EVALUATION OF LAND USE AND LAND COVER CHANGE IN MT KENYA AND NGARE NDARE WILDLIFE CORRIDOR

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DECLARATION

This project report is my original work, and it has not been presented for award of degree in any other university.

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This project report has been submitted for examination with our approval as the University supervisors.

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DEDICATION

This work is dedicated to my son David Abuya for patience during my study and my mum Mercy Nkatha for her commitment in support of my education.

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LIST OF ACRONYMS AND ABBREVIATIONS

AWF	-	African Wildlife Foundation
DRSRS		Department of Resource Surveys and Remote Sensing.
ENVI		Environment for Visualizing Images
FCC	-	False colour composite
FEGN	-	Florida Ecological Greenways Network
GLCF	-	Global Land Cover Facility
GOK	-	Government of Kenya
GPS	-	Global position systems
HH	-	Household
KNBS		Kenya National Bureau of Statistics
KWS	-	Kenya Wildlife Service
MSS		Multi-Spectral Scanner
OLI	-	Operational Land Imager
RS & GIS		Remote Sensing and Geographic Information System
TIR	-	Thermal Infrared Sensor
TM	-	Thematic Mapper

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ABSTRACT

Wildlife corridors are features connecting two or more otherwise isolated patches of habitat, wildlife corridors are among the areas of land affected by human activities. Securing wildlife dispersal areas and migratory corridors is one of Kenya's blueprint agenda under Vision 2030, which is essential in the economic and social pillar. This research sought to evaluate land use and cover changes between Mt Kenya and Ngare Ndare Wildlife Corridor that will contribute to the Vision 2030 development Agenda. The aim and focus of the study was to investigate the status and recent trends in the wildlife corridor by considering land use and land cover changes, drivers of land use changes, conservation, and management measures. The study used primary data collected using a questionnaire, key informant interviews, field observation and geospatial techniques. Land cover and land use change analysis was undertaken through the use of satellite images of 1973, 1986, 1995, 2010 and 2017 in order to analyze the land use and cover change. This was done using supervised image classification using ENVI software. In addition, 135 respondents were interviewed from Ntirimiti and Subuiga locations to determine the drivers of land cover and land use change in the corridor. 135 respondents interviewed were selected as follows; the first respondent was selected randomly and every ninth respondent was interviewed. In addition, three key respondents were interviewed. Key informant interview was done to gather information about the past and present land use and cover within the study area. Chi square and correlation were used for data analysis. Based on the data analyzed using correlation, the study found out that, the forest, grassland and bush land vegetation cover had reduced at an alarming rate from 1973 through to 2017. However, the statistical test indicated that the decline is at (-0.94,-0.95 & -0.96 Pearson statistic) for the forest, grassland and bush land vegetation cover respectively. While an increase in the crop cover, building and bare soil were observed over time statistically at 0.98, 0.97 and 0.89 Pearson statistic respectively. In addition, the chi-square significant findings at 0.05 alpha showed that the underlying cause for land use and land cover change in the corridor was attributed to high immigration of people from Katheri, Meru town, Githongo, Egoji and Abuthuguji in response to increasing quest for land. These drivers were influenced mainly by government policy and the ready market for the horticultural crops that are grown hence influencing farmers' demand for quick and high returns. The findings of stakeholder consultation showed that land use and cover changes have been taking place along the wildlife corridor. Similarly, land use and cover classification done using the satellite image confirmed the land use and land cover has changed. The study concludes that there has been land use and land cover changes along the wildlife corridor and recommends formulation of land use policies that will aid sustainable land use and land cover. Efforts towards the conservation of the wildlife corridor should be taken into account in spatial land use planning.

CHAPTER ONE - INTRODUCTION

1.0 Background

This chapters covers introduction into the research problem, reseach questions, research objectives, hypothesis, research scope and limitations.In addition it entails the definitions of terms used in the study and the chaper outline of the project report.

Land use affects land cover; land use means the utilization of land resources by human beings. Land use is dynamic in nature and shows the interaction and relationship of human activities with the environment (Prakasam, 2010) In addition, land use involves modification either direct or indirect of natural habitats and their impact on the ecology of an area. Moreover, land use change is becoming a key component currently in natural resources management and environmental changes monitoring (Tiwari & Saxena, 2011). Land use information about a region portrays natural and socio-economic factors as well as human livelihood and development of the area. Like other natural resources, the land resource is becoming limited due to a high demand for agricultural products and increasing population pressure. Therefore, information on land use and possibilities of their optimal use are essential for the allocation, planning, and implementation of the land use schemes to meet the increasing human needs and wellbeing. This also provides information for management of dynamic land use and the demand for increasing human population. Evaluation of land use and land cover is performed on a temporal scale to assess landscape changes caused by human activities on the land (Gibson & Power, 2000). Human activities are because of rapid human population growth and increased demand for food resources. Land use change has been recognized as an important driver of global environmental change (Turner *et al*., 1994). Land use change information of the earth's surface is becoming important in monitoring the local, regional and global environment.

Wildlife corridor is essential for biodiversity conservation. Wildlife corridor is a device that maintains or restores coherence in fragmented ecosystems, made up of vegetation cover that connects two large forest areas. Wildlife corridors help in dispersal and movement of wildlife between different habitats in search of food, fodder, shelter, breeding and other activities. Corridors connect habitat patches for the exchange of materials and energy in the form of the food web and dispersal for land genetic exchange (Vogt *et al*., 2007). Degradation of vegetation connectivity in between landscape occurs due to fragmentation and anthropogenic activity, which causes biodiversity decline. Conservation of wildlife corridors requires knowledge of species habitat requirements. In addition, it also requires past and current land use practices such as agriculture, forestry and human habitations that alter vegetation cover, land surface, biochemistry, hydrology and biodiversity (Lambin *et al*., 2001). Vegetation is a key component of the terrestrial ecosystem and wildlife habitat (Pickett *et al*., 2001). Information on land use change supports the assessment of wildlife habitat and identification of corridor status.

Securing the dispersal routes and migratory routes is one of the Vision 2030 flagship projects in Kenya. The Mt. Kenya to Ngare Ndare wildlife corridor is among the mapped corridors in Kenya that needs to be conserved and managed. Moreover, Mt Kenya – Ngare Ndare wildlife corridor connects the Mt Kenya ecosystem with other ecosystems in the Northern part of Kenya. However, this wildlife corridor is under threat of blockage due to different land use and land cover activities that are practiced along the corridor (Ojwang'*et al*, 2017).

Incorporation of Remote Sensing and Geographic Information System (R.S & G.I.S) in land use and land cover evaluation provides an effective method for management of ecosystem. This method has been used extensively in the tropics for generation of valuable information on the vegetation cover type and land use changes (Forman, 1995). Geospatial technology has improved the efficiency of mapping of land use changes. Therefore, the study used geospatial techniques to evaluate the land use and land cover changes along the wildlife corridor.

1.1 Problem Statement

Many protected areas are becoming isolated at an alarming rate due to land fragmentation, yet the long-term viability of the protected areas depends on various factors such as watersheds, the animal movement to and from the protected areas. The reasons for the increasing isolation of protected areas in Kenya are complex. Some of the reasons include increasing human population and new settlement in previously uninhabited areas, land use change towards agriculture and expansion of infrastructure. Wildlife corridors are important for ensuring the long-term health of the protected ecosystems. Unfortunately, the opportunities for establishing, maintaining or managing corridors between protected areas are rapidly diminishing, endangering the future of the ecosystem services and biodiversity supported by protected areas. Land use and land cover change leads to a reduction in the total area available for wildlife hence disrupts the movement of wildlife between the mountain and the grassland habitats of the surrounding plains.

Mt Kenya and Ngare Ndare wildlife corridor is facing the threat of diminishing due to increased demand for land for settlement, farming and infrastructure expansion. Most of the community living adjacent to the corridor are poor rural dwellers who really on natural vegetation for their livelihood. Direct use of natural resources leads to encroachment hence land use and land cover change. Therefore, land use and land cover change lead to a reduction in the total area available for wildlife thus disrupts the movement of wildlife between Mt Kenya National Park, Mt Kenya Forest Reserve, the grassland habitats and open woodlands on the Laikipia areas. In addition, the connection is extended into Samburu National Reserve, Lewa Wildlife Conservancy and buffalo springs National Reserve.

This study will aid the stakeholders involved in wildlife management sector to develop strategies and action plans to reclaim wildlife corridors and migratory routes that have been lost because of land use and cover changes. Moreover, the study will provide knowledge of compatible land use approaches with wildlife conservation by all the relevant stakeholders and interested parties in wildlife conservation. This includes land

and environmental managers, Kenya Wildlife Services, Ministry of Agriculture and Irrigation, local and international non-governmental organizations, policy experts and advisory at the Ministry of Environment and Forestry and Ministry of Tourism and Wildlife.

1.2 Research Questions

a) What is the nature and magnitude of land use and land cover changes along the wildlife corridor?

b) What are the drivers of land use changes and land cover?

c) What are the possible viable options that can be used to conserve the wildlife corridor?

1.3 Objectives

The main objective of this study is to evaluate the land use changes in the wildlife corridor between Mt Kenya and Ngare Ndare national reserves.

Specifically, the study seeks to;

1) Analyze the land use and cover changes along the wildlife corridor from 1973-2017.
2) To identify drivers of land use and land cover changes along Mt Kenya and Ngare Ndare wildlife corridor.
3) Assess the possible viable options that can be used for conservation and management of the wildlife corridor

1.4 Hypotheses

1. Ho -There are no significant land use and land cover changes in the wildlife corridor between 1973 and 2017.
2. Ho -There are no significant drivers of land use and land cover changes along wildlife corridor.

1.5 Justification of Study

The study was motivated by the spirit of Kenya Vision 2030 especially the flagship project aimed at reclaiming wildlife corridors and migratory routes in Kenya. This is due to diminishing and loss of wildlife corridor (Government of Kenya, 2007). The national atlas of wildlife corridors and migratory routes in Kenya reveals the emerging issues related to the extent and trends of the land use and land cover changes that have taken place along the wildlife corridor and give a projection of the future if no efforts are done.

Moreover, this establishes relationships between the land uses and cover changes in line with the socioeconomic factors along the wildlife corridor. This information is aimed to help in planning land use activities that are compatible with wildlife conservation, along the wildlife corridor hence better conservation measures will be formulated in line with provisions of the Convention on Biological Diversity. This will have a wider application in Kenya given the current extensive land use changes, population growth trends and the fact that more than 60 percent of Kenya's wildlife lives outside national parks (Ojwang' *et al*., 2017).

1.6 Scope and Limitations

1.6.1 Scope

The study covered wildlife corridor and surrounding areas that included Ntirimiti and Subuiga locations. The satellite images covered duration of forty-five years with five-time series 1973, 1986, 1995, 2010 and 2017. The study determined land cover and use change using satellite images and field verification. Land use and land cover changes were generated and determined. In addition, the socioeconomic survey was done to determine drivers of land use and land cover changes. The study generated information that will be used by policy makers and planners on land use and cover and wildlife conservation in policymaking. Moreover, recommendations were made on sustainable wildlife corridor conservation and management strategies.

1.6.2 Research Limitations

The challenges encountered during the study include; lack of satellite images from 1970 with 10 years intervals which were proposed to be used due to unavailability of cloud-free images of the same season. Thus, change of season's image chosen for the study to be between January and February. It is due to this, that the study used 1973, 1986, 1995, 2010 and 2017 satellite images. Field verification for 1973, 1986, 1995 and 2010 was not done because the fieldwork was done in 2017. Hence, data collected was used to verify all the years because it was not possible to go back in time. In other instances, the respondents were unavailable because the fieldwork was conducted during the day and at this time, most of the respondent had gone out for work.

1.7 Definition of Terms

Land cover refers to the physical characteristics of earth's surface that includes the distribution of vegetation, water, soil and other physical features of the land.

Land use refers to the way the land is being used by humans and their habitat for economic activities.

Wildlife corridor devices that maintains or restores coherence in fragmented ecosystems, made up of vegetation cover that connects two or more large forest areas.

