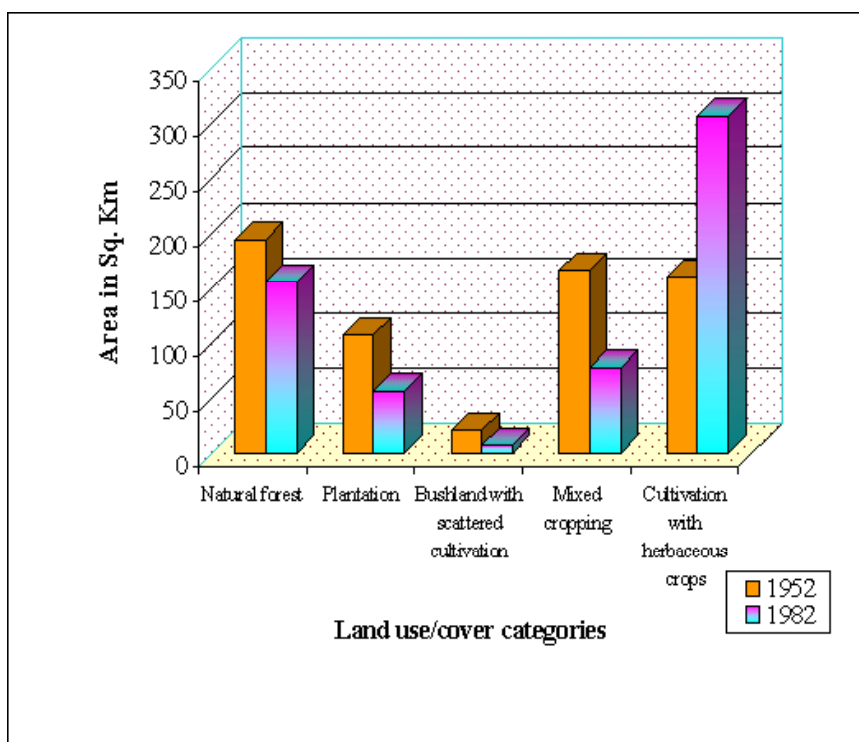
The extent of the natural forest in 1952 may be explained by the presence of minimum anthropogenic pressure on the forest due to low population density and the resultant low demand for forestry products (Yanda and Shishira, 2001). Various forms of human disturbances, however, particularly timber harvesting by big companies, in the natural forest are reported to have taken place in the study area. Consequently, different parts of the forest have experienced various levels of degradation and transformation.

In 1982, the dominant land use/cover category was cultivation with herbaceous crops which covered 306.44 Km² or 42.6%. Natural forest accounted for 155.8 Km² or 21.7%. Other major land use categories in 1982 were plantation 7.8%, open grassland (4.4%), bushed grassland (4.2%) and mixed cropping (10.8%).

Table 3.1. Extent of Land use/cover of the study area on the Southern slopes of Mount Kilimanjaro in 1952 and 1982.

Land use/cover type	Area for 1952		Area for 1982		Area change (1952-1982)	
	Km ²	%	Km ²	%	Km ²	%
Forest						
Natural Forest	194.41	25.78	155.80	21.66	-38.91	-4.12
Woodland						
Open Woodland	0.11	0.01	4.79	0.66	4.68	0.65
Woodland with Scattered Cultivation	-	-	6.29	0.87	6.29	0.87
Bushland						
Open Bushland	0.22	0.02	0.14	0.01	-0.08	-0.01
Bushland with Scattered Cultivation	20.65	2.73	7.46	1.03	-13.19	-1.70
Grassland						
Open Grassland	-	-	31.36	4.36	31.36	4.36
Grassland with Scattered Cultivation	2.25	0.29	15.87	2.20	13.62	1.91
Bushed Grassland	-	-	30.02	4.16	30.02	4.16
Cultivated land						
Mixed Cropping	166.07	22.02	78.01	10.84	-88.06	-11.18
Plantation	107.48	14.25	56.42	7.84	-51.06	-6.41
Cultivation with herbaceous crops	260.43	34.54	306.44	42.61	46.01	8.07
Water Features						
Inland water	0.16	0.02	0.10	0.01	-0.06	-0.01
Others						
Urban	1.61	0.21	25.99	3.61	24.38	3.40
Airport	0.47	0.06	0.45	0.06	-0.02	0.00
TOTAL	753.86	100.00	719.14	100.00		

Figure 3.1. Land use/cover change between 1952 and 1982.



In all the periods considered, cultivated land constituted the predominant land use/cover on the southern slopes of Mount Kilimanjaro. This is not surprising at all as historical records suggest that the slopes of the Mountain had been cultivated some 200 years ago (O'king'ati and Kessy, 1991). Analysis of the land use/cover changes between 1952 and 1982 shows that cultivation with herbaceous crops had increased by 46% from 260.4 Km² (34.5%) to 306.4 Km² (42.6%) (Figure 3.1). Overall, however, cultivated land showed a declining trend. Whilst it comprised 533.98 Km² or 70.81% of the entire study area in 1952, it had decreased to 440.87 Km² or 61.29% in 1982. Mixed cropping had also declined from 166.1 Km² in 1952 to 78.01 Km² or 10.84% in 1982.

Other land use/cover categories that show an increase during the same period include woodland with scattered cultivation, bushed grassland, grassland with scattered cultivation and the urban area (Table 3.1). For example, in 1952 open grassland and bushed grassland were insignificant but by 1982 they had increased to 31.36 Km² or 4.36% and 30.02 Km² or 4.16%, respectively. Woodland with scattered cultivation, which was almost insignificant in 1952, was 6.29 Km² or 0.87% in 1982. This implies that agricultural activities have been expanding at the expense of other land use/cover types. In addition, this could be a transition of the land use/cover to other forms of land use/cover such as grassland with scattered cultivation, particularly when selective cutting of woody vegetation for firewood and other domestic uses are practiced.

While some land use/cover categories increased between 1952 and 1982, natural forest decreased during the same time period. Data in Table 3.1 show that it decreased by 38.91 Km² between the two time periods. This means that the natural forest decreased at a rate of 0.1% per annum.

These findings show that there have been conversions and transformations of the different land use/cover types over time. The forest has, in some places, been replaced by cultivation with herbaceous crops, mixed cropping, plantation and cultivation with tree crops (shade trees) (Map 3.3 in Appendix, page 49). In some areas, such as Kitowo village and Oera sub-village in Mweka, the forest in the HMFS has been transformed to bushed grassland. In Marawe sub-village

in Lyasomboro the forest has been degraded. The remaining forest is characterized by the presence of minimal saplings in the under story due to frequent fodder collection, selective cutting of poles and grazing. Moreover, cultivation with herbaceous crops was largely transformed into cultivation with tree crops (shade trees) and mixed cropping. Similarly, mixed cropping, cultivation with herbaceous crops and cultivation with tree crops (shade trees) replaced plantation.

In light of the above findings, the two hypotheses for this study are accepted. The first hypothesis presupposed the occurrence of different types of land use changes over time, Table 3.1 and Map 3.3 illustrates this. The second hypothesis states that land use changes in the area have led to a decline in forest cover and plant species diversity of the HMFS. This has also been partly proved by Table 3.1, where extent of forest cover is shown to have declined by 4.12% and replaced by other cover categories.

3.2.2. Types and extent of land use/cover and change in 2000

The spatial distribution of the various land use/cover types in 2000 based on the interpretation of satellite imagery is presented in Map 3.4. (Appendix, page 50). The extent of the various land use/cover types in the study area is presented in Table 3.2

Particularly evident in table 3.2 is the dominance of cultivated land (428.5 Km²) in the study area in 2000. Cultivation with tree crops (shade trees) that covers 180.65 Km² or 23.5% dominates other land use/cover types under the cultivated land category. Forest cover constituted 156.8Km² or 20.4% of the area while woodland and bushland categories occupied 35 Km² or 4.6% and 64.6 Km² or 8.4%, respectively.

This suggests that the forest cover is continuously affected by human activities through encroachment. The degradation/transformation of the forest stands in both the HMFS and KFR is also reported by Lambrechts, et al. (2002).

A comparison of the 1982 and 2000 land use/cover maps show a decreasing trend in cultivation although it is not possible to tell exactly the percentage decrease because of the limitations posed by different sources from which the land use/cover maps and data were generated. The dominance of cultivated land, particularly cultivation with tree crops, over other land use types suggests that largely the area is intensively cultivated. Agroforestry practice in the *Vihamba* has been practiced for long in the area (Katigula, 1992; O’Kting’ati and Kessy, 1991; Maro, 1974). No significant change in the forest cover is evident from the 1982 and 2000 maps (Figure 3.2).

Findings from other studies e.g. Maro (1974); O’kting’ati and Kessy (1991); Lambrechts et al. (2002) and Larsson (2001) reveal that agricultural practices have been changing over time and change in cropping system is common.

Initially the lands at altitudes 700-2000m, where the *Vihamba* are located, were used for coffee and banana growing while the lowlands (*Porini*) were for growing maize, beans and millet (O’Kting’ati and Kessy, 1991; Maro, 1974). Currently, however, maize, beans and other vegetables are intercropped with banana and coffee plants in the *Vihamba* while at the same time these crops, with exception of vegetables are grown in the lowlands. The falling coffee prices, government’s removal of subsidies on farm inputs and the growing need for food and income have been a disincentive to farmers such that they are changing their cropping system to horticultural crops such as tomatoes, onions, cabbage and carrots. Horticultural crops fetch higher prices in urban and sub-urban areas, such as Moshi, Arusha and Tarakea at the Tanzania-Kenya border in Rombo District. Larsson (2001) observed a similar change in cropping system on Mount Meru, where horticultural crops are widely cultivated on the slopes of the mountain. The role of coffee as a cash crop on the slopes of Mount Meru is currently declining.

Table 3.2. Extent of Land use/cover of the study area on the Southern slopes of Mount Kilimanjaro as at 2000.

Land use/cover type	Area for 2000	
	Km ²	%
Forest		
Natural Forest	156.84	20.39
Riverine Forest	4.23	0.54
Woodland		
Woodland with Scattered Cropland	35.00	4.55
Bushland		
Dense Bushland	25.13	3.26
Open Bushland	3.13	0.40
Bushland with Emergent Trees	13.00	1.69
Bushland with Scattered Cropland	23.30	3.02
Grassland		
Open Grassland	33.47	4.35
Grassland with Scattered Cropland	56.18	7.30
Wooded Grassland	1.97	0.25
Cultivated land		
Cultivation with Tree Crops (Shade Trees)	180.65	23.48
Cultivation with Tree Crops	120.74	15.59
Mixed Cropping	61.67	8.01
Cultivation with herbaceous crops	65.43	8.50
Others		
Urban	7.11	0.92
Airport	0.73	0.09
Rock Outcrop	5.74	0.74
TOTAL	769.19	100.00

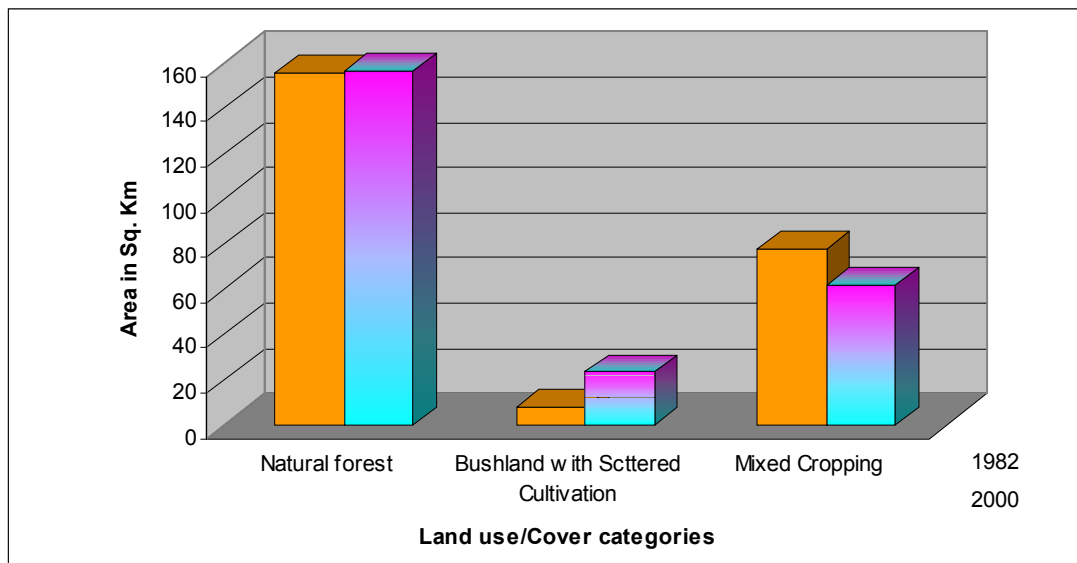
Source: Data calculated from a map derived from the interpretation of a Mosaic of Landsat 7ETM+ Satellite imagery of October 1999 and February 2000 at a Scale 1:150,000

3.3. Local peoples' perception of land use changes

In the previous sections, it is observed that there have been land use changes in the study area over time. These changes involved transformation of one form of land use/cover to other types of land use/cover. Discussions held with village leaders and other elderly persons revealed that the land use changes in both villages have been complex and diverse. There has been a replacement of natural vegetation by cultivation particularly at altitude 1500m. Grazing land, in most cases on individual household's land close to the HMFS edge has been replaced by cultivation. There has also been a replacement of natural vegetation by settlements. Moreover, there has been a change in the cropping pattern. In the past such crops as maize and beans were grown in the lowlands while banana and coffee were more significantly grown at higher altitudes.

O'king'ati and Kessy (1991) observed the same cropping pattern, with coffee and bananas grown in the middle and high altitudes 700-1400m and 1400-2000m, respectively. However, due to a recession in coffee prices in late 1990s some farmers have uprooted coffee trees and replaced them with bananas, beans and maize. There has also been a replacement of some indigenous trees by exotic trees particularly in the home gardens (*Vihamba*). Exotic trees are mainly planted for fodder, firewood, poles and timber.

Figure 3.2. Land use/cover change between 1982 and 2000



Some individuals indicated that they have changed the use of their land from the time they acquired it. While some changed the use from either forest or grazing land to cultivation, others just changed the cropping pattern as the land was already under cultivation. One percent (1%) of the respondents in the study area said that in 1978 they changed use of their land from grazing or pasturage to agricultural use and settlement. The majority (94%), however, reported that they had not significantly changed the use of their land since they first acquired it. Five percent (5%) could not tell whether there were changes in land use in the study area since the establishment of the villages or not. In Mweka village, 6% of the respondents pointed out that the land they have, was initially forested. The same percentage of respondents indicated that their land was grazing land when they first acquired it. Only 8% of the respondents had their land bushy. The majority of the respondents (80%) acquired cropped land. In Lyasomboro, 66% of the respondents acquired cropped land while 26% said they acquired their land when it was a bush. Those who acquired grazing land were 6% and those, whose land was forested when they first acquired it, were 2%.

Those who acquired cropped land in Mweka planted additional crops (84%) replacing such crops as aged banana and coffee trees. This was also the case with 72% of the respondents in Lyasomboro village. Two percent (2%) of people interviewed in Mweka said that they grazed the land they acquired while 14% cleared the bushed and/or forested land for agricultural use, mainly, for growing of bananas and coffee.

The clearing in both villages, however, was selective, as they had to leave shade trees for coffee. This practice has resulted in the existence of indigenous tree species in the Chagga home gardens (*Vihamba*). In Lyasomboro village, none of the respondents had put the land first acquired to grazing use. Those who had their land bushed or forested, they cleared it for growing of coffee and bananas. In both villages, however, there was no abandoned land after having put it to particular uses. This, again, validates intensive use of the land in the study area.

The above findings are similar to those reported by Maro (1974) and Larsson (2001) on land use changes on the slopes of Mount Kilimanjaro. The researcher's findings and those of other studies imply that land uses change with time and that these changes are induced.

The findings also reveal that the land on the slopes of Mount Kilimanjaro has for long been put to agricultural land use. Misana (1991) argued that there had been a spectacular development of agriculture on Kilimanjaro during the last one hundred and fifty years. Even before coffee was introduced in 1906, permanent cultivation of bananas was taking place particularly in the highland

areas between 1200-1800m where the soils were fertile (Maro, 1974). Misana (1991) referring to Meyer (1891) presented detailed records of cultivation around Marangu, which dates back as far as 1886. This may explain why some of the respondents in the study area, acquired plots of land that had already been cropped as early as 1930s a practice that continues to date.

3.4. Impacts of land use/cover change on the forest cover and biodiversity

A change in land use may either have positive or negative impacts on forest cover. Various authors, such as Wood et al. (2000); Wunder (2000); Campbell (1994) and Christiansson and Kikula (1996), however, have pointed out that land use changes are known to impact adversely on forests and biodiversity. This section focuses on the adverse impacts on the forest cover and plant species diversity of the HMFS associated with changes in land use in the study area.

3.4.1. Forest degradation and loss of biodiversity

3.4.1.1. Forest cover loss and degradation

The findings in the preceding sections have revealed that the forest declined at a rate of about 0.1% per annum between 1952 and 1982. Thirty one percent (31.1) of the forest was replaced by agriculture. The findings tally with those of Lambrechts et al., (2002), Katigula, (1992) and Yanda and Shishira, (2001) who point out that the forest on Mount Kilimanjaro (KFR and the HMFS) has declined. Yanda and Shishira (2001) showed that forests on the southern slopes of Mount Kilimanjaro had declined by 41.04Km² between 1952 and 1982.

When asked about the impacts of the land use changes in the study area on the HMFS, 90% of the respondents reported over-dependence on the HMFS, particularly for extraction of wood and non-wood products, both for domestic use and for sale. The local communities rely heavily on the forest reserve for fodder, firewood, timber and poles. As such many areas of the forest have been degraded. It was observed during the field survey that the forest in various parts of the HMFS is degraded. According to the villagers in Mweka and Lyasomboro the degradation has taken place since 1952 and has continued through the 1980s up to the present time as indicated by 58% of the respondents (Table 4.3)

1980-1990	Status	No. of respondents	Percentage
	Improved	12	12
	Degraded	58	58
	No change	5	5
	Don't know	25	25
	Total	100	100
1990-2000	Further improvement	13	13
	Further degradation	58	58
	No change	3	3
	Don't know	26	26
	Total	100	100

Table 3.3 Status of the Half Mile Forest Strip over time (n=100)

Source: Field Survey (2001)

Areas that are considered by the respondents to have been severely degraded by human activities are along river Kyarongo, Orera and Kifura in Mweka and Marawe in Lyasomboro. Other areas severely degraded include Mbahe and Kitowo villages in Marangu east ward, Vunjo village in Vunjo ward, Kilema, Rongai and Masia. Kitowo village in Marangu east was frequently referred to as one of the severely degraded part of the HMFS (Plate 3.1).

Plate 3.1.. Degraded forest in Kitowo village. Note the bushes, grasses and stunted trees (Photo by William, C.M.P 2001).



In Kitowo and Marawe in Lyasomboro village the current forest land cover in parts of the HMFS is severely degraded such that trees in these areas are stunted. Besides, the regeneration of the natural vegetation in these areas is heavily intervened by such anthropogenic activities as lumbering, grazing, poles cutting, fodder and firewood collection (Plates 3.2 and 3.3).

Plate 3.2. Exploitation of few remaining mature stands in Kitowo village (Photo by William, C.M.P 2001)



Plate 3.3. Livestock grazing in the HMFS at Kitowo village. Note the almost bare soil, stunted trees and bushes. The bushes in the background have cattle. (Photo by William, C.M.P 2001)



These findings are in line with those by Katigula (1992), Yanda and Shishira (2001) and Lambrechts et al. (2002) who report severe exploitation and degradation of forest resources in both the HMFS and the KFR due to increased human pressure on forest resources. The exploitation is mainly through logging, firewood, collection of fodder, grazing and charcoal making. Lambrechts et al. (2002), for example, reports of livestock that encroach on the forest in Marangu where Lyasomboro and Kitowo are located; these contribute largely to the degradation of the vegetation cover. The degradation of the HMFS is likely to continue if the pace of exploitation of the forest products continues unabated

In other areas of the HMFS, for example, Orera sub-village in Mweka, there is some natural regeneration of the vegetation. If secondary succession is allowed to perfect its course, there will be a promising trend of the vegetation to grow into mature forest stands. In Mweka Juu sub-village, the Central government through the South Kilimanjaro Catchment Forestry Project has replanted *Ocotea Usambarensis*, and the trees have grown to about five meters or more.

Plate 3.4. Secondary vegetation growth at Olele sub-village, Mweka. Note ferns growth in the foreground and trees at the background (Photo by William, C.M.P 2001)



3.4.1.2. Loss of plant species diversity

The preceding sections have revealed that the HMFS is severely degraded in many parts. Wood et al. (2000) pointed out that degradation of the forest implies loss of plant species. This is true of the forest in HMFS as observed by the respondents who identified different plant species that are difficult to obtain from the HMFS. This means that these plant species are declining in abundance. Thus, if the current degradation of the forest proceeds unchecked, these plant species are likely to become extinct in the future.

Interviews with respondents revealed that plant species such as *Embelia schimperi* (Ngets) and *Myrsine africana* (Ngets ndogo), an antihelminthic medicinal shrub, have become scarce in Mweka area. Other plant species that are not easily found from the HMFS include *Myrica salicifolia* (Iruka/Mruka) and a timber tree species *Ocotea usambarensis* (Camphor). These findings on *Ocotea usambarensis* (Camphor) are in line with those of Lambrechts et al. (2002) who observe that camphor stand in Marangu area, particularly in the HMFS, has been depleted because the species was heavily extracted some decades ago.

Xymalos monso (Ndiri/Ndidji/Ndidi) was named as scarce in both Mweka and Lyasomboro villages while *Teclea simplicifolia* (Kiarai) was scarce in Lyasomboro village. In the two villages, some forest areas that had formerly been encroached on have been replaced by secondary vegetation that mainly consists of ferns, grasses, brambles and regenerating trees (Plate 3.4). This implies that the forest was opened up when mature stands of, for example, Camphor and other trees were extracted. In other areas, such as Kitowo, regeneration seems to have been heavily intervened by anthropogenic activities such that current vegetation consists of grasses, stunted trees and bushes. The only remaining mature stands in most areas of the HMFS are further vulnerable to cutting for timber and other uses as it was observed in Lyasomboro and Kitowo.

In order to test the hypothesis that 'Land use changes in the area have led to a decline in forest cover and plant species diversity of the HMFS' a Chi-square Test (χ^2) was used in relation to levels of degradation of the forest cover as stated by the respondents, which ultimately imply that adverse impacts on plant species diversity were inevitable (Table 3.4).

Table 3.4 Status of the forest cover in the HMFS at different time periods

Number of responses on status of the forest cover in the HMFS									
Year	Improved		Degraded		No change		Don't Know		Total
	Observed value	Expected value	Observed value	Expected value	Observed value	Expected value	Observed value	Expected value	
1980s-1990s	12	7.5	58	58	5	4	25	25.5	100
1990s-2000	13	7.5	58	58	3	4	26	25.5	100
Total	15		116		8		51		200

Calculated $\chi^2_{0.05,3}=7.252$ and theoretical $\chi^2_{0.05,3}=7.815$

The H_0 and H_1 are stated as follows:

H_0 - Land use changes in the area have led to a decline in forest cover and plant species diversity of the HMFS.

H_1 - Land use changes in the area have not led to a decline in forest cover and plant species diversity of the HMFS.

Since the calculated $\chi^2_{0.05,3}=7.252$ is less than the theoretical $\chi^2_{0.05,3}=7.815$ the null hypothesis is accepted implying that the land use changes in the area have led to a decline in forest cover and plant species diversity of the HMFS. This is further proved by scarcity of the various plant species as mentioned by the respondents and data in Table 4.1

3.4.2. Forest products that have disappeared or not easily obtained

The degradation of the HMFS has been associated with scarcity of certain forest products. Products that are believed to have been scarce are firewood, fodder, timber and some of the medicinal plants (Figure 3.3). About 35% of the respondents said that firewood was the scarcest product from the HMFS followed by fodder (23%) and timber (<10%) for timber, medicine and fodder. When asked about the availability of these products from the HMFS, 51% of the respondents acknowledged that there is scarcity of these products from the HMFS while 45% believe that there is no scarcity.

The preceding findings reveal that land use changes have occurred in the study area since the 1950s. These changes have significantly led to a decline in forest cover and plant species diversity in the HMFS. It is important at this juncture to know the processes that have led to these changes and the associated impacts. This will be the focus of the next section.