Remote sensing is the science or art of acquiring data of a phenomenon using a device that is not in contact with phenomenon under investigation

Kappa Statistics is a measure of how well a classified map and its reference data agree.

Underpass a tunnel passing under a road or a railroad.

Geofencing the use of GPS to create a virtual geographic boundary, that enables the software to trigger a response when wildlife enters or leaves a particular area.

1.8 Chapters Outline

Therefore this research will be used to strengthen wildlife conservation and management. This project report is organized as follows; chapter two- Literature review that indicate the views of other scholars on land use and land cover changes, Impacts of land use and land cover on wildlife corridor, wildlife corridor conservation and management strategy that are being used in other areas. Similarly the report contains chapter three- Research Methodology that indicates the sampling frame, types and sources of data used and data collection techniques employed in the study. Moreover, the study entails chapter four- Results and discussions that shows the finding from the survey and the comparison of the research observation with other scholars. Chapter five- Summary, conclusions and recommendations, shows the summary of researchers observations and endorsement towards wildlife corridor conservation and management.

CHAPTER TWO - LITERATURE REVIEW

2.0 Introduction

This chapter indicates introduction to the land use and cover concept, the network development of wildlife corridor in various parts of the world and narrows down to Kenya. In addition, it reviews the literature of previous research findings and case reports about impacts of land use changes on wildlife, human population growth on the wildlife corridor conservation and the measures that are being used for the restoration of the already diminishing wildlife corridors.

2.1 Background

Land use and land cover change in sub-Saharan Africa and its impact on nature and society is an important issue that requires scientific and societal attention (Lambin & Meyfroidt, 2011). Land cover can be defined as physical and socioeconomic characteristics that affect a spatial unit of the earth surface (Jansen & Gregorio, 2002). While land use describes the intended, purposes by humans to exploit the land cover. However, land cover change is defined as changes in spatial characteristics that either occurs in land cover modification and or land cover conservation. Land cover conservation means replacement of a spatial unit to another type, whereas lands cover modification refers to a change of the earth surface component without altering the land cover type (Lambin *et al*., 2001). Land use changes is a widespread and accelerating process that is caused by natural phenomena and anthropogenic activities that affect the natural ecosystem (Ruiz-Luna & Berlanga-Robles, 2003).Information on landscape patterns, changes, and interactions between human activities and natural phenomenon are essential for proper land management and decision-making. However, earth satellite image data is very useful for land use and cover change analysis (Yuan *et al*, 2005).

2.2 Land use and cover changes and wildlife corridors

Land use changes within the migratory corridor have several consequences, for instance, they modify the natural environment that supports the migratory wildlife and block their seasonal migration into and out of the park. This result in the parks carrying capacity being exceeded or blocking immigration thus, deaths from conflicts and changed environment significantly reducing wildlife population. The increased human population and land use changes translate into increased human-wildlife Conflicts. This result into more wildlife deaths and injuries, human beings injury or loss of life, more economic losses being incurred by land developers within the corridor, and the park's biodiversity decline hence unsustainable conservation. For example in Laikipia West, a study by (Waithaka, 2010) indicated enormous losses incurred by farmers who have encroached into wildlife dispersal areas. Moreover, twenty years ago, the area between Nairobi Park and Amboseli National Park was not heavily under human utilization. However, this has changed now, and a high proportion of the land is now farmed (Campbell *et al*., 2002). This has affected the movement of wildlife from Nairobi national park to Amboseli during dry seasons.

Despite the prevailing realization of land use changes and population increase together with associated activities within the corridor, no empirical examination has been carried out to determine the extent and trends of these challenging factors. Similarly, there has been no documented attempt to study any relationships between these challenges and the impacts on the wildlife corridors into wildlife dispersal areas. Moreover, twenty years ago, the area between Nairobi Park and Amboseli National Park was not heavily under human utilization. However, this has changed now, and high proportion of the land is now farmed (Campbell *et al*., 2002). This has affected movement of wildlife from Nairobi national park to Amboseli during dry seasons.

According to Vision 2030, the Government of Kenya seeks to reclaim wildlife dispersal areas and the corridors especially those impacted by human activities. In Kenya, most of the wildlife dispersal areas and corridors are diminishing due to land use change. For instance, the Aberdare - Mt. Kenya corridor has been completely blocked. Land subdivision on both sides of the Nanyuki-Meru road that results in different land use types (Ojwang' *et al*, 2017) is also blocking Mt Kenya –Ngare Ndare wildlife corridor.

Thus, the need for evaluation of land use and land cover changes that facilitate the diminishing of the wildlife corridors.

2.2.1 Land use and cover changes and demographic change

In efforts to meet resources demand for the growing population, land use changes occur to provide food for the population. In return, the production increase is achieved through forest clearing in order to intensify production on already cultivated land. Moreover, infrastructure expansion is done to support the growing human population. The 2009 census showed an increase in population from 4.6 million people in 1999 to about 5.6 million in 2009 in Eastern Province (Willkomm *et al*, 2016). Anthropogenic causes of changes in land use lead to habitat fragmentation and loss as well of important species hence biodiversity loss.

During archaeological periods, increases in population prompted changes in land use patterns through changes in methods of agricultural production. Thus, an increase in population results in a shift of traditional societies that previously depended on hunting and wild plant gathering to agriculture of permanent cultivation and introduction of permanent livestock. Generally, population growth is associated with the the growth of resource consumption and degradation, expansion, and intensification of land use, increasing poverty, exploitation of marginal lands and the breakdown of traditional resource management systems. At the local Level, population growth is attributed to urbanization, displacement, and migration. Local population growth directly affects the use of resources and their degradation and often drives habitat conversion in areas important for biodiversity conservation. Moreover, at the global level, population growth is continually raising the consumption of resources (Kates, 2000).

Kenya’s population grew from about 5.4 million in 1948 to about 41 million in 2012. However, it is projected to reach 94 million by 2050 (Bongaarts & Sinding, 2011). This rapid population growth inserts high pressure on natural resources such as forests, water, and land. Moreover, the scarce farmland is sub-divided among more people resulting in smaller and overused plots and poorer land quality. In order to produce food for consumption, natural vegetation is cleared to create land for agriculture and settlement.

2.2.2 Socio economic dynamics and wildlife corridors

Vegetation along the corridor is a source of livelihoods for the local people in most developing countries. Local people depend on vegetation for various consumptive use benefits such as fuel wood, construction materials, medicine, and food. Globally, it is estimated that between 1.095 billion and 1.745 billion people depend to varying degrees on natural vegetation for their livelihoods sources and about 200 million indigenous communities are almost fully dependent on vegetation (Chao, 2012) Moreover, 350 million persons that live adjacent to the wildlife corridor depend on its vegetation for subsistence and income (Chao, 2012). It is estimated that 20–25% of rural peoples' income is obtained from environmental resources in developing countries (Vedeld, *et al*, 2007) and cushion in periods of crisis or during food shortages seasons (Shackleton & Shackleton, 2006).

Moreover, the Mt. Eburu in Kenya has become an island in relation to the surrounding landscapes due to human activities. This is influenced by poor land-use practices that have led to the enclosure of wildlife in fenced farms and inhibiting their movement to open and forested lands. In addition to overdependence on natural resources for direct consumptive values such as grazing, fuel-wood, illegal extraction of forest produces, wildlife poaching and encroachment for settlement and agriculture is too fuelling the menace of inhibiting wildlife movement (DRSRS, 2014).

Kibale Forest Game Corridor in the southwest of Uganda established in 1926 to allow large mammal movement between the Kibale Forest and the Queen Elizabeth National Park almost lost all its special biodiversity due to encroachment by 40,000 settlers and the clearing of most of the natural forest and grass for cultivation (Pretty & Ward, 2001). The Kitendeni corridor between Amboseli and Mt Kenya too diminished due to human encroachment (Okello, 2005). In addition, extensive expansion of croplands that is fuelled by economic factors such as profitable inclusion into global value chains.

Integration of agricultural production in global value Chains has played an important role for economic revenues generation in the Mt. Kenya region (Mithöfer *et al*., 2008; Krone *et al*., 2016; Ouma, 2010). This has been facilitating land use and land cover changes.

2.2.3 Ecological Networks

The concept of ecological networks was initially designed mainly for terrestrial ecosystem based on the patch-matrix-corridor model developed in Europe (Haslett *et al*., 2010) In addition, the ecological network is supported by the theory of island biogeography by (Mac Arthur & Wilson, 1967). In the adoption of the concept, Estonia was the first country, the Estonian ecological network was created in the 1970's and now known as the Estonian Green Network (Bennett & Wit, 2001). Since then the networks have been adopted at the national level. From the 1990's, onwards implementation of the ecological network, the idea has grown significantly in Europe (Opermanis *et al*. 2012). European Union Legislation that established the natural 2000 network (Bonnin, 2007) has facilitated this. Moreover, the political emphasis was facilitated by the launch of the Pan European Ecological Network (PEEN) by 2001 around one hundred and fifty ecological network programs had been established (Bennet & Wit, 2001). This number has since grown to over 250 programs, many of which combine conservation with sustainable development goals (Bennet & Wit, 2001). The programs vary in extent from local to continental scale.

The Florida Ecological Greenways Network (FEGN) is used to provide a scientific foundation for the Florida Wildlife Corridor. FEGN was developed to elucidate the importance of protecting wildlife corridors and a network of conservation lands spearheaded by Larry Harris and Reed Noss at the University of Florida in the 1980s. Currently, the Florida Wildlife Corridor benefits from the partnership Conservation Trust for Florida a statewide land trust. Land trust works with the Department Office of Greenways and Trails and other partners to educate and implement protection of the FEGN. The Florida Wildlife Corridor combines all the FEGN critical Linkages from the Everglades to Okefenokee to highlight the importance of protecting a functional network of public and private conservation lands throughout the Florida peninsula to protect native biodiversity, essential ecosystem services, and the rural natural heritage that is so unique to Florida (Bonnin, 2007).

In Africa, African Wildlife Foundation (AWF) began a landscape conservation approach by supporting national parks. However, wildlife is not confined to park hence AWF started working with local communities near parks and other wildlife areas to help manage lands for conservation across broad landscapes. AWF works to unite villages, parks, and reserves in a vast cohesive landscape. Moreover, the AWF offer training and compensating to local communities in order to encourage them to conserve wildlife and migration routes while protecting and advancing their own economic interests. For instance, in Tanzania wildlife travel 40 km between Lake Manyara National Park and Tarangire National Park, however, migratory routes began to disappear as agriculture and settlements cropped up. AWF helped establish Manyara Ranch Conservancy owned by the government where wildlife can roam between the two parks (Goldman, 2011).

Historic wildlife dispersal route and corridor that extends from Amboseli National Park to Chyulu Hills and Tsavo West National Park provides wildlife migratory path in these protected areas, facilitated wildlife movements such as lion, zebra, elephant, giraffe, and other species. However, this corridor is under threat due to increased population growth, agricultural expansion, and a tourism boom that has led to land subdivision by developers' encroach into the ecosystems hence threatening wildlife survival (Okello & Kiringe, 2004).

2.3 Drivers of Land Use Changes

Several explanations have been put across about land use variations (Boserup, 1965) argued that population increase contributes to land use changes. This theory overlooked other driving factors like demand for goods, government policy, accessibility and soil fertility. Moreover, Von Thunen (1966) in his theory argued that agricultural land use is depicted by the distance to market centers and transport cost. This forms the basis upon which land use explanations are built on. However, this explanation overlooks the biophysical and socio-economic factors contributing to land use. Change in agricultural systems is the primary causes of land use and cover change in Africa (Veldkamp & Lambin, 2001). Agricultural expansion is influenced by population needs for food, settlement and infrastructure development. Other drivers of land use change include socioeconomic factors such as increased local and international demand for commodities, improved technology such as agro technological changes and urbanization (Mertens *et al*, 2000). Recently climate change has been recognized as a driver of land use and land cover change. The climatic change includes a shift in average values and extreme events, and land use changes.