4.0. ROOT CAUSES OF LAND USE CHANGE AND LOSS OF SPECIES DIVERSITY

4.1. People’s perception on causes of land use change

Respondents in the study area had different views on factors that have driven changes in land use. According to the majority of the respondents (96%), land use changes in the study area are attributed to population increase (Table 4.1), which ultimately result in pressure on land. Only 1% pointed out that the changes in land use were due to introduction of cash crops such as coffee. Again, 1% of the respondents argued that the changes in land use were related to individual household’s behaviour rather than gross population growth of the study area.

Table 4.1. Causes of changes in land use (n=100)

Reason	No. of respondents	Percentage
Population increase	96	96
Introduction of commercial crops	1	1
Individual behaviour	1	1
Don’t Know	2	2
Total	100	100

Source: Field Survey (2001)

One respondent, for example, explained that when his family grew in size he was obliged to cultivate the land he had allocated for grazing (Box 4.1). He said,

Box 4.1. Factors of land use changes

“When my family was small I used to keep a lot of cattle because I had an area where I could graze. As the family grew in size through births I had to cultivate more bananas for food and coffee for income and, therefore, reduced the number of cattle I used to keep.”

4.2. Immediate causes

The immediate causes are those factors that directly impact the forest cover and plant species diversity these factors include expansion for agriculture and encroachment. The encroachment may be for lumbering and/or pit sawing, grazing, fuelwood collection and agriculture.

4.2.1. Expansion of agriculture

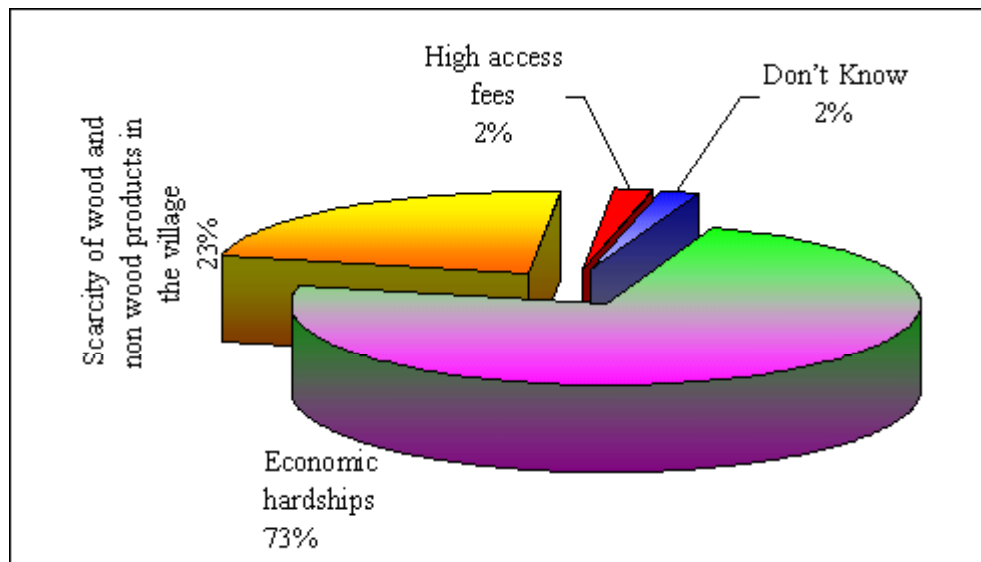
As it has been observed in the previous chapters agriculture has been expanding at the expense of the forest cover and other land use/cover types. For example, due to expanded agriculture, cultivation was extended to steep river valley, that together with scarcity of pasture may have instigated overexploitation and clearing of riverain forest. There has also been expansion of agriculture into the HMFS. These may explain the current status of some denuded banks of rivers and streams flowing through the *Vihamba* in the study area and the degraded parts of the HMFS in Lyasomboro, Mweka and Kitowo. Maro (1974) also observed such extensification of agriculture to marginal lands on the southern slopes of the Mountain.

4.2.2. Encroachment on HMFS

The preceding findings have shown that there has been encroachment on the HMFS for wood and non-wood products. The local people encroach on the forest for fuelwood, poles, timber, agriculture and fodder. Encroachment on the forest is largely associated with changing land uses in the study area. According to the respondents, two major reasons explain the prevalence of encroachment on the forest. These are economic hardships and scarcity of the forest products in the village.

Majority of the respondents (73%) said that the major reason for people to encroach on forests was economic hardships (Figure 4.1). As such it is an attempt to subsist. They said that returns from dairy products (e.g. milk) and food crops (e.g. bananas) were very low. These products fetch very low prices in local weekly markets such that the earnings cannot sustain a household for basic needs, like food, salt, soap, clothing, medication, school fees etc. Therefore, they supplement with selling of firewood (mainly bought by local brewers), timber, and poles. 23% believed that encroachment was due to scarcity of the wood and non-wood products in the villages. Others (2%) pointed out that the user fees were not affordable to a local villager who, for example, needed to fetch firewood from the HMFS.

Figure 4.1. Causes of encroachment



Source: Field Survey (2001)

The Forests (Amendment) rules 2001 stipulate that licenses for firewood are issued either by quantity or by time in accordance with circumstances. The fee for quantity license is 3,000 Shillings per stacked cubic meter and time license to enter the forest reserve and remove one head load (28Kgs) of dead fallen wood daily costs 700 Shillings for a calendar month or part thereof.

The fact that most rural communities live below the poverty line (Lindberg, 1996), the respondents may be right to say that the user fees are high. But when one assesses the ability to pay 700 Shillings per month an equivalent of 23.3 Shillings a day or 163 Shillings a week, the inability to pay the amount is refuted by logic.

The villagers may be right to suggest that economic hardships, scarcity of wood and non-wood products, and high user fees were the causes for people in the two villages to encroach on the forest reserve. But when one ponders out the forces behind villagers' encroachment on the forest he/she might argue that these forces are just precursors of the main driving or root causes. The next section analyses the root causes of land use/cover change and biodiversity loss in the study area.

4.3. Root causes of land use/cover change, forest degradation and biodiversity loss

The root causes may be grouped into such major categories as demographic, economic, policies, institutional, politics, infrastructure and social/cultural factors. These factors, either independently or in complex combination, may have altered and or changed resource use patterns that may have culminated into change in land use, forest encroachment and ultimately habitat destruction and species loss.

4.3.1. Demographic change

Demographic change, particularly population growth and migration, may form the basis for explaining the land use changes observable in the study area and the resultant negative changes in forest cover and plant species diversity of the HMFS. The southern slopes of Mount Kilimanjaro are said to have been settled and cultivated, particularly at altitudes between 1200-1800m, some 250 or more years ago (Katigula, 1992). Since then the population has been increasing over time.

Gamassa (1991) estimated the population on the mountain to be 122,300; 133,400 and 155,900 in 1913, 1921 and 1931, respectively. The population in Moshi Rural District alone increased from 241,490 in 1967 to 474,562 in 2000 (Table 4.2). The population showed increasing trend over time. The high growth of population led to increased demand for agricultural land and settlement. Consequently, settlement and/or agriculture in the study area have replaced small areas of grazing land that were on individual plots and those which were running along the HMFS margin.

Table 4.2. Population Data for Moshi Rural District 1967-2002.

Year	1967	1978	1988	2000	2001	2002
Population	241,490	311,600	342,760	474,562	489,199	504,287
Area (Km ²)	1,558	1,558	1,558	1,558	1,558	1,558
Population density	155	200	220	305	314	324

Source: Calculated from Population data 1967, 1978, and 1988 based on Population census whereas 2000, 2001 and 2002 is based on Population projection (Source: <http://www.tanzania.go.tz/population.html>).

Moshi Rural District is reported by various studies, such as Gamassa (1991), Katigula (1992), Harrison (1987) and Mbonile (1999), to be the most densely populated District in 1988 (Table 4.2.). The high density of the population in the study area, particularly on the slopes of the mountain, may have created pressure on the prevailing resources including land leading to land fragmentation. Maro (1974) also observed Land fragmentation on the slopes of Mount Kilimanjaro, stemming mainly from population pressure on land.

This study found that there are individual households with a land lot of less than 0.1ha. The majority of the respondents (84%) owned a *Kihamba* of between 0.1 and 0.8 ha. These plots are too small to sustain a living. Yet there is no further room for expansion of farms nor intensification of agriculture, as observed by Moyo et al.(1993). Therefore, marginal levels of productivity of land per unit of input may have been reached. Beyond the marginal level of

productivity returns per unit of input from the cultivated land starts to decline (Kjærby, 1976). Consequently, people have been forced to encroach on the forest.

The findings, therefore, refute what could have been anticipated by, for example, Boserup (1965) who assumed that the pressure on land was a likely pre-requisite for agricultural intensification, which could proceed indefinitely. It is, therefore, possible to say that with increasing population density and the resultant pressure on land, *Ceteris paribus*, marginal levels of intensification are likely to be reached despite the level of technology and people's aspirations for development. This is particularly true of the study area because 60% of the respondents reported a decline in productivity of their *Vihamba*.

Beyond marginal levels of productivity of land, and given the small holdings, people lack alternatives other than to diversify their production. This has instigated exploitation of formerly non-commercial wood and non-wood products. The selling of firewood, for example, is common in both villages, though it is more pronounced in Lyasomboro village where stacks of firewood are usually ferried down to the village from the HMFS at around 4 and 5 a.m.

Livelihood and income diversification through exploiting wood and non-wood products from the forest has resulted into forest degradation through conversions and modifications. According to Lambrechts et al. (2002), Katigula (1992) and Yanda and Shishira (2001) illegal logging, charcoal making and cutting of firewood and poles for sale, for example, have predominantly degraded the forests on Mount Kilimanjaro including the HMFS. Pit sawing, charcoal making and poles cutting, for example, start as selective cutting. When the supply of such trees dwindles, as in the case of the HMFS, all trees fall victims (Lambrechts et al., 2002).

Studies elsewhere also have observed the same. For example, Wood et al (2000) observed that illegal logging, stemming from population pressure, among other factors, contributed to forest degradation and loss of biodiversity in Vietnam. In most ecosystems, therefore, without adequate and reliable management of natural resources such as the forest, a rapid increase in population is likely to contribute to deterioration and depletion of natural resources resulting, often in, among others, loss of vegetation cover and species diversity.

Apart from being involved in forest exploitation, other individuals, particularly youngsters, in Lyasomboro village are engaged in tourism as porters and tourist guides for climbers of Mount Kilimanjaro. Others, particularly those aged 20-49, conduct businesses in and out of designated markets such as Himo, Boma ya Ng'ombe and Sanya juu (Mbonile, 1999). Some, particularly youngsters, move to such gemstone mine areas as Mererani/Semanjira in Mbuguni area to search for their fortunes.

Circular migration and commutation to Himo, Moshi and Tarakea and Holili characterize the diversification of livelihood and income of some local people in the study area. These are places within commuting distance from mountain homesteads and where local entrepreneurs have their networks of market contacts, business partners and patrons. Those who move to Mererani gemstone mines spend temporarily a number of days away from home-a week or few months. Some of the temporary absentees send remittances and/or save some money on their return home. Mbonile (1999) observed similar patterns of migration on the southern slopes of Mount Kilimanjaro while Larsson (2001) has reported of a similar pattern of people moving from the slopes of Mount Meru to Mererani.

Despite the fact that there is out migration in the study area, the pattern of out migration does not relieve pressure on resources in the two villages. This is because the out-seasonal migrants maintain ties to the land (*Kihamba*) they own in the village regardless of its size. Mbonile (1999) also observed these absent landlords on the slopes of Mount Kilimanjaro. The out-migrants, who often migrate to urban areas, pay periodic visits to their home villages, particularly, during Christmas and New Year holidays. Some out-migrants periodically send remittances back home,

which serve the family and may be used to attend the *Vihamba* they own. Maintaining a *Kihamba* not only strengthens one's patrilineal ownership and inheritance of land and ties with the clan but also a *Kihamba* is a respectable burial place for an individual wherever and whenever he dies.

Although population pressure is believed by Wood et al. (2000) to be one of the major factors driving land use change, it may not be adequate in explaining why people do their activities in the forest reserve. Other non-demographic factors, such as policies, management and institutional change, economic and social/cultural factors are pivotal in understanding the changes in land use of the study area.

4.3.2. Policies

Policies tend to influence human behaviour in a particular sector of the economy in order to achieve desired development goals and objectives. Some of the policies, however, may have adverse impacts on land use and the management of the forest. The next section discusses how past and present policies have influenced changes in resource use patterns and land use, and ultimately led to forest degradation and biodiversity loss.