2.4 Remote sensing and Land Use

Remote sensing and Geographical Information System (GIS) techniques is a useful tool that makes it possible to select areas that are for agricultural, urban and industrial land use (Selçuk *et al*., 2003). The use of remotely sensed data has made it possible to study the land cover changes in less time, at low cost and with better accuracy (Yuan *et al*., 2005). GIS as a tool is a suitable platform for data analysis, update, and retrieval (Cihlar, 2000). The use of high spatial resolution satellite images, advanced image processing, and GIS technologies has led to consistent monitoring and modeling of land use and land cover patterns. In addition, remote sensing is being used to update land use and coverage maps and most important land use and cover mapping is becoming one of the applications of remote sensing (Lo & Choi, 2004). Satellite images for example Landsat contain valuable and continuous records of the earth's surface (Cihlar, 2000). Moreover, the Landsat archive is now available free of charge to the public. In addition, it contains a lot of information for identification and monitoring of changes in human-created and physical environments (Chander *et al*., 2009).

2.5 Interventions for Maintaining Ecological Connectivity

Several plans have been formulated to increase patch connectivity across anthropogenically altered landscapes, for instance, the Lincolnshire Biodiversity Action Plan in England has been working to improve the condition of agricultural hedgerows so that they might harbor a higher diversity of animals within farming regions. This focuses on the importance of general hedgerow upkeep such as appropriately timed cutting of hedgerow vegetation, non - use of pesticides and fertilizers close to hedgerows and replacing dead vegetation with seedlings (Corbit *et al*, 1999). In the U.S, the National Cooperative Highway Research Program has carried out research to examine the negative impacts urbanization imposes on wildlife. However, they recognized the importance of habitat connectivity, advocating continued research by individual states to determine how to address conservation issues better.

In the Kenyan case, the landscapes of the protected area that are wildlife habitat are becoming isolated hence need for connectivity. This has become an area of concern through a recent initiative by the Government of Kenya. The process seeks to map all wildlife migratory pathways, linkages, and corridors in the country. This initiative comes against the backdrop of continuing efforts of protecting the few remaining wildlife habitat linkages between the Mount Kenya forest ecosystem and lowland grassland and savannah habitats by the Kenya Wildlife Service (KWS), private wildlife conservancies, and large-scale farms and non-governmental conservation bodies. However, the role of corridors and connectivity in wildlife conservation is seen as a high priority area for the conservation of large mammal particularly charismatic herbivores such as the African Elephant-Loxodonta African (Nyaligu & Weeks, 2013). Moreover, fencing is being used as an alternative conservation strategy in a majority of wildlife habitats in Kenya including National Parks, Private Conservancies, and Community lands. However, fencing is not the solution to the wildlife corridor conservation instead; the land use changes are the critical issues that need to be addressed to have a well-informed decision on migratory route conservation. One of the government's vision 2030 flagship projects is to secure wildlife corridors and migratory routes (KWS, 2008). The main challenge the government is facing in conservation is the inadequacy of data to aid decision-making (KWS, 2011). This study provides information on land use changes that will aid in the planning sector.

2.6 Theoretical Framework

In this section, three theories that inform wildlife corridor management are discussed and the theory that was best suited for the study selected.

2.6.1 Island Biogeography Theory

The theory of island biogeography (MacArthur & Wilson, 1967) is referred to as the First Law of Conservation Biology. Because of human activity, natural habitats are being isolated in a human-dominated matrix hence protected areas become islands. The number of species on the remaining areas varies by the rate of immigration and extinction. Through identification of potential mechanisms underlying the loss of species diversity, Island Biogeography Theory helps suggest ways in which we can design nature reserves to maximize their ability to maintain high species diversity. However, this theory suggests that linear reserves should be connected with corridors. Moreover, it is argued that unless reserves are connected many species with large home ranges will face increased extinction rates because the current reserves may not be large enough to support them. In addition, migration between reserves is important to maintain the genetic health of populations. Large islands typically have more species than comparable smaller islands. The equilibrium theory of island biogeography, explain the species-area relationship as the outcome of the effect of area on immigration and extinction rates.

However, these theories do not apply to taxa on landmasses, including continents and large islands that generate most of their species in situ. Extinction and recolonization on an island are predicted to produce species equilibrium on a given island however, this is influenced by island size and isolation. Large and less isolation island is predicted to support more species. Oceanic islands are likened to reserves and this forms the basis for protected areas design. This theory is based on the following principles; large reserves are better than small reserves. Similarly, a single large reserve is better than several small reserves. In addition, there is a need for the reserve to be close together than far apart. Compact clusters of reserves are better than a line of the reserve. This also argues that a circular reserve is better than a long narrow reserve due to the edge effect. Lastly, the reserves connected by a corridor are better than those not connected.

The island biogeography theory is usually associated with a number of limitations. The theory examines the species richness but does not make any assumption about species composition. Similarly, the theory assumes that extinction and immigration rate are equal for all species, which is not true for example; some species have lower mobility than others like amphibians cannot be equal to avian in terms of mobility. The degree of isolation is dependent on taxon involved for instance mammals, reptiles or avian. The theory assumes that the extinction rate relates to island size and distance of the island from the source of species. Extinction and immigration rates could be independent. However, extinction of a species could be halted by the influx of immigrants also referred to as rescue effect.

2.6.2 Patch-Corridor-Matrix Model

Landscapes are composed of spatial elements that make up the landscape. A convenient and popular model for conceptualizing and representing the elements in a categorical pattern called patch-corridor-matrix model (Forman, 1995). In this model, three major landscape elements are recognized namely; patch corridor and matrix. The extent and configuration of these elements define the pattern of the landscape. The patch represents relatively discrete areas of a spatial-temporal domain of relatively homogeneous environmental conditions where the patch boundaries are distinguished by discontinuities in environmental character states from their surroundings of magnitudes that are perceived by or relevant to the organism or ecological phenomenon under consideration (Meurant, 2012). While the corridor is, a linear landscape element that is defined based on structure and function. The corridor is a narrow strip of land that differs from the matrix on either side (Hess & Fischer 2001). Corridors may be isolated strips that are attached to a patch of similar vegetation, the functionality of corridor is demonstrated when the immigration rate to the target patch is increased over what would be if the linear element was not present (Vos *et al*., 2002). Matrix is the most extensive and most connected landscape element type, and therefore play the dominant role in the functioning of the landscape (Hess & Fischer, 2001).This clearly indicates the importance of corridor in landscape therefore in conservation a wildlife corridor is required to facilitate the movement as well as the exchange of materials.

Wildlife reserves are patches in a matrix of human disturbance regimes that include farming, timber logging, the introduction of alien species, infrastructure expansion. Due to continuous fragmentation, the patches reduce in size and they are left unconnected. Small patches are an edge, increase in edge leads to loss of interior species and area-sensitive species hence loss of biodiversity. The Patch-Corridor-Matrix model seeks to evaluate landscape functionality and ignores forces that would hinder the functionality of its elements.

2.6.3 The Root Causes of Biodiversity Loss

The Root Causes of Biodiversity Loss (Wood *et al*., 2013) was used in an analysis of 10 case studies of biodiversity loss from Brazil, Cameroon, China, the Danube floodplain, India, Mexico, Pakistan, the Philippines, Tanzania, and Vietnam. The cases represented specific ecosystem types, socio-political context, or biodiversity hotspots. Unavailability of ecological data and accurate government records lead to the developing of descriptive, model of biodiversity loss. The model lays emphasis on anthropogenic processes, biophysical processes such as climate change. Moreover, causes of biodiversity loss addressed proximate causes, such as agricultural expansion, logging, and hunting. This biodiversity loss concept needs policymakers to understand and address the drivers of biodiversity loss. Moreover, the theory sought to consider the following issues that are drivers of biodiversity loss.; demographic change, consumption and production patterns, public policies, social change and development bias.

In addition, rapid loss of biodiversity and habitats around the world is due to farmers clearing new fields, settlements and timber companies opening new forests for logging (Black, 2016). However, socio-economic forces, for example, macroeconomic policies, demographic changes, development biases, public policies, poverty, and inequality contribute to these activities. These forces originate from national and international levels from policies in shaping the decisions made at the local level on resource use patterns (Cash & Moser 2000).The socio-economic factors lead to change in resource use patterns that are associated with infrastructure construction, forest overexploitation, immigration, pollution and land use changes. These activities cause habitat destruction and ultimately biodiversity loss. This study seeks to evaluate land use changes along the wildlife corridor and drivers of the land use change hence this theory was modified to suit this study.

2.7 Conceptual Framework

The study sought to evaluate land use and cover changes along the wildlife corridor between Mt Kenya and Ngare Ndare. Moreover, the study assesses the drivers of land use and cover changes. Thus, the root cause of biodiversity loss theory was adopted for the study. The theory argued that the following factors influence biodiversity loss, demographic change, consumption and production patterns, Public policies, Social change, and development bias. These factors are interlinked and have inter-relationships hence reinforce each other. Moreover, these factors lead to change in resource use patterns that result in land use and cover changes in the wildlife corridor. The land use and land cover changes along the wildlife corridor leads to the blockage of the wildlife corridor and habitat destruction thus causing wildlife blockage and loss of biodiversity.

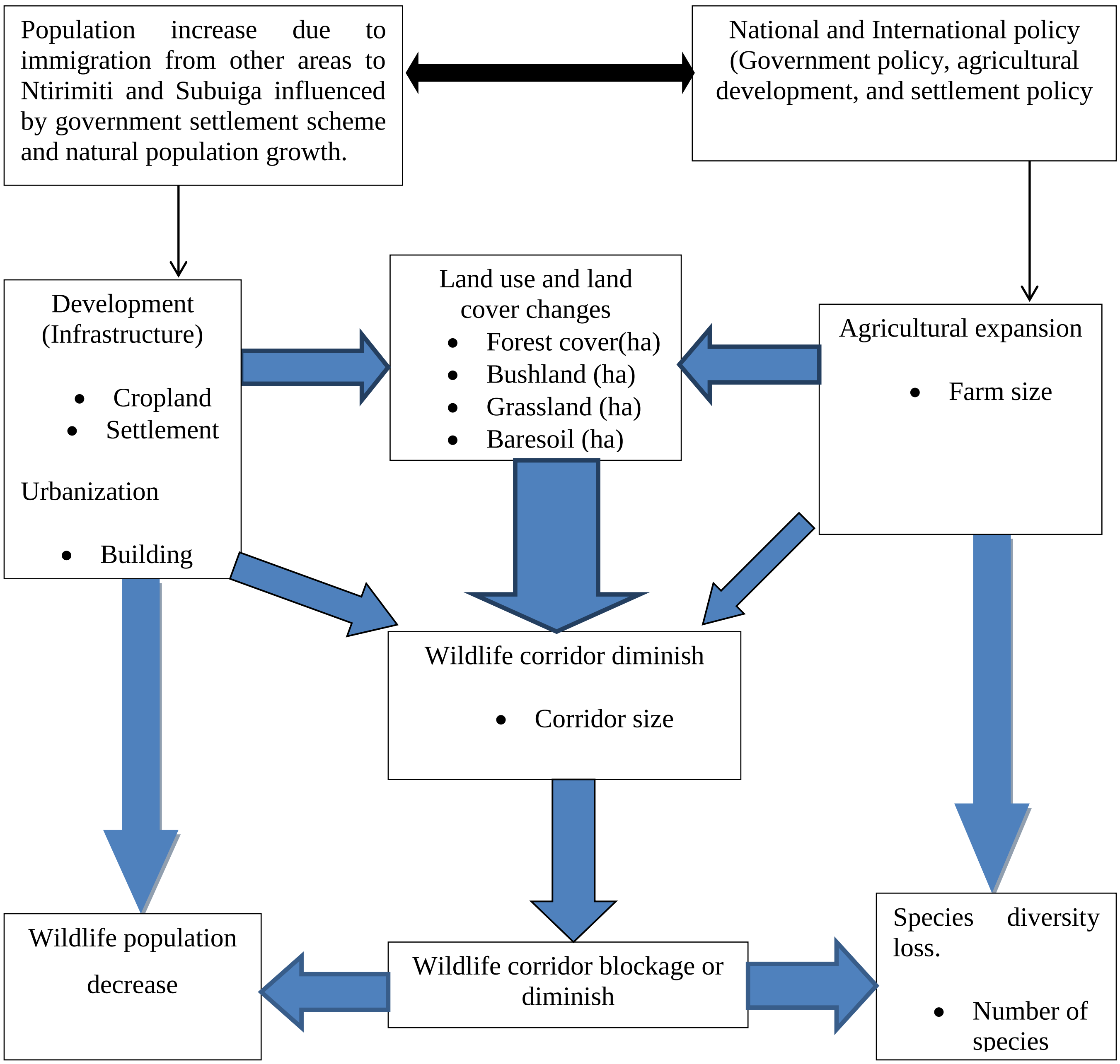

Figure 1: Conceptual framework adopted from (Wood, *et al*, 2013)

The above conceptual framework in Figure 1 indicates that national and international policy influences the population increase due to immigration. For example in Ntirimiti and Subuiga, there was population influx that was influenced by government settlement programs. High population results in the clearing of natural vegetation to create land for settlement and farming. Infrastructure development occurs to meet transportation needs and provide access to the market for agricultural produce. Social change through neighborhood influence leads to demand for more settlement, agriculture an opportunity to venture into alternative land use activities that have more economic returns, for example, horticulture farming compared to rain-fed agriculture and livestock keeping.

At the global level, there are favorable national and international policies, for example, agricultural production mechanization, the ready market for products that are supported by high global demand. Because of a high population in the study area and high demand for agricultural produce, there was increased landscape fragmentation hence encroachment into wildlife corridor that is a crucial requirement for movement and survival of wildlife. Highly fragmented landscape lead to biodiversity loss and to some extent the impact may be catastrophic leading to the local extinction of interior species.

CHAPTER THREE – RESEARCH METHODOLOGY

3.0 Introduction

This chapter entails the study area; methods used for data collection and summarizes the statistical techniques used in this research.

3.1 Study Area

This study was carried out along the wildlife corridor found within Mount Kenya ecosystem that is located along Latitude -0.1667S and longitude 37.1333E. The Mt. Kenya ecosystem covers five counties of Kenya that includes Laikipia, Meru, Embu, Nyeri, and Kirinyaga. Mt. Kenya National Park and Mt.Kenya Forest Reserve are designated as Natural World Heritage site and as Man and Biosphere Reserve (Nyaligu & Weeks, 2013). Ngare Ndare, on the other hand, is an indigenous forest in Kenya with intensive canopy cover. Ngare Ndare has old African Olive and Red Cedar trees species that are nearly 200 years of age (Bussmann, 2006). Wildlife such as elephants and buffalos often use the 14 kilometers wildlife corridor and move from Lewa Wildlife Conservancy to the rich foraging areas on the hills of Mt. Kenya. Mount Kenya - Ngare Ndare wildlife Corridor is located north of Mount Kenya; pass through the main Nanyuki - Meru /Isiolo highway into the Ngare Ndare Forest Reserve and Lewa Wildlife Conservancy to the north as illustrated in Plate 1.

The Mount Kenya Elephant Corridor offers the migratory route for wildlife to move from the forests on the north of the Mt. Kenya to northern part and western part into the Ngare Ndare forest, Lewa Wildlife Conservancy, Borana and other protected areas and vice versa. Elephant populations in the low-lying savannah areas and the Mount Kenya National Forest Reserve are now interlinked. The Corridor has 14km in length and an average width of 100m plus links the Mount Kenya National Reserve to the northern historical dispersal areas of Laikipia and Samburu (IUCN, 2014). Mt Kenya Lewa-Ngare Ndare wildlife corridor is clustered among the Northern Rangeland migratory routes and corridors (Ojwang'*et al*., 2017). The corridor connects to other conservancies as shown in

Figure 2.In addition, the corridor cuts across the infrastructure where the artificial underpass is constructed as illustrated in Plate 1.

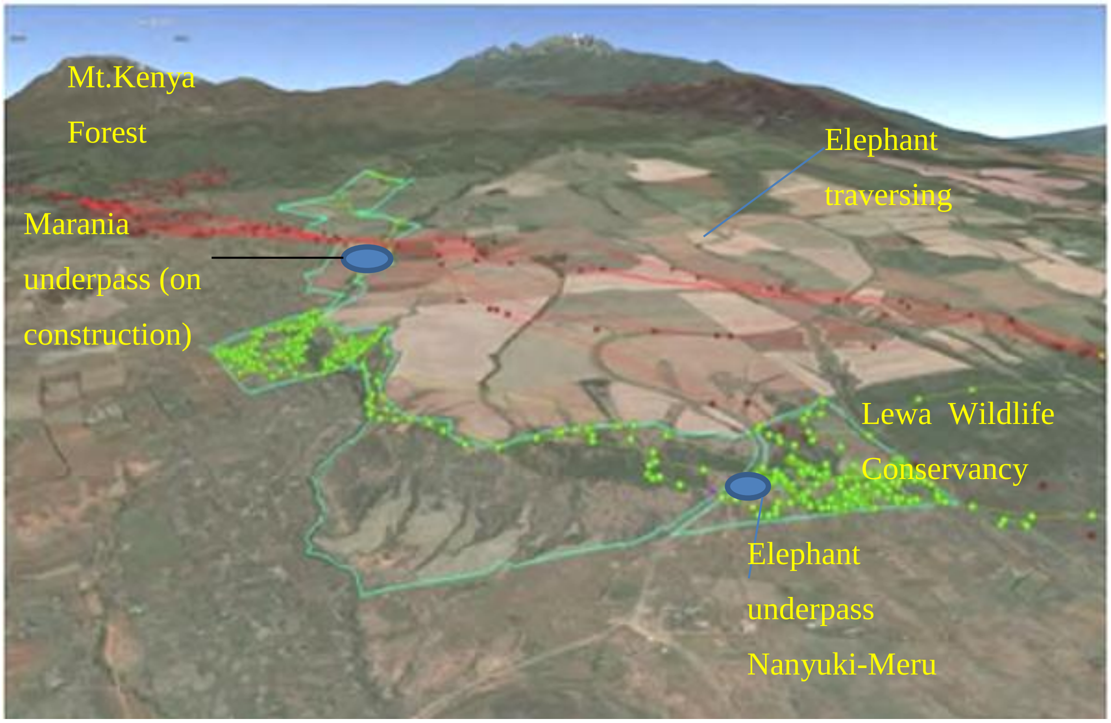

Plate 1: Mt.Kenya-Ngare Ndare wildlife corridor adopted from Ojwang'*et al*., 2017).

However, the Mt.Kenya-Ngare Ndare wildlife corridor connects the Mt Kenya forest reserve with other wildlife habitat areas on the Northern part of Kenya as shown in Figure 2. Moreover, this connectivity led to the inclusion of Lewa Wildlife Conservancy and Ngare Ndare national reserve into the Mt Kenya ecosystem and world heritage site. by the International Union for the Conservation of Nature and Natural Resources (IUCN, 2014).

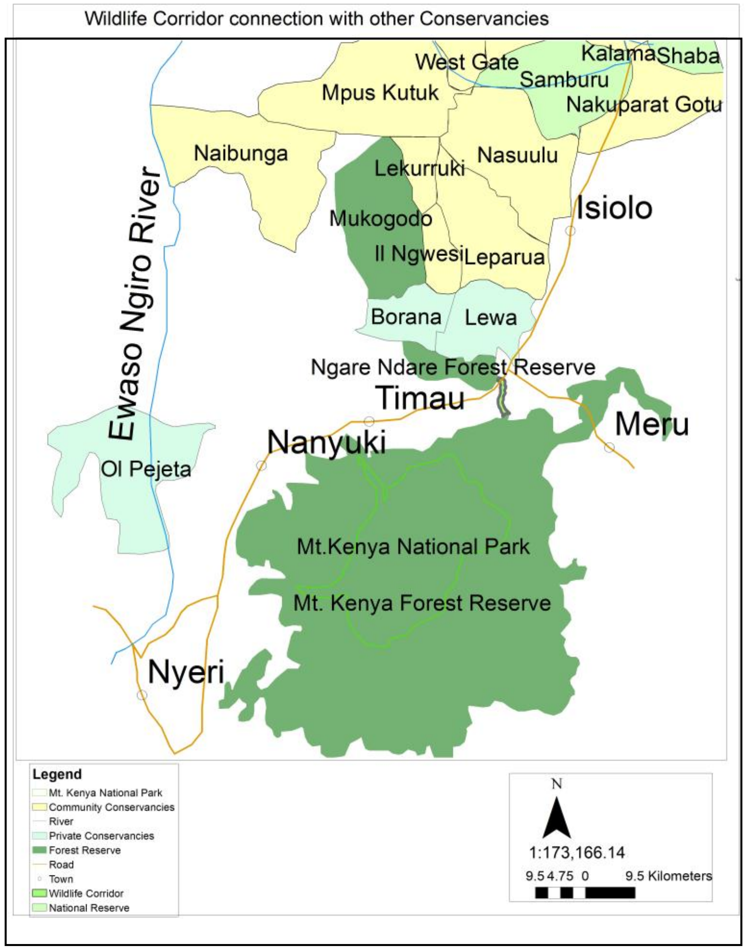

Figure 2: Mt.Kenya-Ngare Ndare wildlife corridor connection with other conservancies adopted from (IUCN, 2014).

3.2 Biophysical and Socio-Economic Description

The study area is as illustrated in Figure 3

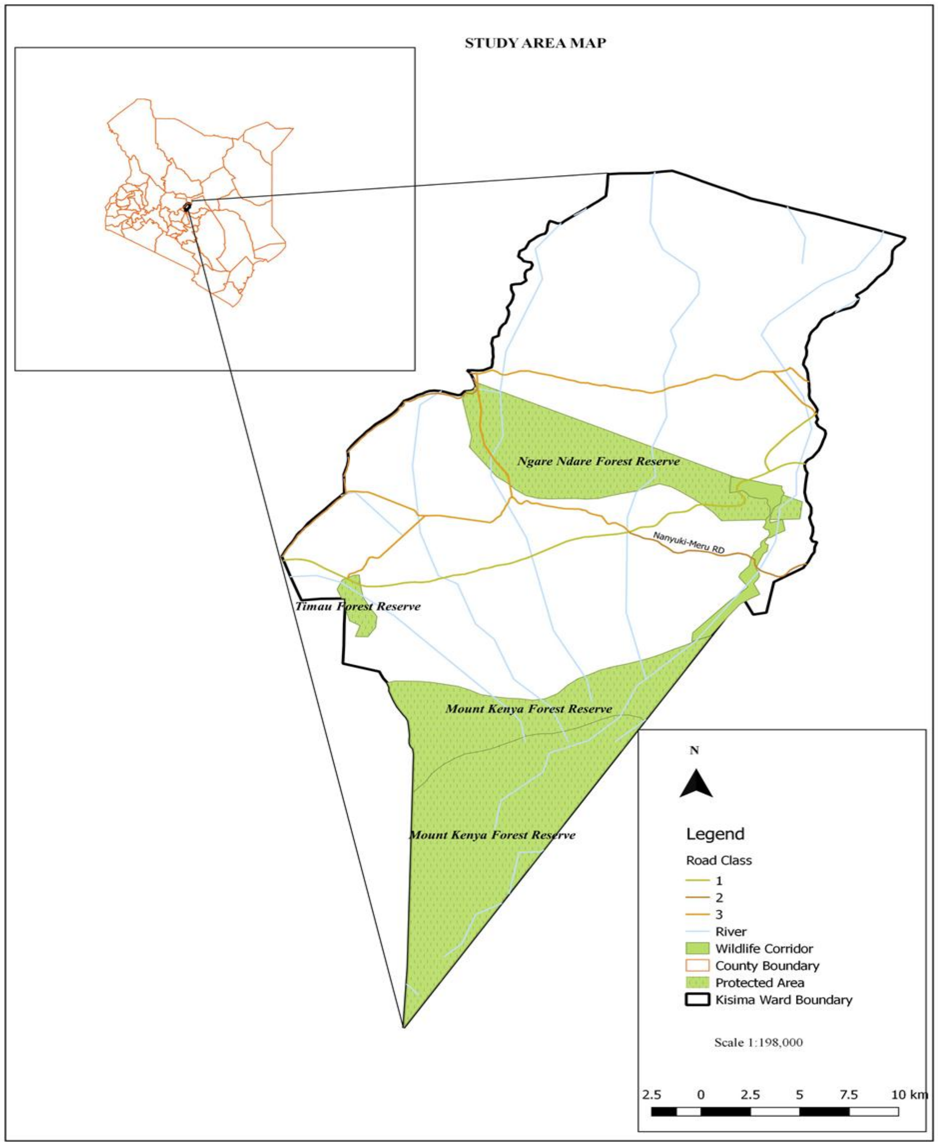

Figure 3: The study area map (Researcher)

3.2.1 Topography

Mount Kenya Forest Reserve is found within the Mt Kenya Ecosystem that signifies one of the most vital mountain ecosystems in the world and the most impressive landscapes in East Africa because of its high rugged glacier-clad mountain peaks and diverse forests. Mt. Kenya formation was as a result of volcanic activity and the mountain has a base diameter of nearly 120km. Mt. Kenya is the highest mountain in Kenya and second highest in Africa. In addition, it has fascinating peaks, the highest peaks are Batian at 5,199 m and Nelion at 5,188 m above sea level all found within Mt. Kenya national park. Moreover, it has broad cone-shaped deeply incised valleys radiating from the peaks, the valleys occur because of glacial erosion. In addition, it has around 20 glacial tarns and several glacial debris landscapes found between 3,950m and 4,800m height above sea level (ZhaoPing *et al*., 2010).