4.3.2.1. Colonial policies

The prevalent land use/cover changes in the study area and the subsequent degradation of the forest cover and loss of biodiversity are to some extent, a legacy of past colonial policies, particularly the land policy. The British reigned German East Africa with the exception of Rwanda and Burundi effectively from 1922. During that time land use and tenure issues were addressed under a legislation passed under article 8 of the Tanganyika Order in Council, which made all rights in any public land to be vested in and exercisable by the Governor in trust of the British crown (Mung'ong'o, 1995).

The Land Ordinance of 1923 concretised land use decision-making powers in Tanganyika that instigated mass evacuation programs (Mung'ong'o, 1995). As a result much of the fertile land on the mountain slopes was alienated for establishment of settler estates e.g. Ngomberi and Machare coffee estates. The situation was further worsened by the Wildlife Conservation legislation passed in 1921, which led to the gazettement of the forests on the mountain slopes as a forest reserve (KFR). The local people were denied access to the forest resources as they were regarded as destroyers of their own environment.

Denial of access to resources in their vicinity might have affected the idiosyncrasy of the people, who therefore lost a sense of ownership of the forest and stewardship of the same. The colonial officers believed that they had the duty of protecting the environment from the activities of the 'native tribes', by enclosing many valuable wildlife sanctuaries and forest reserves, and alienating the best agricultural land for white settlers' intensive agriculture (Mung'ong'o, 1995). Since the land left for peasantry agriculture by the local communities was small and in most cases infertile, pressure on the land was high, land fragmentation was inevitable and land productivity declined shortly afterwards (Maro, 1974). This may have led to expansion of cultivation into former grazing lands and encroachment for agriculture in the HMFS.

The colonial regime through her agricultural policy emphasized production of cash crops, which were mainly exported to the metropolis. The emphasis implied a change in land use and cropping patterns in Chagga land. German missionaries introduced coffee as a cash crop on the slopes of the mountain in the last decade of the nineteenth century (Illife, 1969). It spread rapidly due to suitable conditions on the slopes, including, soil, ample water and shed (Kimambo, 1991). The crop was, in most cases, intercropped with bananas, except in estates. The spread of cultivation of coffee led to expansion of cultivated land at the expense of the forest area, particularly the margins of the HMFS. Furthermore, it necessitated intercropping of the bananas and coffee with shade trees. The latter cropping pattern is persistent to date.

4.3.2.2. Post independence policies

Colonial policies that were beset with myriad of restrictive laws and regulations prohibiting the use of certain resources together with the establishment of game reserves (Mahalu, 1989) had far reaching implications inherent in the post independence era. Features of the post independence policies are a legacy of the past colonial policies.

a) Villagization policy

A socialist *Ujamaa* policy was the dominant development paradigm since 1972. Thus in July 1973, the Parliament passed the Rural Lands Planning and Utilization Act, which was followed by the President's announcement in August 1973 of compulsory living in *Ujamaa* villages (Kikula, 1996). All villages in Tanzania had to be registered as *Ujamaa* villages. In other places, the settlements had to be reorganized under the *Ujamaa* villages settlement scheme or *Operesheni vijiji*. On the southern slopes of Mount Kilimanjaro, people in Mweka and Lyasomboro villages were not resettled, rather they were coerced and registered as *Ujamaa* villages in 1976 on condition that each village had to agglomerate not less than 500 households. During *Operesheni vijiji* Kilimanjaro region relocated less than 2% of the total regional population (Schuler, 1991).

Despite the variability of the actual number of families that a village could hold, no criteria for establishing *Ujamaa* villages were set in consideration of the natural environment. Indeed the basis for allocating households to the villages, remain, until to date contentious. Kikula (1996) reported that, the Village and *Ujamaa* Villages Registration Act of 1975 and the Prime Minister's Circular of the same year set a general maximum of 600 families per village. Besides, the Village Registration Act laid down a minimum of 250 families per village while the United Nations Development Program (1976) suggested 250 to 450 families.

Although the village settlement scheme did not affect the study area in terms of settlement pattern and land ownership, as in other parts of the country, the condition for registration of the villages may have instigated influx of the other neighbouring villagers and/or people who were 'absentee landlords'. The 'village titling' and the population composition may have affected the land use pattern due to the pressure the population may have exerted on the prevalent land resources.

Generally, pressure on resources could be expected because of the consequence of high population density surviving on local resources in a subsistence economy. The density of 200 people/Km² that existed in mid 1970s on the slopes of the mountain, could, therefore, have been a source for incursion on the HMFS for different needs.

b) Forestry policies

Forestry policies have been influential in shaping the past and current resource use patterns land use changes and their impacts on the forest and plant species diversity of the HMFS. Tanzania has formulated a number of forest policies and action plans (Bagachwa et al., 1995). The first policy was adopted in 1953, which led to the establishment of forest reserves and charged the Forestry Department with overseeing their management. The exploitation of the forest resources, particularly for commercial logging was controlled through licensing (Kivumbi and Newmark, 1991; Yanda and Shishira 2001). It was regarded illegal for the local people to access the forest for wood and non-wood products. Damage to forest produce, grazing, collection of bee products, construction and occupation without permit was prohibited (NEMC, 2000). The restrictions imposed on the local people necessitated them encroach on the forest for subsistence. This could explain the change in land uses and resources use patterns, which culminated into encroachment on the HMFS.

The 1998 National Forestry Policy of Tanzania has introduced Joint Forest Management (JFM), which intends to, not only involve the local people in the management of the forest in their areas, but also ensure equity in benefits sharing (Ministry of Natural Resources and Tourism, 1998). The Policy, however, retains the unlawfulness of the local people exploiting forest resources from the forest reserve. The only new component is the JFM (Ministry of Natural Resources and Tourism,

1998). The implementation of the policy is still in its early stages such that the JFM component has not been well imparted to the local people in rural areas including the southern slopes Mount Kilimanjaro. Therefore, the implementation of this policy has not effectively achieved the desired objectives.

c) Agricultural Policies

In 1983, Tanzania adopted an agricultural policy designated to respond to the crisis facing the sector (Bagachwa et al., 1995). The foci were to develop an egalitarian agricultural community using modern husbandry; to achieve national self-sufficiency in food; and to increase output so as to earn foreign exchange and raise the rural standard of living. The objectives had to be achieved through a monopolistic State-controlled system. The government set higher producer prices to stimulate production. Parastatal supplied inputs and the government controlled cooperative unions served as intermediaries between the farmers and the monopolistic boards and crop authorities. Implementation of the policy relied heavily on the central government; hence, many problems in agriculture, which were a reflection of sectoral macroeconomic distortions persisted.

The land and agricultural policies have been promoting private investment and trade in the sector (Speirs and Marcussen, 1999; Tevera, 1994). However, national strategies in relevant policies rarely respond to the growing need for greater understanding of the links between policies, development goals and sustenance of natural capital such as the forest and land. Ignoring the links amplified resulted into either fragmentation or overlapping mandates amongst sectoral responsibilities. This confusion consequently led to mismanagement of the forests and habitat destruction in the forest reserves.

4.3.3. Management of the HMFS and institutional change

The HMFS has been under different management systems and their objectives have been varying over time (Yanda and Shishira, 2001). This temporal institutional change in the management of the HMFS affected resource management responsibilities to the extent that the use of the forest resources reached detrimental levels (Kivumbi and Newmark, 1991), either due to laxity, corruption and or collusion by responsible officials. This negatively affected the forest cover and plant species diversity.

4.3.3.1. The HMFS under the Chagga Council

According to Kivumbi and Newmark (1991), the first institution to manage the HMFS after its demarcation by the colonial government in 1941 was the Chagga Council. In the first two years after the demarcation, the Chagga Council planted approximately 208 ha of the degraded forest area using communal labour. Later, the Chagga Council levied a 50 cents forest user tax to be able to hire full time forest workers other than using communal labour that had problems.

In the early stages of the HMFS, the Chagga Council provided finances and labour for planting, thinning, and harvesting while the Central Government was responsible for providing and covering the expense of the field supervisory staff (Kivumbi and Newmark, 1991). By the late 1950s, the Chagga Council had sufficient trained staff to take over the supervision of the HMFS. The Council was very successful in enforcing forestry regulations within the HMFS and in preventing the grazing of livestock and the felling of trees adjacent to streams and rivers outside of the HMFS.

Despite receiving less royalty than the central government (one-quarter of what the central government was receiving) from forest products, the Chagga Council's financial management was very sound. Between 1941 and 1961, the costs of management were offset by the revenues generated from selling wood and wood products.

A wide variety of trees species were initially planted for poles, fuelwood and other uses within the HMFS (Table 4.3). Such species include *Acacia mearnsii*, *A. melanoxylon* and *Grevillea robusta*.

Other species planted included *Rapanea* and *Pygeum africanum* for water conservation while *Cinchona sp.* was established for quinine production.

Table 4.3. Tree species planted in the HMFS between 1941 and 1990.

Species	Hectares planted			Uses
	1941-1962	1963-1972	1987-1990	
<i>Acacia mearnsii</i>	52.2	35.8	-	Tannin production
<i>A. melanoxylon.</i>	44.9	-	-	Railroad ties
<i>A. mollisina</i>	47.6	30.0	-	
<i>Cryptomeria japonica</i>	3.2	-	-	Timber
<i>Cupressus lucitanica</i>	98.6	26.7	129.1	Timber
<i>Eucalyptus citriodora</i>	23.6	19.2	-	Poles and fuelwood
<i>E. maideni</i>	20.0	1.0	-	Poles and fuelwood
<i>E. resinifera</i>	2.0	2.2	-	Poles and fuelwood
<i>E. robusta</i>	14.3	-	-	Poles and fuelwood
<i>E. saligna</i>	27.0	1.2	-	Poles and fuelwood
<i>Grevillea robusta</i>	3.9	-	-	Poles and fuelwood
<i>Cinchona</i>	-	-	-	Quinine production
<i>Olea weltwitschii</i>	0.7	-	-	
<i>Pinus caribaea</i>	2.4	-	-	Timber
<i>P. patula</i>	72.5	-	-	Timber
<i>Rapanea</i>	-	-	-	Water conservation
<i>P. radiata</i>	1.8	-	-	Timber
<i>Pygeum africanum</i>	3.8	-	-	Water conservation
<i>Widdringtonia whytei</i>	31.9	-	-	Decorative bows during Christmas season
Total	450.4	116.1	129.1	

Source: Kivumbi and Newmark (1991:84)

According to Kivumbi and Newmark (1991) the management under the Chagga Council provided the local people with wood and non-wood products at either minimal cost and/or free. For example, debarked wattle trees were freely used for firewood. Also, after paying rental fee the local people initially were allowed to plant pyrethrum in the process of afforestation of the HMFS.

4.3.3.2. Management under district councils and the central government

After independence in 1962, the management of the HMFS was turned over to the District councils in Kilimanjaro (Kivumbi and Newmark, 1991). The emphasis in the management of the HMFS changed considerably under the district councils. More interest was directed to making the HMFS a commercial than a social forest because the district councils did not have the capability of controlling and managing the HMFS as the Chagga Council did. The district councils managed the HMFS less actively than the Chagga Council due to comparatively low return rates from the HMFS. Between 1963 and 1972 only a total of 116 ha of trees were planted (Table 5.3). Katigula (1992) argued that during the district councils' management of the HMFS there was more harvesting of trees mainly for timber than replanting the harvested and degraded areas.

With the abolishment of the district councils in 1972, the central government took over the management of the HMFS and the jurisdiction of the HMFS was placed within the South Kilimanjaro Catchment Project. The primary objective of management was promotion of soil and water conservation; thus it became difficult to address the former social forestry objectives of the HMFS within this project. Moreover, the personnel that were managing the HMFS during that time had little expertise in plantation forestry. This could partly explain the mismanagement that occurred in the HMFS and the resultant destruction of the forest cover.

The afforestation activities that occurred while the HMFS was being managed as part of the South Kilimanjaro Catchment Project were restricted to enrichment planting in forest gaps adjacent to streams and rivers. Indigenous species were used and they included *Albizia sp.*, *Rauvolfia caffra*, *Ficus sycomorus*, and *Rytigynia sp.* (Katigula, 1992; Kivumbi and Newmark, 1991). The areas adjacent to streams and rivers may not have been adversely impacted through exploitative anthropogenic activities such that gap enrichment planting could suffice recuperating the degraded parts of the forest.

Kivumbi and Newmark (1991) pointed out that one effect of the transfer of the HMFS to the central government was that the HMFS was managed under ordinances governing forest reserves. The management of the forests was done under the Forest Ordinance Cap. 389. It revolved around a philosophy of Problem Situation Analysis (PSA) and therefore opted for an interventionist approach in the management of the HMFS. Section 15 (1) of the Ordinance, for example, put it clear that any consumptive utilization of forest produce must be licensed. The issuing authority in the Central Government Forest Reserve was the Director of Forestry while local governments did issue licenses for utilization of forest produce in Local Government Forest Reserves.

Under the Forest Ordinances damage to forest produce, grazing, collection of bee products, construction and occupation without permit was also prohibited and this was further emphasized in the Forest Orders, 1996 [Government Notice No. 462 of 1996]. It also prescribed that no forest produce as trees, timber, logs, poles, charcoal, firewood, fibres and flosses etc. should be removed from any forest or woodlot under the control of the Forest and Beekeeping Division or any other local government. The burden of proof was on a person found within or in the vicinity of the forest reserve, without a lawful cause, with an implement likely to be used in cutting or damaging forest produce [S. 15(2)]. As such the exploitation of forest resources by the villagers from the forest reserve was, according to the Ordinance, unlawful.

Royalties for cutting trees within the HMFS were raised and local people were denied the privilege of collecting forest products freely or at minimal cost as they used to under the Chagga Council. This aroused considerable resentments among local people as they had contributed considerably in terms of labour for planting and thinning of the trees, demarcating the boundary, and fighting fires. The local people felt insecure as their basic daily needs such as firewood, poles and fodder, etc. were ignored. Therefore, many people resorted to illegal cutting of trees and even arson. This could explain why such activities as timber sawing, firewood collection, poles cutting, fodder collection, barrel caving, etc. are clandestinely being done in the forest.

Another effect of the management transfer, which is more persistent to date and which Kivumbi and Newmark (1991) could not amplify, is the psychological trauma of the local people. The idiosyncrasy of the local communities may have been negatively affected. As a result the utilitarian value the villagers had placed on the HMFS may have changed to non-utilitarian. The non-utilitarian value is implied in the negative attitudes of the people towards the management of the forest, which may also explain the lack of rapport to the management of the HMFS and the KFR (Box 5.2).

In 1987, the management of the HMFS was handled back to the district councils of Hai, Moshi Rural, and Rombo after the Local Government (District) Authorities Act, 1982 was passed. Part of the reasons for the transfer from the central government to the district councils was to encourage the lost social forestry aspects of the HMFS. The district councils were given the responsibility for setting royalties and selling forest products. Since then, however, the management of the HMFS has been contentious because the desired management goals have not been explicit, at least to the local people, thus creating more confusion than before. The primary emphasis of the district councils' to date has been to improve the management of the commercial forests within the HMFS although watershed protection remains an important objective for the portions that are covered by indigenous vegetation.

Box 4.2. Resentment of the local people against forest management

“In 1987 one old man was threatened to be stabbed to death by his fellow village men in Machame division after being suspected that he was an informer to our forest patrol crew that managed to confiscate about 50 pieces of illegally cut Camphor wood planks! There was virtually no public outcry against the threat within the area and this indicated passive support to the forest poachers! In other words one who is against forest produce poaching is an enemy.

In 1987 one Old man in Nkweshoo village (Hai district) was segregated from and discriminated by his fellow villagers for what appeared to be his efforts to facilitate seizure of a vehicle carrying illegally obtained forest produce. He was threatened even to be denied the rights of worship in a local Lutheran Church by his fellow clergymen; thus the local community saw him as an enemy.

In 1987 villagers in Saawe (Hai) smashed down bridges and culverts in order to obstruct forest protection activities. The villagers did the resistance in unison and no one seemed to condemn the act. Within a short time a Tanzania National Park vehicle that was on patrol work was pelted and stoned by the local people of the neighbouring Kyeeri village on August 21 1987.

In May 1992 local people at Mese and Samaki Maini villages made nail traps which were buried in the road after learning that forest patrol vehicles were to use the roads. As a result the patrol car tires were punctured and the villagers celebrated by devouring gourds of the local brew “Mbege”.”

Source: Katigula (1992:18)

Between 1987 and 1990 Moshi Rural and Rombo districts planted 129.1 ha of *Cupressus lucitanica*. Unfortunately, the rate of tree felling exceeded the rate of replanting in many areas even though the emphasis had been placed upon the development of nursery stock. Laxity on the part of district councils and mal-administration (corruption, collusion etc.) may have contributed to overexploitation of the forest resources from the HMFS, hence the prevailing status of the forest cover and plant species diversity in the HMFS. Several parts of the forest including the HMFS have been severely degraded (Yanda and Shishira, 2001). This may explain the current vegetation cover at Kitowo and parts of Mweka and Lyasomboro villages, which ranges from stunted trees and bushes to wooded grassland and degraded forest.

Discussions conducted with the Moshi Rural District Natural Resources Officer and officials from the South Kilimanjaro Catchment Forest office, all based in Moshi, revealed that the Moshi Rural District council has shortage of staff for the management of the HMFS following retrenchment of some of the workers. Yanda and Shishira (2001) reported the shortage of staff at district level as among forest management constraints. Moreover, although the district council is responsible for the management of the HMFS, it was disclosed that it lacks funds such that it cannot meet its obligations, including replanting degraded areas of the HMFS. The sources of revenue for the district authority were reported to be poor and funding from the central government insufficient.

It was reported from the district authority, for example, that the office could neither raise any seedlings in 1992-1993 nor plant trees in degraded areas in the same period. The district authority, therefore, leans heavily on the role played by the South Kilimanjaro Catchment Forest Project; Non Governmental Organizations (NGOs) and other potential donor funded projects operating on the Mount Kilimanjaro. It seems though that the district authority has delegated the management of the HMFS to South Kilimanjaro Catchment Forest Project. The NGOs and other donor funded projects are not primarily managing the HMFS and so is the South Kilimanjaro Catchment Forest Project. Therefore, this could provide an avenue for further degradation of the forest cover and loss of species diversity.

Incursions in the forest are evident and have been continuing day after day. In February 1997 having seen the alarming rates of forest overexploitation on mount Kilimanjaro as a whole, the Prime Minister ordered a ban of any exploitative activity in the forests on the mountain. Those who had encroached on the forest had to be evacuated, tree felling was to be halted, grazing in the forest was to cease and all lumbering and/ or pit sawing activities were to be stopped. The regional and district authorities were ordered to strategize on how to mobilize and educate the local communities on what their role should be in the management of the forests.

At the time of the survey, however, the people (dominated by the Maasai) in west Kilimanjaro had not yet been evacuated. Efforts to evacuate them were more diplomatic than forceful but the process was promising. Illegal pit sawing and grazing were also observable in several places of the HMFS, for example, Kitowo, Mweka and Lyasomboro in Marangu. Lambrechts et al.(2002) have observed similar activities being undertaken not only in the HMFS but also in the area under catchment forestry. Livestock were predominantly found grazing in Marangu forest area up to eight kilometres deep into the forest.

The above discussion reveals that with succession in management of the HMFS, when management of the forest was taken over by the central government and the district councils, traditional resources management systems may have slowly but surely been 'eroded'. Although the forest was still managed based on the utilitarian approach, a change in management had far reaching implications in terms of the values that the local people placed onto the forest. The local community may have lost the sense of ownership of the forest as it was then managed under Ordinances governing forest reserves. The Ordinances denied the local people in vicinity access to the HMFS, which ultimately led to loss of security they previously had- supply of the forest products at minimal prices. This may partly account for the encroachment on the forest in the HMFS and its currently degraded state.

It is observed that the adverse impacts of managerial changes were more pronounced when the forest was managed under the District Councils and the Central Government than during the Chagga Council. These findings are in line with the findings by, for example, Wunder (2000) who asserted that changes in traditional forest management systems in Ilha Grande, Latin America resulted in 70% vegetation cover change and loss of such plant species as *Haematoxylum basilleta*. The pioneer tribes of hunters and gatherers confined exploitation of forest resources to hunting, gathering and felling of large trees for canoe making (for certain tree species). These systems collapsed after the Tupi-Guaran Amerindians replaced the pioneer tribes, the latter introducing slash-and-burn agriculture, which adversely altered the forest. From such practices, only 30% of the area remains as primary forest that has never been cleared or heavily intervened. Ahlcrona (1986) also observed that the collapse of the traditional management systems of the pastoral communities in Sudan which used to sustain the presence of perennial palatable species for livestock led to the dominance of such plant species as *Acacia nubica* and *Calotropis procera* that are not palatable for animals.

4.3.4. Economic factors

Tanzania embarked on economic reforms in 1980s under the structural Adjustment Programs following the deterioration of the state of the economy. Measures to revamp the national economy were a necessity. The first phase of the Economic Recovery Program (ERP I) was accompanied with market liberalization, rolling back the state in provision of agricultural subsidies, price and institutional reforms. These had significant impacts on land use and resource management practices as they influenced land use, cropping pattern, resources allocation and the quality of natural capital.

Peters and Sankhayan (1994) assert that while formulating and implementing the economic reforms, no special attention was paid to their effects on the natural resources use and the quality of the environment. The removal of agricultural subsidies for example, has resulted into failure of peasants in the two villages to manage coffee trees. Prior to the 1980s, coffee performed well as

some of the necessary farm inputs were subsidized by the government (Bagachwa et al., 1995; Maro, 1974; Sevaldsen, 1997; Larsson, 2001). But since 1980s the same crop has been losing its role, due to, among other reasons, removal of government subsidies on farm inputs, which have led to low returns from coffee growing.

Ideally, market liberalization was expected to improve prices for farm inputs through suppliers' competition, instead the prices for such farm inputs as insecticides have hiked (Larsson, 2001) and have become unaffordable to a peasant farmer. As a result Coffee Berry Disease (CBD) has widely spread, lowering coffee productivity. This has been detrimental not only to individual households' economy but has also led to changes in cropping patterns. Villagers have changed their cropping patterns by uprooting or ignoring coffee trees and concentrating on food crops like bananas, maize and vegetables. Banana is an important food and cash crop for which there is a reliable market. Larsson (2001) observed a similar diversification strategy on the slopes of Mount Meru where vegetables and bananas have replaced 'permanently' uprooted coffee. Also vegetables, particularly tomatoes, have been substantially in high demand from Arusha and Dar es Salaam. As such tomato cultivation has spread on the slopes of the mountain recently. Tomatoes grown in the study area are highly in demand in Moshi, Tanga, Dar es Salaam, Himo, Tarakea, Holili, and Nairobi. Other villagers have farms in the lowlands (*porini*) where they cultivate millet, maize, beans and other cereal crops.

In addition to low produce from coffee growing, coffee prices are low making sales from coffee less and less profitable. Under such circumstances, the peasant farmers have been forced to diversify their livelihood strategies and this could explain why some women in Lyasomboro village are involved in selling firewood obtained mainly from the HMFS. The situation could also explain why, despite forest guards patrolling the forest, illegal lumbering has not been halted. It is possible that people see timber business more profitable as timber is sold dearly in the villages and the urban areas like Moshi and Himo. Katigula (1992) observed similar findings in the forests of Mount Kilimanjaro, where villagers reported that some rich timber traders in areas such as Moshi hired villagers in close proximity to the forest to pit saw. During the field survey, this researcher encountered a case where few logs of timber had been ferried out of the forest to be sawn inside an unroofed house.

In attempt to subsist, the local people increasingly engage in felling trees for timber, poles and fuelwood for sale from the HMFS. Margins of the forest have also been cultivated. This may explain the almost non-existence of Camphor in the HMFS.

Holden and Shanmugaratnam (1994) observed that the concomitants of SAPs in Ulanga District-Morogoro were increased clearing of forests for agricultural purposes, fuelwood, building materials, etc. Also, logging had increased as a means of generating some income. These have been attributed to population pressure and poverty of the local people.

4.3.5. Social/cultural factors

The Chagga on the slopes of Mount Kilimanjaro have for long been known to respond to ecological deterioration by intensification of agriculture (Harrison, 1987). The practice is accompanied with zero grazing, a system that is as old as the Chagga community itself (Katigula 1992, O'king'ati and Kessy, 1991). These farming systems together with the kinship structure, patrilineal ownership and inheritance of land have had significant implication on the nature of resources use and management in the study area.