3.2.2 Climate

The climate of Mt. Kenya region is mainly determined by altitude. Climate variation occurs within a short distance, this is facilitated by change in height above sea level. Temperature decreases by one degree Celsius for every 100m increase in altitude. Mt. Kenya high altitude influences it to experience the afro-alpine climate. High rainfall within Mt. Kenya is experience between altitude 2,700 and 3,100m, while above 4,500m precipitation falls as ice or hail. Mt. Kenya ecosystem precipitation is bimodal that ranges from 900 mm to 2,300 mm in the northern (leeward side) and on the southeastern slopes (Windward side) of Mt. Kenya (Thompson, 1966). Long rains occur in March to June and October to November. While January and February are the driest months on the southeastern side of the mountain experiencing the strongest influence of trade winds.

In January and February, the daytime temperature goes high up to 20^{0} C. This temperature variation causes warm air to descent down the mountain during the night and early morning and ascends the mountain from mid-morning to evening. As a result, the mountain top clear in the morning and shortly before sunset. Similarly, the mountaintop becomes cloudy from 11.00 am to 5.00 pm. Along the transition zone between 3600-3700m above sea level down to 2900m there are several geographical features that include plateaus, foot ridges, valleys and inselbergs (Thompson, 1966).

3.2.3 Wildlife

Elephants, Leopards, Spotted Hyenas, Bushbucks, and Reedbucks, Warthogs, Plain zebras, Waterbuck, Grey duiker, and Buffalos. Frequently use the wildlife corridor as they move from Lewa Wildlife Conservancy through the Ngare Ndare Forest Reserve to the rich grazing areas on the hills of Mt. Kenya National Reserve (IUCN, 2014).

3.2.4 Population characteristics

The study area had a relatively high human population density of 102.27 and 34.46 in Ntirimiti and Subuiga respectively. Majority of the occupants are males, according to 2009 population census the number of males in Ntirimiti was 1588 while the female was 1422. Similarly, in Subuiga males were more than the female, the number of males was 1061 and 919 females (KNBS, 2009). The study area has high population density, high population density leads to land use and land cover changes.

3.2.5 Land Use Activity

The area surrounding Mt. Kenya forest is among areas of high agricultural productive areas in Kenya. Agriculture is the main source of livelihood in the areas adjacent to Mt. Kenya forest reserve. Agricultural productivity of the area surrounding the Mt. Kenya is influenced by altitude. Altitude influences temperature and rainfall amount of the area. Rainfall is high on the eastern and southern part of Mt. Kenya. On the eastern and southern part of Mt. Kenya intensive arable agriculture is practiced. On the upper parts, tea, pyrethrum, and potatoes are grown. Coffee, maize, beans, rice, bananas, and mixed livestock farming are practiced in the mid-altitude areas, while sorghum, tobacco, pigeon peas, cotton, millet, and cowpeas are grown on the low altitude areas.

Generally, the area of study is fertile and within high altitude, an area experiencing very low temperatures and high rainfall amount. The soils are conducive for sustaining the growth of a variety of crops from vegetables to cereals i.e. carrots, cabbages, wheat, maize, beans & peas (Plate 2) indicate the land use activities along the wildlife corridor.

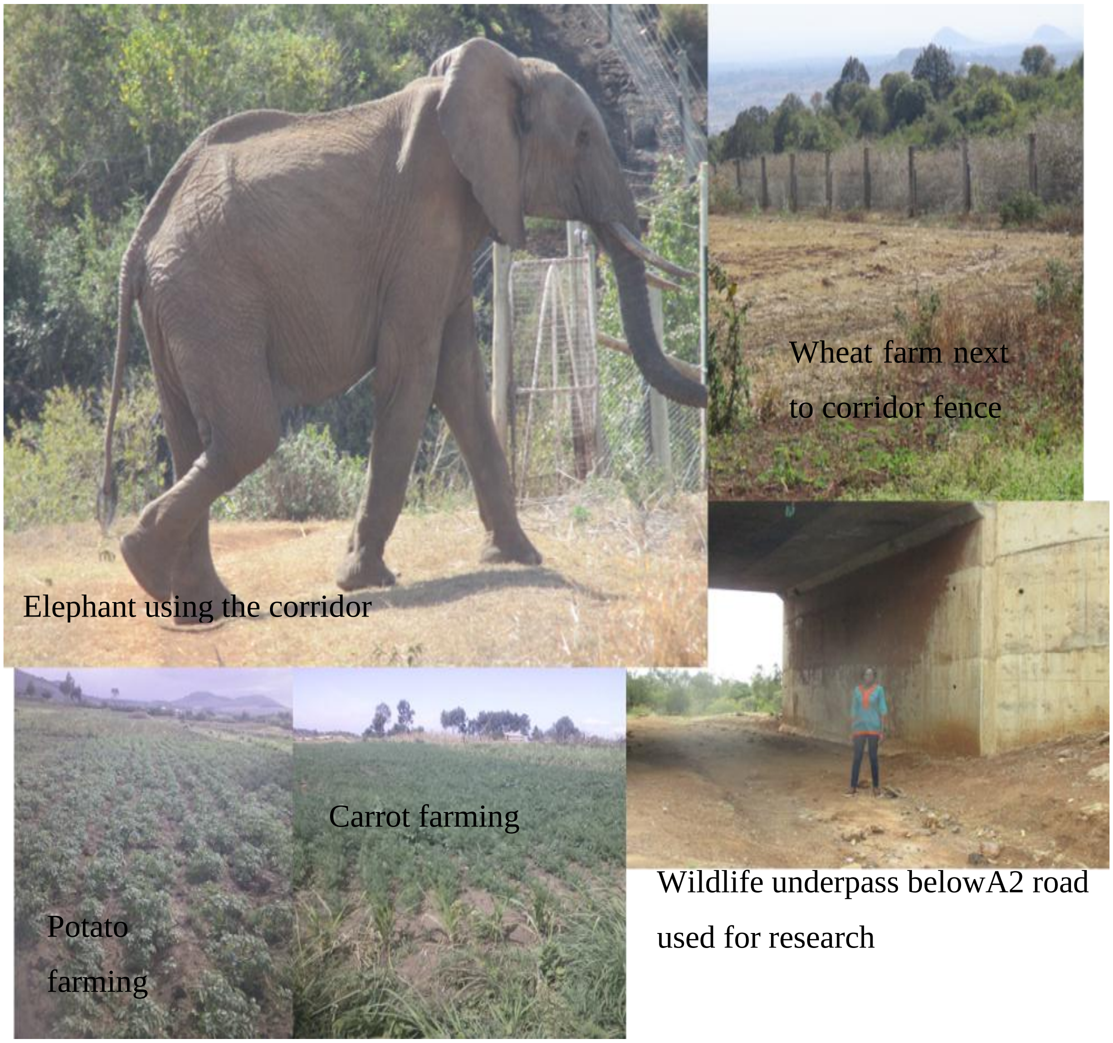

Plate 2: Land use activity along wildlife corridor (Source Researcher).

3.3 Methodology

3.3.1 Research Design

The study utilized a cross sectional research design to evaluate the land use and land cover changes between Mt. Kenya and Ngare Ndare wildlife corridor. This was used because a large population was being studied. In addition household questionnaire was used as the main tool for data collection to confirm the land use and land cover changes analysed from the sataellite images.

3.3.2 Sample frame and sample size

Questionnaire surveys were conducted in the Ntirimiti and Subuiga locations where 80 and 55 questionnaires were administered respectively. The questionnaires were administered in the households (HHS) that are located along the wildlife corridor. The first household was selected randomly and every ninth household was selected. Selection of the sampled households ensured representation of the population in the study area. However, respondents were selected based on their experience in the study area. The household heads were interviewed and where they were not available, another family member was interviewed only if they were 18 years old and above, in addition, gender balance was considered to ensure representation of both males and females.

The samples were selected using systematic random sampling from the Ntirimiti and Subuiga locations that have 841 and 650 households respectively. The level of accuracy used for sample size calculation was 95 % confidence level and estimated standard deviation error of scale 0.34. The formula used was as follows and in accordance to (Bartlett *et al*., 2001).

$$n_o = \frac{(t)^2*(p)(q)}{(d^2)} \qquad \frac{1.96^2*0.34*0.34}{0.05^2} = 178$$

$$n_1 = \frac{n_o}{1 + n_o/\text{population}} = \frac{178}{1+178/1491} = 159$$

Where:

n_o= required sample size

n_1= final sample size

t = Z value. 1.96 For 95% confidence level

pq= estimation of variance

d = marginal error,

Thus sample size expected was 159 and in relation to central limit theorem that states that the sampling distribution of the mean of any independent, random variable will be normal or nearly normal, if the sample size is large enough and any sample that is more than or equal to 30 is assumed to be representative enough of the study population (Mugenda & Mugenda, 2003). However, due to research limitations, the collected sample size was 135.

3.3.3 Types and sources of data

The study used both the primary and secondary data. Primary data involved information on human activities in relation to wildlife corridor, population trends and land use changes in Mt Kenya and Ngare Ndare wildlife corridor. This data was obtained through household questionnaire interviews, key informant interview with Kenya Wildlife Service officer and Mt Kenya Research Scientist that have done research within the study area and field observations. Moreover, this study used satellite images to analyze land use and land cover changes using geospatial techniques and population census data as secondary data sources

3.3.4 Data collection techniques

Data were collected using questionnaires interviews designed for the household, field observation, key informant interviews and satellite image analysis to gather information about the past and current land use and cover changes along the wildlife corridor.

3.3.4.1 Questionnaire

Questionnaires were administered to the household where the head of the household was interviewed and where the household head was not available, another representative was chosen to provide information on behalf of the household head. A research interpreter was used in cases where the respondents were not able to understand the English language and translate into local language. The questions covered socio-economic and demographic information such as age, sex, education level, the source of income and number of people in household (HH) and resident status of the interviewed respondents. The other part of the questionnaire covered questions about the farm characteristics, land tenure systems, and land use activity.

3.3.4.2 Key informant interviews

One old managed 80 years was interviewed; he provided information about the past and present land use and cover along the wildlife corridor. In addition, he provided historical information about the initial migratory route and species diversity that was there in the past and present. Other discussions were held individually with Mount Kenya trust research scientist; field coordinator, the chief executive officer, and Kenya wildlife service officer who gave information on how the wildlife used to move between the conservation areas before the establishment of the wildlife corridor. In addition, they provided information on the daily operation of the currently established wildlife corridor and land use and land cover changes that have occurred along the wildlife corridor.

3.3.4.3 Field observations

This involved patrolling the wildlife corridor and it edges where there was land uses activities. This aided in the observation of the distance of farms from the corridor and their impacts on the corridor. This was recorded using photographs.

3.3.5 Remote sensing and GIS

The satellite images were obtained from the Regional Centre for Resources Mapping and Resources Development. The images were of the same season to get the best spatial-temporal comparison. The satellite images were from path 180 and row 060 all from

Landsat satellite. Moreover, the ten-year interval was not possible as planned but images were chosen close to the stipulated interval. The images were dated as follows 30 January 1973 Landsat 1 image from the multispectral scanner sensor that contained 0% cloud cover. 21st January 1986 Landsat 5 image was used from MSS with 0% cloud cover. 30th January 1995 Landsat 5 image was also used, from thematic mapper sensor and had 0% cloud cover. Moreover, 8th February 2010 Landsat 5 image from TM sensor was used had 10% cloud cover. In addition, 10th January 2017 Landsat 8 image was also used from OLI and TIRS sensor with 8.65 % cloud cover.

3.3.5.1 Satellite Image Processing

The satellite images were imported into ENVI software for image processing; false color composite (FCC) was created using the layer stack option in the basic tool. The images were subset into the study area to save on storage space and processing speed. The study area delineation from images was based on collected GPS coordinates, topographical maps and researcher's knowledge about the area. Moreover, an image georectification was done to ensure one on one image overlap and registration; this was done because satellite images captured on the same area tend to have a shift between them due to different sensor heights during data capture. Satellite images geo-rectified were done using the GPS points captured in the field. Table 1 provides a summary of the Remote Sensing and GIS methods used in the study.

Table 1: Summary of the satellite image processing techniques (Source: Researcher).

Components	Description	Tools	Deliverables
1. Data search, identification and acquisition	Different datasets were identified and acquired from the existing database of Regional Centre for Resources Mapping and Resources Development. and Kenya topographic features. Ground truthing data was collected using the handheld GPS	• Internet for downloading satellite images, • scanners for converting hard copy maps to digital format • GPS for field data collection.	Raw data layer
2. Delineation of the wildlife corridor.	The wildlife corridor was delineated by digitization	Q GIS software	Wildlife corridor boundary
3.Data processing	The acquired data was processed and maps compiled	Q GIS and ENVI software	Formatted dataset
4.Data analysis and interpretation.	Data was analyzed to generate the information that was presented on the maps.	Q GIS and ENVI software	Information layers datasets
5.Map compilation	Generated information was used to prepare different maps	Q GIS software	Different thematic maps

a) Satellite Image Correction

Satellite images were corrected for radiometric and geometric errors. This ensured efficient identification of changes being detected. Hence, change detection separation from radiometric and geometric errors. The images were also aggregated to the same scale to enable comparison.

b) Image Classification

An unsupervised classification was done to give anticipated land cover types. The classes obtained were refined using a set of training sites that were identified through field data. The field data were collected using a visual image inspection based on the local knowledge of the ecosystem. This was complemented by the land use and land cover points collected in the field using the GPS. The sites identified were both from field data collected using GPS and other sites picked based on the researcher's knowledge of the area as well as landscape features. Using the training sites, reflectance signatures different cover classes were created. The signature files were used to run a supervised classification with a maximum likelihood algorithm in ENVI. The classified image was checked and compared with the original image. However, in areas where classification seemed to have mixed pixels, more training sites were added, and the classification process repeated. Each of the classified raster images was converted to a vector file in Q GIS using raster to vector conversion command. Each signature was assigned specific land use and land cover class.

3.4 Data Analysis and Presentation

Data collected from different sources was summarized and presented using frequency tables, charts, photographs, and maps. However, frequencies, percentages, and other statistical measures were computed and used for analysis. Descriptive analysis was used to analyze information collected from informal interviews and information captured through observation and discussion. In addition, inferential statistics; chi-square tests were used to test the for the significance of the second hypothesis there are no drivers of land use and cover changes and correlations analysis were used to show the land use and cover changes relationship with the population density. Thematic analysis of satellite images showing land use changes over time was carried out too. The spatial trend was analyzed using ENVI to show the spatial dynamics. Similarly, a kappa statistics that is a measure of how well a classified map and its reference data agree was generated. Moreover, information obtained from questionnaires, interviews, and observations was used to beef up land use information obtained from satellite image analysis.

CHAPTER FOUR - RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter illustrates and explains the demographic information of the respondents who took part in this study, land cover and land use changes between January 1973 and January 2017. Further, it illustrates and discusses the relationships between land use and cover change, human population, socioeconomic factors and possible viable conservation and management strategies in the wildlife corridor between Mt. Kenya and Ngare Ndare forest reserves.

4.1 Household Characteristics

From the survey of the respondents, 54% were male and 46% were females. In addition, the majority of the respondents were aged between 40-49 years (27%). 21% were aged 30-39 years, 19% between 50-59 years, 12% aged above 70 years and 11% were aged 60-69 years and 9% 20-29 years old as shown in Table 2.

Similarly, from the survey majority of the respondents had the primary education that was 52%. While 30% of the respondent had secondary education, 15% had no formal education, 3% had the college education and only 1% had a university first degree as shown in Table 2. Majority of the respondents depended on agriculture 85% as their source of livelihood, livestock keeping 6%, business 5%, 2% for casual labor, 1% charcoal making and minority cited employment 1% as the source of livelihood illustrated in Table 2

Table 2: Household Characteristics (Source: Researcher).

Variable	Male		Female			Variable	Male		Female	
	Frequency	Percentage	Frequency	Percentage			Frequency	Percentage	Frequency	Percentage
Sex Ratio	73	54%	62	46%		6-10	25	19%	16	12%
Age (Years)						>10	2	1%	0	0%
20-29	6	4%	6	4%		Education Level				
30-39	12	9%	17	13%		No Formal Education	8	6%	12	9%
40-49	20	15%	17	13%		Primary	45	33%	25	19%
50-59	17	13%	9	7%		Secondary	19	14%	21	16%
60-69	9	7%	6	4%		College	1	1%	3	2%
Above 70	9	7%	7	5%		University 1^{St} Degree	0	0	1	1%
Marital Status						Livelihood				
Single	1	1%	3	2%		Agriculture	61	45%	54	40%
Married	65	48%	55	41%		Livestock Keeping	5	4%	3	2%
Divorced	1	1%	2	1%		Employment	0	0	1	1%
Widowed	6	4%	2	1%		Business	6	4%	1	1%
Household Size						Charcoal Making	0	0	2	1%
1-5	46	34%	46	34%		Casual Labour	1	1%	1	1%

In addition from the survey, the majority of the household had 1-5 members (68%). while 6-10 family member size was 30% and greater than 10 family members was 2% (Table 2).

4.1.2 Settlement

From the finding, 44% of the respondent settled between 1970 and 1980's and 19% settled between 1991 and 2000. While 16% of the respondents settled in between 2001 and 2016 and 13% of the respondents settled before 1970. In addition, 9% settled between 1981 and 1990 as illustrated in Figure 4.

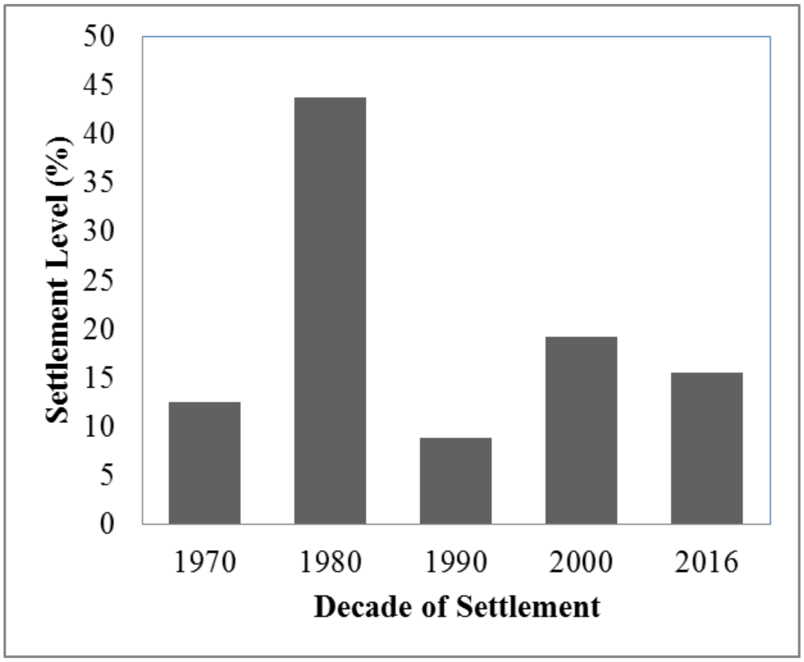

Figure 4: Settlement year (Source: Researcher).

Most of the respondents 59% came from Kibirichia. While 19%, 10%, 3%, 2% and 1% came from Katheri, respectively. However, 6% of the respondents were living in Ntirimiti and Subuiga that was the study area.

From the survey agriculture contributed to the highest pull factor (55%), followed by settlement 40%, 4% livestock keeping and 1% employment that facilitated the migration into the Ntirimiti and Subuiga areas. The pull is observed to be continuous and will progressively increase over the years which in-turn is likely to have impacts on land use and land cover.

4.1.3 Household land tenure

The government settlement scheme dominated land tenure at 53%, followed by inherited land at 31%. While rented land was 12%. Moreover, most of the land was historically acquired through the government settlement schemes 76% and 6% was self-allocation. The rest of the land is rented (7%) and 10% had bought the land. However, a few respondents 1% were not sure of historical acquisition of the land.

4.1.4 Household farm size

From the survey, 38% of respondents owned 1-2 acreage of the farm that ranked the highest followed by 35% who owned less than one acre of land. While 3-5 acreage was owned by 24% of the respondent. In addition, 6-10 acreage was owned by 2% of the respondents and more than 10 acres by 1% (Figure 5).

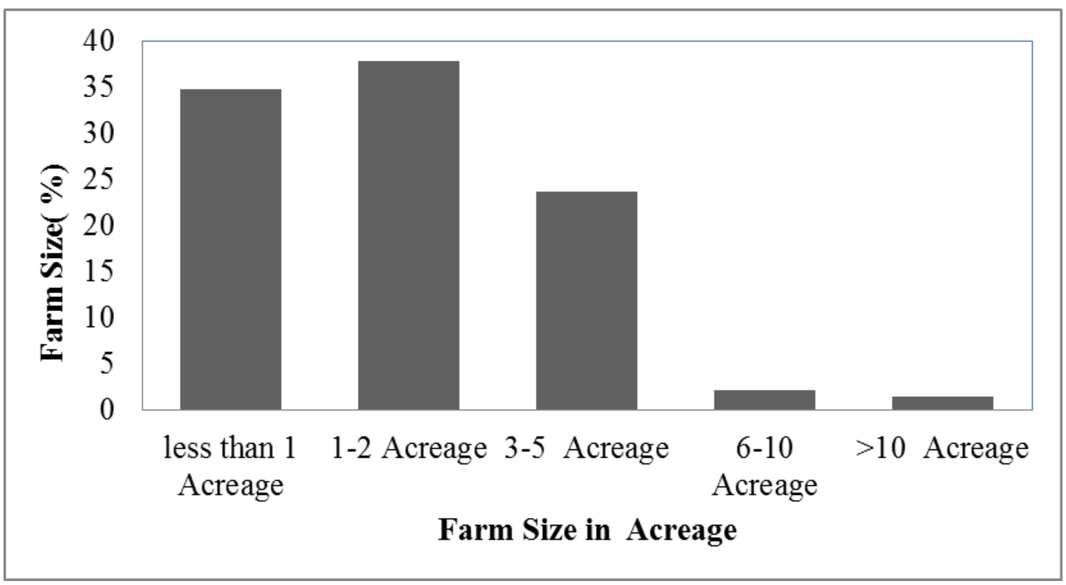

Figure 5: Household farm size (Source: Reseacher).

4.1.5 Land Utilization

From the survey, 93 % of the land was used for small-scale farming, 4% for grazing, 1 % for large-scale farming and 1% for fuel wood collection. In addition, 67% of the respondents were living within 500 meters from the wildlife corridor, 17% lived within a kilometer from the wildlife corridor and 16% were a distance greater than a kilometer from the corridor. This means that there is a high likelihood of unsustainable land use along the wildlife corridor as illustrated in Figure 6. Moreover, there was a positive relationship between the land use and distance from the wildlife corridor at 0.775 person's value.