Land inheritance and ownership, for example, have been responsible for the fragmentation of *Kihamba* due to increased pressure resulting from increase in population density. It is phenomenal, for example, for one's descendants to have plots of land, some of which are less than 0.1 of a hectare, even if they are absent from the village (absent landlords). The more the descendants one has the more fragmented his/her land is.

Maro (1974) observed that in central Machame, the coffee-banana *Vihamba* varied between one and four hectares and *shamba* varied between 0.3 and 4.8 ha. This anecdotal data, when compared to current findings of the study area discussed in chapter four imply a decrease in individual landholdings through land fragmentation.

Dominantly, the land in the study area has been fragmented with exception of coffee estates because of the tenure rights associated with them. During the field survey much of Ngomber estate was on fallow while Machare estate was being replanted with coffee.

Fragmentation of the *Vihamba* into even smaller units than they are now is expected, *Ceteris paribus*, given the continuing population increase and its ultimate pressure on land. This further fragmentation of the home gardens may be inevitable because a *Kihamba* is, among other values, a respectable burial place for a *Kihamba* owner wherever and whenever he dies. Nevertheless, when the land units will not allow further fragmentation, it is possible that a class of landless people will emerge. Larsson (2001) reports of a class of landless people arising from fragmentation of landholdings on the slopes of Mount Meru, who mainly live on off-farm activities.

A *Kihamba* is very rarely sold because the values placed on it are both economic and social-cultural. When this is converted in monetary form, it becomes unaffordable to an 'outsider'. Whenever it is necessary to sell the land, the clan ensures that the land is bought by one of the clan members and not otherwise. In the future, however, this is likely to change because of the changing expectations of the young generation and the 'power of money'. Selling land, which is managed under restrictive economic and social-cultural traits of the Meru community is already occurring on the slopes of Mount Meru (Larsson, 2001). So, there is a likelihood that the same may occur in the study area and on the slopes of Mount Kilimanjaro, generally.

Land fragmentation could be considered as a source of diversification from agriculture to other income and/or food sources, some of which include cultivation in the lowlands and encroachment on forests for forest products for sale. This is exemplified by a story of one woman as narrated by Katigula (1992)(Box 5.3).

Box 4.3. Diversification of agriculture

“In 1989 the forest guards in Kibosho ward used to apprehend one old woman from (Mkomilo village) in the forest reserve with huge bundles of firewood. The old woman usually trespassed in the reserve at dawn. On their investigation they discovered that her farm was no longer productive, it also had crops in very poor conditions. Thus the old woman had decided to rely on selling firewood on open markets to earn some cash for purchasing food and other basic needs.”

Source: Katigula (1992:15)

A study on Mount Meru (Larsson, 2001) observed that land fragmentation had produced landless people. Larsson further observes that with land being fragmented into tiny plots, the flexibility and fallback option of subsistence farming is lost. Instead of flexibility and a range of income options there is increased fragility as the young generation is forced into a limited range of lowly paid off-farm alternatives. In this way, 'de-agrarianisation' converges into de-peasantization and economic and occupational polarization. This is likely to be the case in the study area as land units continue to contract year after year while population density continues to increase.

Unique to the study area, however, is the increasing trend of the people heavily leaning on exploitation of forest products for sale. Katigula (1992) observed that local people collaborate with affluent timber traders, mainly in town, to encroach on the forest for timber pit sawing.

Humans are part of the forest ecosystem, therefore, villagers in Lyasomboro and Mweka and the HMFS are inseparable. The culture of the Chagga defined the value they placed on the HMFS and the use and management of the same. This may have influenced the idiosyncrasy, motivation, attitude, and behavioural patterns of the Chagga that had helped to assure sustenance and preservation of social order that led in the past to proper traditional forest management. They also influenced the value people ascribed to the management of the HMFS; the decisions they made and actions were based on the same factors. This is true of the time when the management of the HMFS was under the Chagga Council, an institution that had a strong local rapport.

The local people had placed a utilitarian value to the HMFS, which provided them with security of obtaining wood and non-wood products at minimum cost. The HMFS' management under the Chagga Council tallied with the needs of the local society in the vicinity, therefore, captured the beliefs and attitudes of the local villagers in the management process. Besides, the population prevalent was in equilibrium with the forest's ability to supply goods and services for local consumption (Katigula, 1992) and, therefore, the HMFS' role as a buffer zone was sufficient.

The period (1962-2000) during which the District Councils and the Central government managed the HMFS, the social/cultural values of the local people collapsed. This may have manifested itself in the patterns of land use in the villages and the struggle to subsist on the forest non-wood and wood products. Since, they had no any other alternative but clandestinely encroach on the forest for basic subsistence needs it culminated in loss of forest cover and plant species diversity in the HMFS, which is persistent to date.

4.3.6. Top-down Approach to forest management

At a national level political power as well as political ideologies can significantly influence land use changes and the associated impacts such as loss of forest cover and plant species diversity. Wood et al. (2000) pointed out that political power and ideologies may drive many inappropriate decisions concerning resource use and allocation. It has been observed in the previous sections, for example, that the management of the HMFS started with the Chagga council after demarcation of the strip by the colonial government in 1941. The colonial rule considered local people as destructive to the forest reserve and, therefore, they had to be buffered by the HMFS, which also provided them with goods and services at minimum cost. The colonial government through its indirect rule delegated some of its powers to the Chagga Council, which successfully managed the forest until the eve of independence.

After independence, the management of the HMFS was put under Kilimanjaro District Councils, in this respect Moshi Rural. During that time period, TANU was the only supreme ruling party. As such there were strong links between political power and the decisions over the management of forest resources in the HMFS. Decision-making was centralized and it is doubtless, therefore, that the decision to place the management of the HMFS under the district councils was centrally made.

Centrally made decisions may have affected the value the people placed on the forest resources, because the local people were denied access to and use of the forest resources in their locality. Yet the villagers were assumed to be responsible for proper rapport to the management of the forest reserve e.g. protection of the forest reserve from fire as it is stipulated under the 1959 Forest Ordinance Part V Section 16 (1). It should be noted from the outset that people's values and attitudes influence land management decisions. Due to a complexity within an ecosystem, of which humans are part, anthropogenic activities or management decisions in turn affect all the biological and physical components of the natural system. The ecological consequences that prevail in the HMFS may have stemmed from that political supremacy in development planning which in turn determined natural resource use in the area.

From the preceding discussion, it is evident that land use changes on the slopes of Mount Kilimanjaro and the resultant loss of forest cover and plant species diversity in the HMFS cannot

be explained in a monolithic perspective. They are a result of a myriad of complex inter-relationships and intra-relationships of root causes and immediate causes embedded in social/cultural, economic, demographic, policies and management/institutional dynamics. Any management approach to be introduced in HMFS must therefore take these factors into consideration.

5.0. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This section summarizes the study's main findings. It relates the findings to the research questions and hypotheses in the first section. A concluding remark and recommendations akin the main findings also form part of the section.

5.2. Summary of Main Findings

The study was conducted in the HMFS and two adjacent villages namely, Mweka and Lyasomboro in Moshi Rural District on the southern slopes of Mount Kilimanjaro. The objective of the study was to examine the nature and extent of land use changes on the southern slopes of Mount Kilimanjaro and their impacts on the forest cover and plant species diversity in the HMFS. Two hypotheses were tested: (i) Different types of land use changes have occurred in the area over time (ii) Land use changes in the area have led to a decline in forest cover and plant species diversity of the HMFS.

Data were collected through a methodological triangulation using different methods. A questionnaire interview was conducted to capture information on land uses and tenure aspects, changing land uses and impacts of the changes on the forest cover and plant species diversity, awareness of the local community and their perceptions of the land use changes and their implications. Additionally, the role of the government in the management of the HMFS and how the local people have been participating in the management of the forest reserve were also sought. The questionnaire interview was complemented by such methods as in-depth interviews, observations and interpretation of satellite images and mapping.

Furthermore, interpretation of satellite imagery and mapping generated data on the current land use/cover of the study area while the 1952 and 1982 land use/cover maps generated from interpretation of aerial photos provided information on past land use/cover. Besides, Geographical Information system (GIS) aided in establishing the spatial and temporal extent of land use/cover change and distribution in the study area. The data for 1952 were used as the baseline, which were compared to information extracted from the 1982 land use/cover map. The data for 2000 were treated separately because they were derived from a Landsat 7ETM+ image whereas the 1952 and 1982 data were based aerial photographs. Above all the scales for the two sources of information were different.

The findings of the study indicate that the major land uses of the area include agriculture, livestock keeping, settlement and infrastructure. Agriculture is largely small-scale rainfed/irrigated using traditional furrows (*Mfongo*). There are also coffee estates at Ngomberi and Machare in Mweka village. The individual plots (*Vihamba*) for the majority varies from 0.1 ha to 0.6 ha. Fragmentation of the land is dominant in the study area such that some households own a *Kihamba* of less than 0.1 ha.

Livestock keeping mainly involves zero grazing and the animals kept include cattle, sheep and goats. The animals are stall-fed and much of the fodder is obtained from the HMFS. Neither grazing land nor fallow land is available with the exception of few plots owned by absent landlords. In Marawe and Kitowo livestock graze freely in the HMFS such that these areas are heavily degraded.

The study has also revealed that the HMFS is the main source of firewood, fodder, poles and timber. According to the forest ordinance 1959 and the Forestry Policy of 1998, the local people are denied access to the forest reserve for exploitative purposes. Thus, the villagers clandestinely exploit forest resources. Access is granted upon payable fees for a particular purpose. Apiculture using traditional beehives is practiced in the area; the beehives are hung in the HMFS and the KFR. The forest is also an area where ritual ceremonies are performed.

The study has revealed that there have been land use/cover changes in the area over time. The changes in land use/cover have been in the form of conversions and transformations of the land use/cover types over time. Settlements have replaced some of the agricultural land particularly in Lyasomboro village where tourist hotels have been constructed. Similarly, agriculture expanded at the expense of grazing land particularly near the margins of the HMFS. Extensification of agriculture and scarcity of pasture have led to clearance of riverine vegetation and cultivation of steep riverbanks.

In all the three time periods considered (1952, 1982, and 2000) cultivated land was a predominant land use with cultivation with herbaceous crops comprising the major land cover of the study area. Cultivation with herbaceous crops increased from 260.43 Km² in 1952 to 306.44 Km² in 1982 and the same was 65.01 Km² in 2000. The forest cover shows a decline from 194.41 Km² in 1952 to 155.8 Km² in 1982. In 2000, the same land cover accounts for 161.07 Km² of the study area. Also, bushland and mixed cropping in 1982 showed a net loss of 13.27 Km² and 88.04 Km² respectively. In 2000, mixed cropping category comprised of 61.67 Km² of the study area.

Traditional cropping patterns have changed; previously bananas and coffee were grown at altitude 700-1400m and 1400-2000m while maize, beans and millet were grown in the lowlands. Currently maize, beans and vegetables are inter-cropped with bananas and coffee while retaining growing of maize, beans and millet in the lowlands. Generally, land productivity has declined and food insecurity increased especially in households with large families.

The findings further reveal that the HMFS has experienced enormous pressure from the surrounding community. The changing land uses have resulted into loss and degradation of the forest cover in many parts of the HMFS. The degradation of the forest is subsequently related to scarcity of such forest products as firewood, fodder, poles and timber. Furthermore, plant species such as *Embelia schimperi* (Ngetsi) and *Myrsine africana* (Ngetsi ndogo) an antihelminthic medicinal shrub; have been scarce. Other plant species not easily found from the HMFS include *Myrica salicifolia* (Iruka or Mruka), *Teclea simplicifolia* (Kiarai) and *Xymalos monso* (Ndidji/Ndidi/). *Ocotea usambarensis* (Camphor) has almost disappeared in the HMFS.

The land use/cover changes in the study area and their associated impacts have been attributed to encroachment arising from scarcity of resources such as firewood, fodder, poles and timber and economic hardships of the individual households. The past and current land use/cover changes, however, have been driven by demographic changes, institutional and management changes particularly of the HMFS, and policies and legislation. Demographic changes have, for example, resulted into the fragmentation and scarcity of land. The role of the government in the management of the HMFS has been through restrictions in the exploitation of the forest resources by putting stringent laws and regulations. This interventionist approach has proved a failure as the HMFS has continuously been degrading despite the efforts to effectively manage it. Besides, institutional changes in the management of the HMFS yielded undesirable results and may explain the current levels of degradation of the forest in various parts of the HMFS, some of which are almost irreversible.