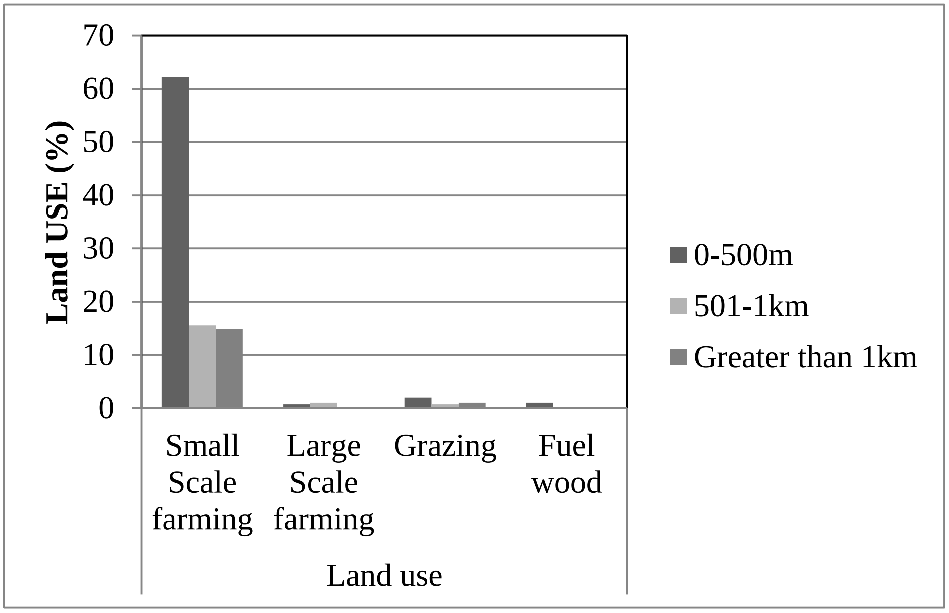

Figure 6: Land Utilization (Source: Researcher).

4.1.6 Factors influencing the land use activities along the wildlife corridor

From the survey results, 67% of respondents cited good income as the leading driver, followed by 22 % need for subsistence, 7% cited demand for the commodity and 2% indicated the ready market for the crops as a motivation factor. In addition, 2% of respondents indicated that inadequate land is a precursor for them to practice that particular land use activity.

4.2 Wildlife Corridors Characteristics, Community Perception and Knowledge

From the survey, most of the respondents (99%) were aware of the presence of wildlife in the study area. In addition, 90% of the respondents indicated that wildlife was found within the corridor and forest while 5% cited the wildlife was found in the wildlife corridor only and 1% believed the wildlife was found in the forest. However, 4% of the respondents had no knowledge of wildlife location.

In addition, the majority of the respondent 93% were knowledgeable on wildlife movement from Lewa Conservancy via Ngare Ndare forest to Mt Kenya forest and Vis Versa while 7% did not have knowledge about movement patterns. This study found that the respondents are aware of the presence of wildlife and their movement across conserved areas like Lewa to other conservation areas, for example, the Ngare Ndare and Mt Kenya forest that was adjacent to them.

4.2.1 Impact of the wildlife to the local community

Similarly, from the study wildlife had an impact on the surrounding community, 52% of respondent cited that wildlife had a negative impact and 48% indicated positive impacts. Figure 7 illustrates the impacts of the wildlife to the community.

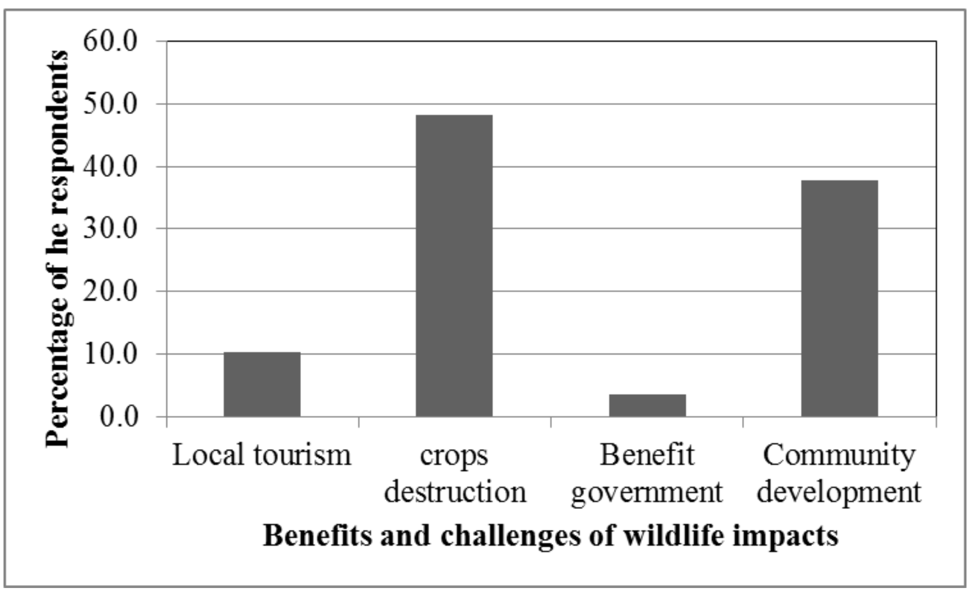

Figure 7: Benefits and challenges of wildlife (Source: Researcher).

From the survey, 48% of the respondents cited the presence of wildlife as a challenge to them because of crop destruction and loss of livestock. Additionally, 37% of respondent indicated that they benefited through community development done by conservancy for example construction of Ntirimiti dispensary by the Mt Kenya Trust and education funds provided by Lewa Wildlife Conservancy. Whereas, 11% of the respondents indicated local tourism as a positive impact of the wildlife within their environment, in that they could go and see animals as they moved within the corridor and. Moreover, 4% of the respondent argued that the government benefited.

4.2.2 Human Wildlife - Conflicts

From the survey, it was observed that as the wildlife used the corridor they interacted with human that lived adjacent to the corridor hence the human-wildlife conflict. Human wildlife conflicts were cited by 73% of the respondents within the study area while 27% of the respondents indicated no conflicts in the area.

Moreover, the study found out that 57% of the respondents were not aware of the activities they practiced that could precipitate wildlife conflict. While 23% and 20% of the respondents indicated that grazing and fuelwood collection respectively precipitated the human-wildlife conflicts. Similarly, 1% of the respondents indicated that the road construction caused wildlife movement obstruction hence human-wildlife conflicts as illustrated in Figure 8.

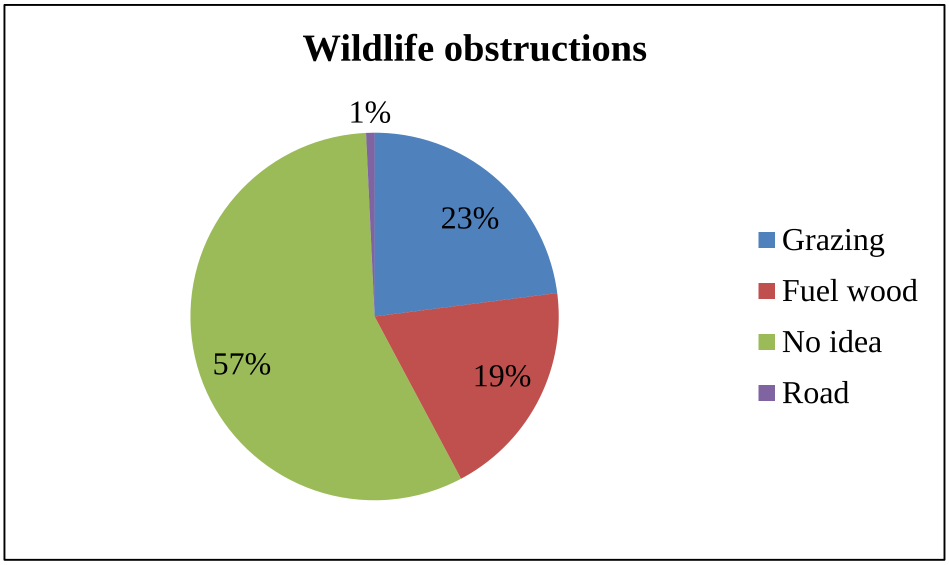

Figure 8: Human causes of conflict through wildlife movement (Source: Researcher).

4.3 Land Use and Cover Changes along the Wildlife Corridor from 1973-2017

There were significant changes in land use and cover that included expansion of agricultural land, building, and bare soils.

4.3.1 Land use and cover Analysis

In 1973, the forest covered the following sub-Locations; the Southern part of Ngare Ndare sub-Location, southwestern part of Maritati, Mt Kenya Forest sub-location and Mutarakwa sub-locations (Figure 9). The wildlife corridor located on the western side along Ntirimiti and Mt Kenya forest sub location had high forest cover in 1973. While the cropland covered the eastern and central part of Maritati, Kiambogo, and parts of Buuri sub locations. A mixture of bushland and forest covered the Ntirimiti sub location, Ethi Sub-location, Thiira sub location, Burat sub location, Sangaa sub location, Aljojo sub location, Mboroga sub location, Kiamigo sub location, Murinya sub location, Kimbo sub location Mutunyi and Ngare Ndare sub location. Bare ground covered the southern part of Mt Kenya forest. Settlementss were found on the southern part of Maritati sub location as illustrated in Figure 9.

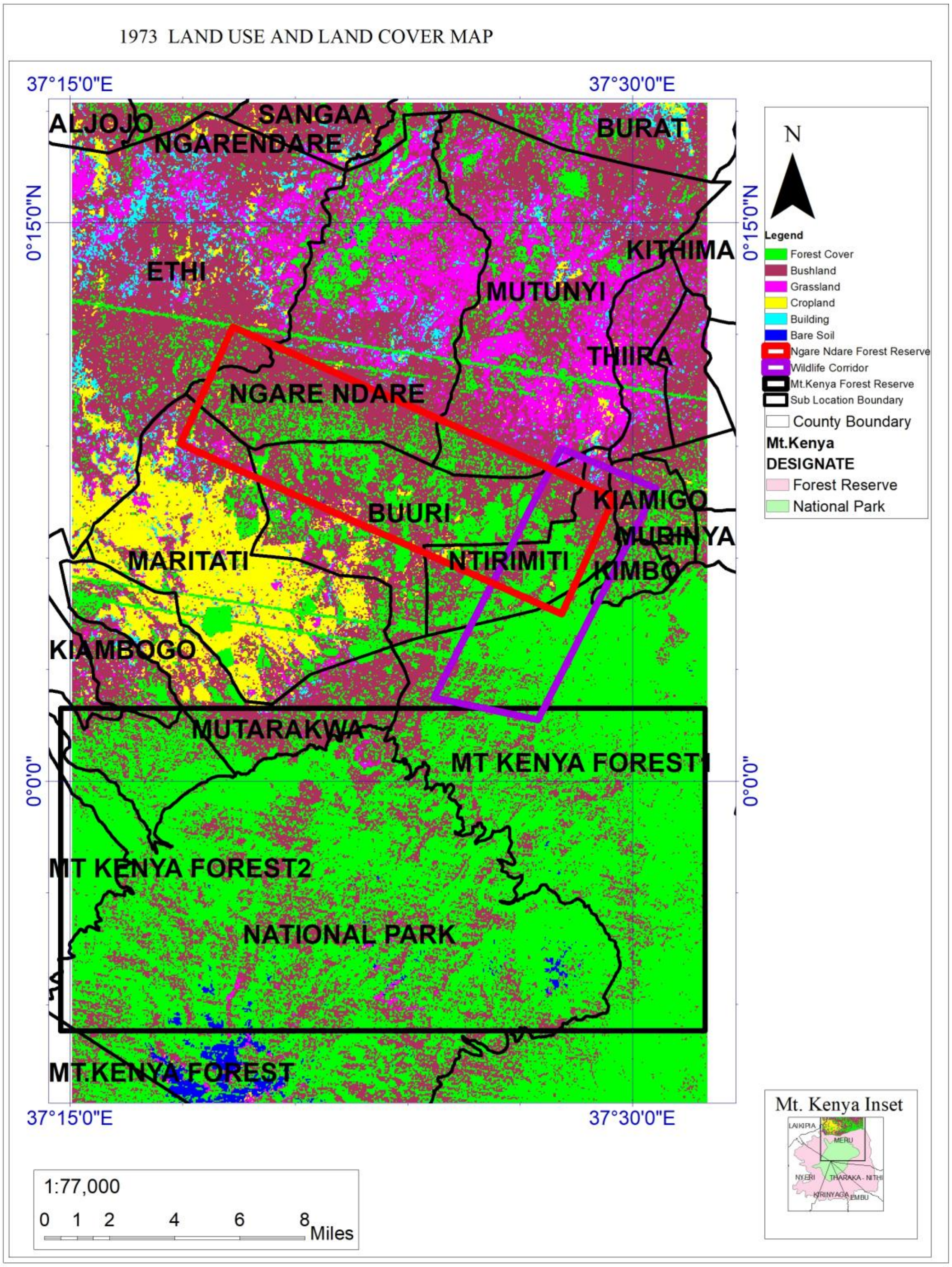

Figure 9: Land use & land cover 1973 (Source: Researcher). .