Other underlying causes include economic policies such as the Structural Adjustment Programs (SAPs) of the 1980s, which led to the removal of government subsidies on agricultural inputs and devaluation of the local currency. This not only altered the land uses in the area but also may have

affected the cultural idiosyncrasy of the local people such that traditional management systems and thus use of the natural resources changed in their area.

5.3. Conclusion

It is evident from the study that the HMFS has been under constant pressure, which has culminated into its degradation and loss of plant species diversity. Changing land uses in the villages have had detrimental effects on the HMFS and plant species diversity. The forest cover has been significantly reduced while degradation of the HMFS is overt in several places. Some plant species used for various purposes by the local communities are also not easily obtained from the forest.

An interplay of causal factors explain the current state of land use/cover in and around the HMFS and these factors are likely to affect the future land uses in the area. For example, given the growing population pressure on land, fragmentation of the land is likely to continue. This is likely to negatively affect the productivity of the land and may lead to further land use changes, encroachment on the forests and food insecurity. In addition, on farm income is likely to be low, underemployment, and unemployment high leading to poverty. With poverty lingering in the community sustainable use and management of the forest resources may not be achieved whatever inputs and mechanisms are put in place. Potential land scarcity together with poverty may result in land related conflicts and may necessitate the Chagga to migrate to other areas of the country.

Increasingly people would engage in non-farm activities to supplement farm incomes. Moreover, the cropping pattern is likely to continue changing in response to the impulses of the market forces. Therefore, short growing crops and those that fetch higher prices in the market are likely to dominate. Probably a crop like coffee is likely to be abandoned in the future given the prevailing dwindling coffee prices and higher crop management costs.

Although numerous management options for the HMFS are available, the best practice should be that which involves the local people, who have been living and utilizing the resources from the HMFS, in the management.

5.4. General Recommendations

In light of the preceding observations and conclusions, it is recommended that:

- There is a need for multi-sector collaboration in management stemming from the fact that no single group or agency possesses the broad information base or broad focus necessary to manage the whole ecosystem. Different parties involved in the management of Mount Kilimanjaro should first recognize that the HMFS plays a critical role as a buffer social forest. Therefore, HMFS should be among core areas of interest for management without which encroachment pressure on KFR and beyond would be inevitable.
- Adequate sensitisation and involvement of the villagers in the management of the HMFS is a necessary prerequisite to tenable management option of the forest reserve. The involvement of the local people should be from the pre-planning phase to implementation and monitoring of the management projects. Efforts should be made to incorporate possible traditional knowledge available, in the management. The local community must be indemnified of their interests (access to resources) in the management process.
- Much investment in terms of time and resources should be directed outside the forest. This means, much of the efforts should be directed to exploring the dynamics within the surrounding communities that impact on HMFS and how to address them. A thorough understanding of the social, cultural, economic, political dynamics that operate in the surrounding villages, including spatial and temporal disparities amongst the Chagga community could provide an avenue to tap 'actual' involvement of the local community

in the management of the forest reserve. Thus, reversing the current state of degradation of the HMFS.

- The HMFS is shared by three districts: Moshi Rural, Hai and Rombo. For effective management of the HMFS, therefore, ecosystem boundaries and transboundary issues must be recognized. The primary focus for action should be on the human actions affecting the components and processes within the boundaries that define the ecosystem and not just within legal and administrative boundaries. Also, the forces external the ecosystem boundaries that influence what happens inside should be taken into consideration when planning for the management of the HMFS.
- Voluntary out migration from the densely populated slopes of Mount Kilimanjaro to other parts of the country should be encouraged. The government and/or other interested parties in the management of Mount Kilimanjaro ecosystem should take part in facilitating voluntary out migration.
- A successful management strategy for the HMFS should recognize prevalent land tenure, right of access or right to use the natural resources from the HMFS. This would strengthen local incentive for management. Ignoring the utilitarian values the local people have placed on the forests could mean rejecting an important input in setting up management priori.

6.5. Recommendations for further studies

More information is required on the social-economic, cultural and political dynamics that are operating in the societies on the slopes of Mount Kilimanjaro. Given the short time available for field survey it was not possible to explore all factors that have led to land use changes and their associated impacts on the HMFS and their implication on the status of the forests and biodiversity. The study had to be narrowed down to manageable specific themes of study.

There is also a need of establishing soil characteristics of the HMFS particularly where degradation of the forest is severe or nearly irreversible. This would be an input to understanding how to improve the soils and which indigenous plant species would thrive well in the areas in question.

A comparative study of the changing land uses and their driving forces in the part of Kenya and other mountainous areas in Tanzania would be paramount to understanding the spatial differences, if any and/or similarities. The findings would form a benchmark for formulation of national tenable management strategies based on the similarities and or disparities of the dynamics of land use changes and the impacts they have on the forest cover and plant species diversity amongst mountainous ecosystems. This would provide a model to solving similar problems elsewhere.

6. REFERENCES

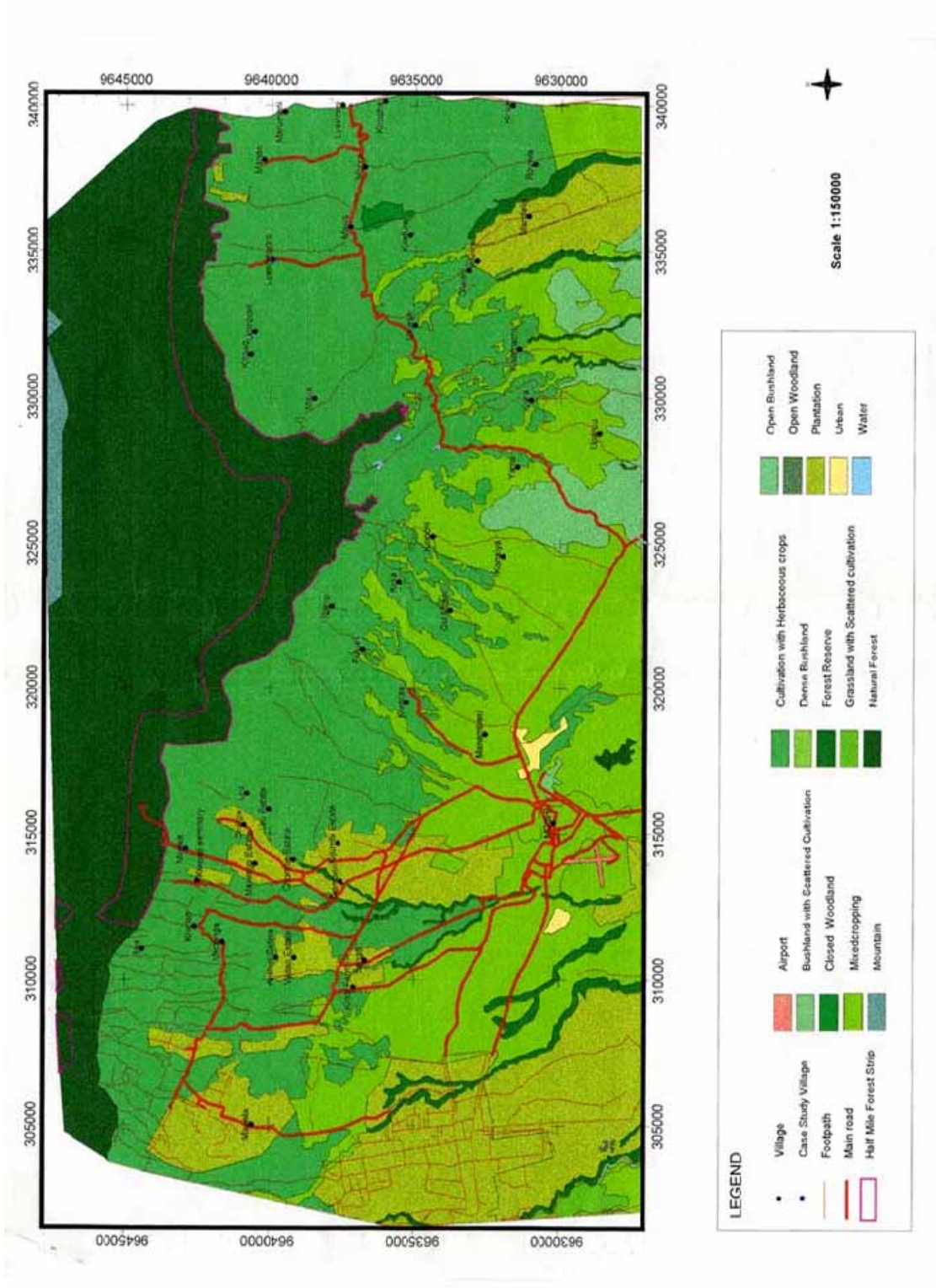
- Ahlcrona, E. 1986. **Monitoring the Impact of Climate and Man on Land Transformation: Study in Arid and Semi-arid Environment in Central Sudan.** Lunds Universitets Naturgeografiska Institution No.66.
- Anderson, D. 1988. **The Economies of Afforestation: A case study of Africa.** The John Hopkins University Press, USA.
- Anderson, G. D. 1993. **The Soils and Land Use Potentials of the Southern and Eastern Slopes of Mount Kilimanjaro, Tanzania.** Resource Management Paper No. 1. Institute of Resources Assessment, University of Dar es Salaam and International Development Program, Clark University, Worcester, Massachusetts, USA. 22-30pp.
- Bagachwa, M.S.D., Shechambo, F.C., Sosovele, H., Kulindwa, K.L., Naho, A.A., and Cromwell, E., eds. 1995. **Structural Adjustment and Sustainable Development in Tanzania.** Dar es Salaam University Press, Dar es Salaam.
- Bojang, F. and Reeb, D., eds. 1998. **Community Forest Ownership: Key to Sustainable Forest Resource Management, The Gambian experience.** International Workshop on Community Based Natural Resource Management (CBNRM). Washington DC.
- Boserup, E. 1965. **The Conditions of Agricultural Growth.** Aldine, London.
- Boyde, H.K, Westfall, R. and Stasch, F., eds. 1981. **Marketing Research: Tests and Cases.** Richard D. Inc., Illinois.
- Campbell, A. 1994. Community First: Landcare in Australia. **IIED**, Gatekeeper Series No. 42.
- Christiansson, C. and Kikula, I.S., eds. 1996. **Changing Environments: Research on Man Land Interrelations in Semi Arid Tanzania.** Regional Soil Conservation Unit, Swedish International Development Cooperation Agency.
- Clark, W.A.V. and Hosking, P.L., eds. 1986. **Statistical Methods for Geographers.** John Wiley and Sons, Inc. New York.
- Croxton, F.E., Cowden, D.J, and Klein, S.1979. **Applied General Statistics.** Prentice- Hall Inc. Englewood Cliffs, N.J.
- Food and Agriculture Organization.1993. **Forest Resources Assessment 1990: Tropical Countries.** FAO, Rome.
- Fisher, S.J. 1992. **Geography and Development: A world Regional Approach** (4th ed.). Macmillan Publishing Co., New York.
- Gamassa, D.M., 1991. Historical change in human population on Mount Kilimanjaro and its implications. In Newmark, W.D. (ed), **The conservation of Mount Kilimanjaro.** IUCN, Gland, Switzerland and Cambridge, UK. 1-8pp.
- Goudie, A. 1981. **The Human Impact.** Blackwell Publishers, UK.
- Goudie, A. 1992. **The Human Impact on the Environment.** Blackwell Publishers, UK.
- Gradwohl, J. and Greenberg, R. 1990. **Saving the Tropical Forests.** Earthscan Publications Ltd., London.
- Harrison, P., ed. 1987. **The Greening of Africa: Breaking Through in the Battle for Land and Food.** Paladin Grafton Books, London.
- Hermansen, J.E., Benedict, F., Corneliussen, T., Hofsten, J. and Venvik, H., eds. 1985. **Catchment Forestry in Tanzania: Status and Management.** Institute for Environmental Analysis, Oslo.
- Holden, S.T. and Shanmugaratnam, N., eds. 1994. **Structural Adjustment, Production Subsidies and Sustainable Land use.** Discussion Paper, NHL, As, Norway.
- <http://www.tanzania.go.tz/population.html>
- Illife, J. 1969. The Age of Improvement and Differentiation (1907-45). **A History of Tanzania.** In Kimambo, I.N. and Temu, A.J., (eds), Evanston, Ill., Northwestern University Press (Published for the Historical Association of Tanzania).

- Katigula, M.I.L. 1992. **Conservation of the Ecosystem on Mount Kilimanjaro: Reality in Experience.** Kilimanjaro Catchment Forest Project, Moshi.
- Kikula, I.S., ed. 1996. **Policy Implications on Environment: The Case of Villagization in Tanzania.** Nordiska, Frikainstitutent, Uppsala.
- Kimambo, I. N., ed. 1991. **Penetration and Protest in Tanzania: The Impact of World Economy on the Pare, 1860-1960.** James Currey, London.
- Kivumbi, C.O and Newmark, W.D. 1991. History of Half Mile Forest Strip on Mount Kilimanjaro. In Newmark, W.D. (ed), **The Conservation of Mount Kilimanjaro.** IUCN, Gland, Switzerland and Cambridge, UK. 81-86pp.
- Kjærby, F. 1976. **Agrarian and Economic Change in Northern Tanzania: A Study of the Pastoral Barabaig and Agro-pastoral Iraqw of Hanang District, Arusha region.** Masters diss. University of Copenhagen, Copenhagen.
- Lambrechts, C., Woodley, B., Hemp, A. and Nnyiti, P., eds. 2002. **Aerial Survey of the Threats to Mount Kilimanjaro Forests.** United Nations Development Program, Dar es Salaam.
- Larsson, R. 2001. **Between Crisis and Opportunity: Livelihoods, Diversification and Inequality Among the Meru of Tanzania.** (Lund Dissertations in Sociology 41). Department of Sociology, Lund University, Lund.
- Lindberg, C., ed. 1996. **Society and Environment Eroded: A case Study of Household Poverty and Natural Resources Use.** Uppsala University, Uppsala.
- Lusigi, J.W. 1992. **Managing Protected Areas in Africa: Report of a Workshop on Protected Area Management in Africa.** Mweka, Tanzania.
- Mabberley, D.J., ed. 1979. **Tropical Rainforest Ecology.** Blackwell, Oxford.
- Mahalu, C.R. 1989. Environmental Degradation and the Law in Tanzania. In **Law and Policies in Africa, Asia and Latin America.** 4th Quarter. Baden-Baden, Germany.
- Maro, R.S. 1974. **Population and Land Resources in Northern Tanzania: The Dynamics of Change 1920-1970.** (Ph.D. diss.), University of Dar es Salaam, Dar es Salaam.
- Mbonile, M.J., ed. 1999. Population Dynamics on the Slopes of Mount Kilimanjaro. **Les Cahiers de l'IFRA 16(March/April):** 18-23pp
- Ministry of Natural Resources and Tourism., ed. 2001. **Inventory Report of Kilimanjaro Forest Reserve in Tanzania.** South Kilimanjaro Catchment Forest Project, Moshi.
- Misana, S.B and Nyaki, F.R. 1993. Population and Deforestation. In United Nations (ed). **Population, Environment and Development.** University of Dar es Salaam, United Nations.41-60pp.
- Misana, S.B. 1991. The importance of Mount Kilimanjaro and the need for its integrated management and conservation. In Newmark, W.D. (ed.), **The Conservation of Mount Kilimanjaro.** IUCN, Gland, Switzerland and Cambridge, UK.103-110pp.
- Misana, S.B. ed. 1999. Community utilization and management of forest of Mount Kilimanjaro. **Les Cahiers de l'Ifra 16(March/April):** 48-58pp
- Moyo, S., O'Keefe, P., and Sill, M., eds. 1993. **The Southern African Environment.** Earthscan Publications Ltd., London.
- Mung'ong'o, C.G. 1995. **Social Processes and Ecology in Kondoa Irangi Hills, Central Tanzania.** (Ph.D. diss.), Arash Tryck and Forlag, Stockholm.
- Mwanje, J.I., ed. 2001. **Qualitative Research Process.** Organization for Social Science Research in Eastern and Southern Africa, Addis Ababa.
- National Environment Management Council. 2000. **Institutional Mandates for Natural Resources Management in East Africa Crossborders Biodiversity Project Sites in Tanzania.** Technical Report No.16. UNDP-GEF East African Crossborders Biodiversity Project Tanzania Component, URT-97-G31.
- Newmark, W.D., ed. 1991. **The Conservation of Mount Kilimanjaro.** IUCN,Gland, Switzerland and Cambridge,UK.

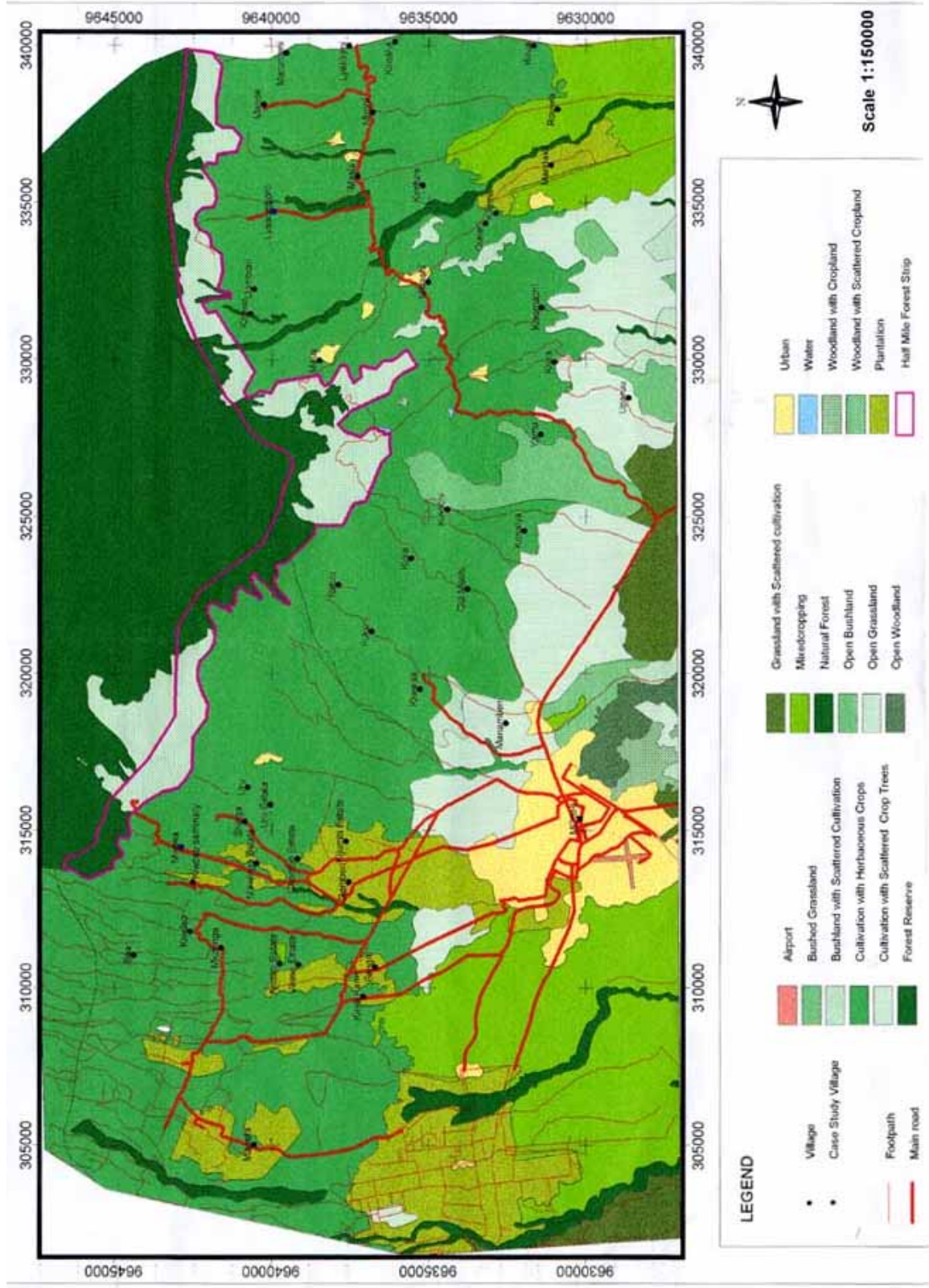
- Ngana, J.O. 2001. Integrated water resources management: The case of the Pangani river basin. In Ngana, J.O. (ed), **Water Resources Management in the Pangani River Basin: Challenges and Opportunities**. Dar es Salaam University Press, Dar es Salaam.
- O'king'ati, A. and Kessy, J.F. 1991. The farming systems of Mount Kilimanjaro. In Newmark, W.D. (ed), **The Conservation of Mount Kilimanjaro**. IUCN, Gland, Switzerland and Cambridge, UK. 71-80 p.
- Peters, H.K.N and Sankhayan, P.L., eds. 1994. Impact of Structural Adjustment Programs on natural resource use pattern at a household level in Tanzania: The case of Ulanga District. **UTAFITI, Journal of the Faculty of Arts and Social Sciences**. University of Dar es Salaam. 59-70pp.
- Rugumamu. 2000. **Globalization and Environmental Management: Prospects for Sustainable Development in Eastern and Southern Africa**. Paper presented on Sixth OSSREA Congress, Dar es Salaam.
- Salih, M., and Tedla, S., eds. 1999. **Environmental Planning, Policies and Politics in Eastern and Southern Africa**. Macmillan Press Ltd., London.
- Sevaldsen, K. 1997. **Competing Interests and Growing Demand for Water: Irrigation in Lowlands of Kilimanjaro: The Case of Makuyuni Ward**. (Thesis), Department of Geography, Noregian University of Science and Technology, Trondheim, Norway.
- Speirs, M and Marcussen, H.S. 1999. Environmental Planning in Africa-action or words? **Geographisk Tidsskrift, Danish Journal of Geography, Special issue, 2**.
- Tevera, D.S. 1994. Population, the environment, and resources in Zimbabwe. In Kalipeni, E (ed.), **Population Growth and Environmental Degradation in Southern Africa**. Lynne Rienner Publishers, Boulder/London. 39-59p.
- Thomas, L.W., ed. 1956. **Man's Role in Changing the Face of the Earth**. University of Chicago Press, Chicago and London.
- Tshibaka, T.B. ed., 1998. **Structural Adjustment and Agriculture in West Africa**. CODESSRIA, Dakar.
- Turner II, B.L., Skole, D., Sanderson, S., Fischer, D., Fresco, L. and Leemans, R., eds. 1995. **Land-Use and Land-Cover Change**. The International Geosphere-Biosphere Program and The Human Dimensions of Global Environmental Change Program, Stockholm and Geneva.
- United Nations, ed. 1993. **Population, Environment and Development**. United Nations. NewYork.
- United Republic of Tanzania. 1997. **Forest Resources Management Project: National Reconnaissance Level Land Use and Natural Resources Mapping Project**. Hunting Technical Services Ltd., UK.
- Whitmore. 1993. **South East Asia Tropical Forests**. Pergamon Press, Oxford.
- Wood, A., Stedman-Edwards P., and Mang, J., eds. 2000. Ten case studies- an overview. In Wood et al., (ed.). **The Root Causes of Biodiversity Loss**. Earthscan Publications Ltd., UK. 36-57pp.
- Wunder, S., ed. 2000. **Big Island, Green Forests and Backpackers Land Use and Development Options on Ilha Grande, Rio de Janeiro State, Brazil**. Center for Development Research, Denmark.
- Yanda, P.Z. and Shishira, E.K. 2001. Forestry conservation and resources utilization on southern slopes of Mount Kilimanjaro: Trends, conflicts and resolutions (ed). In **Water Resources Management in the Pangani River Basin: Challenges and Opportunities**. Dar es Salaam University Press, Dar es Salaam, 104-117pp.
- Zaba, B. and Clarke, J., eds. 1993. **Environment and Population Change**. Derouaux Ordina (eds.), Belgium.

Appendix

Map 3.1. Land Use/ Cover of the Study Area on the Southern Slopes of Mt. Kilimanjaro in 1952. Source: Cadastral maps based on 1952 aerial photographs. Map adopted from Yanda and Shishira (2001)



Map 3.2. Land Use/ Cover of the Study Area on the Southern Slopes of Mt. Kilimanjaro in 1982. Source: Cadastral maps based on 1982 aerial photographs. Map adopted from Yanda and Shishira (2001).



Map 3.4. Land Use/ Cover of the Study Area on the Southern Slopes of Mt. Kilimanjaro in 2000. Source: Interpretation of Landsat ETM+ of Oct. 1999 and Feb. 2000 at a scale of 1:50000.