In 1986, cropland expanded further into western part into Buuri sub location, Kiambogo sub location, Ethi sub location. Sangaa sub location, Burat sub location, Mboroga sub location, Ntirimiti sub location northern part of Mutunyi sub location and Mutarakwa sub location that was previously covered by bushland (Figure 10). The cropland expansion had encroached into Ngare Ndare forest and the wildlife corridor on the western side. Forest remained almost the same in Mt Kenya forest. The settlement started coming up in Ethi sub location, Ngare Ndare and Mutunyi sub location shown in Figure 10.

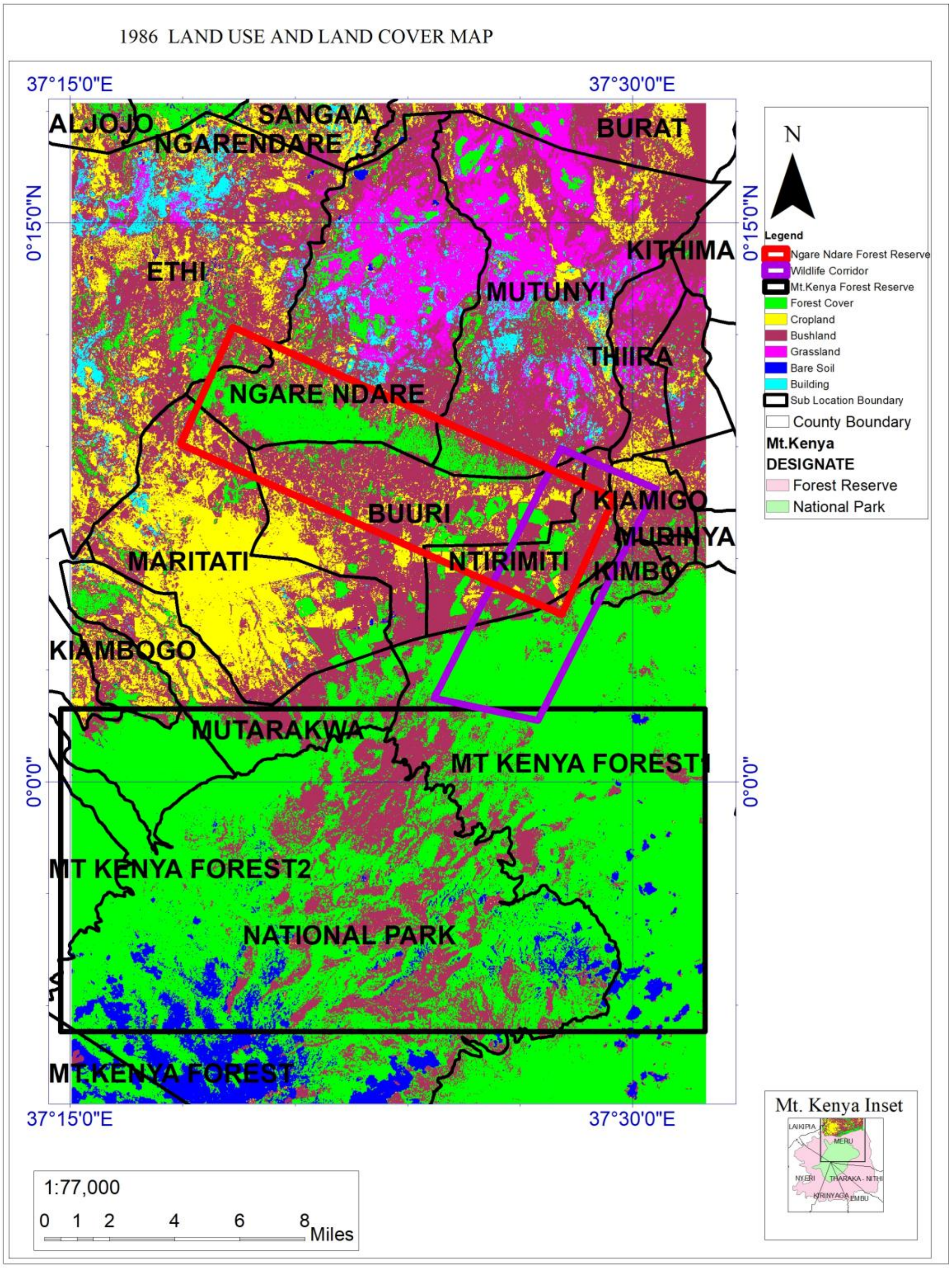

Figure 10: Land use & land cover 1986 (Source: Researcher). .

In terms of the shift in land cover, the forest land cover between 1973 and 1986 lost 3687 ha while cropland doubled from 9,160 ha to 18,633 ha (Table 3).

Table 3:1973-1986 land use and land cover change matrix in hectares (Source: Researcher).

	1973							
	Land use and cover	Forest	Bush land	Grassland	Cropland	Settlements	Bare ground	Row Total
	Forest	47914	16956	244	152	31	180	65479
	Bush land	11404	28358	5493	2652	1555	8	49470
	Grassland	3286	5989	3824	58	367	10	13534
	Cropland	2304	7222	1700	6124	1272	13	18634
	Settlements	4116	1357	149	360	8	942	6608
	Bare ground	140	1115	830	138	323	2	2547
	Class Total	69164	60996	12240	9160	3556	1155	0
1986	Land use change	-3687	-42362	37230	4374	3052	1392	0

In 1995, the cropland stretched into the southern part of Mutarakwa sub location Buuri sub location, Ntirimiti sub location, Kiambogo sub location, Ethi sub location, Thiira sub location, Sangaa sub location, Burat sub location and Kimbo sub location (Figure 11). Moreover, cropland encroachment into the wildlife corridor expanded. Settlements occupied Maritati sub location, Ethi sub location and settlements patches in Ngare Ndare sub location and Mutunyi sub location as illustrated in Figure 11.

In terms of the shift between 1986 and 1995 the cropland gained by 12,469 hectares, while the bushland lost by 15867 ha. Similarly, the grassland lost by 3102 ha and forest cover by 44 ha. While the settlements and bare grounds gained by 3188 ha and 3357 ha respectively illustrated in Table 4.

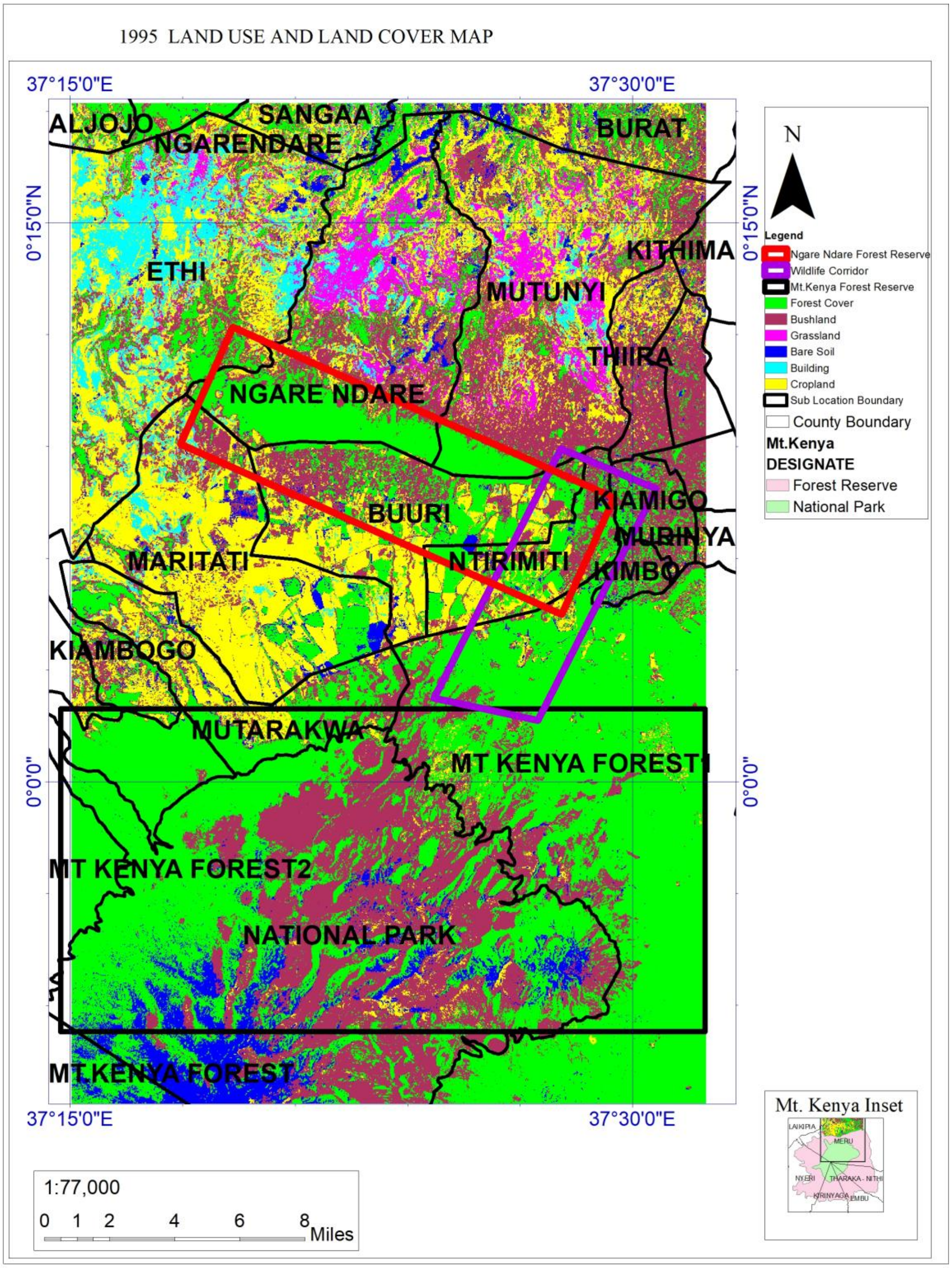

Figure 11: Land use & land cover 1995 (Source: Researcher).

Table 4: 1986- 1995 land use and land cover changes matrix in hectares (Source: Researcher) .

	1986							
	Land use and cover	Forest	Bush land	Grassland	Cropland	Settlements	Bare ground	Row Total
1995	Forest	47436	11525	710	1387	160	1963	63180
	Bush land	10539	25691	1846	2906	762	1018	42763
	Grassland	314	1860	2310	269	730	10	5493
	Cropland	1580	14204	2519	10439	934	105	29780
	Settlements	322	3053	740	1671	1225	10	7021
	Bare ground	3033	2297	469	640	23	3217	9679
	Class Total	63224	58630	8595	17311	3833	6322	
	Land use change	-44	-15867	-3102	12469	3188	3357	

In 2010, the cropland covered the Maritati sub location, Kiambogo sub location, Buuri sub location, Mutarakwa sub location, Sangaa sub location, Ethi sub location, Aljojo sub location, the eastern part of Mt Kenya sub location, Ngare Ndare forest edges and Ntirimiti sub location (Figure 12).

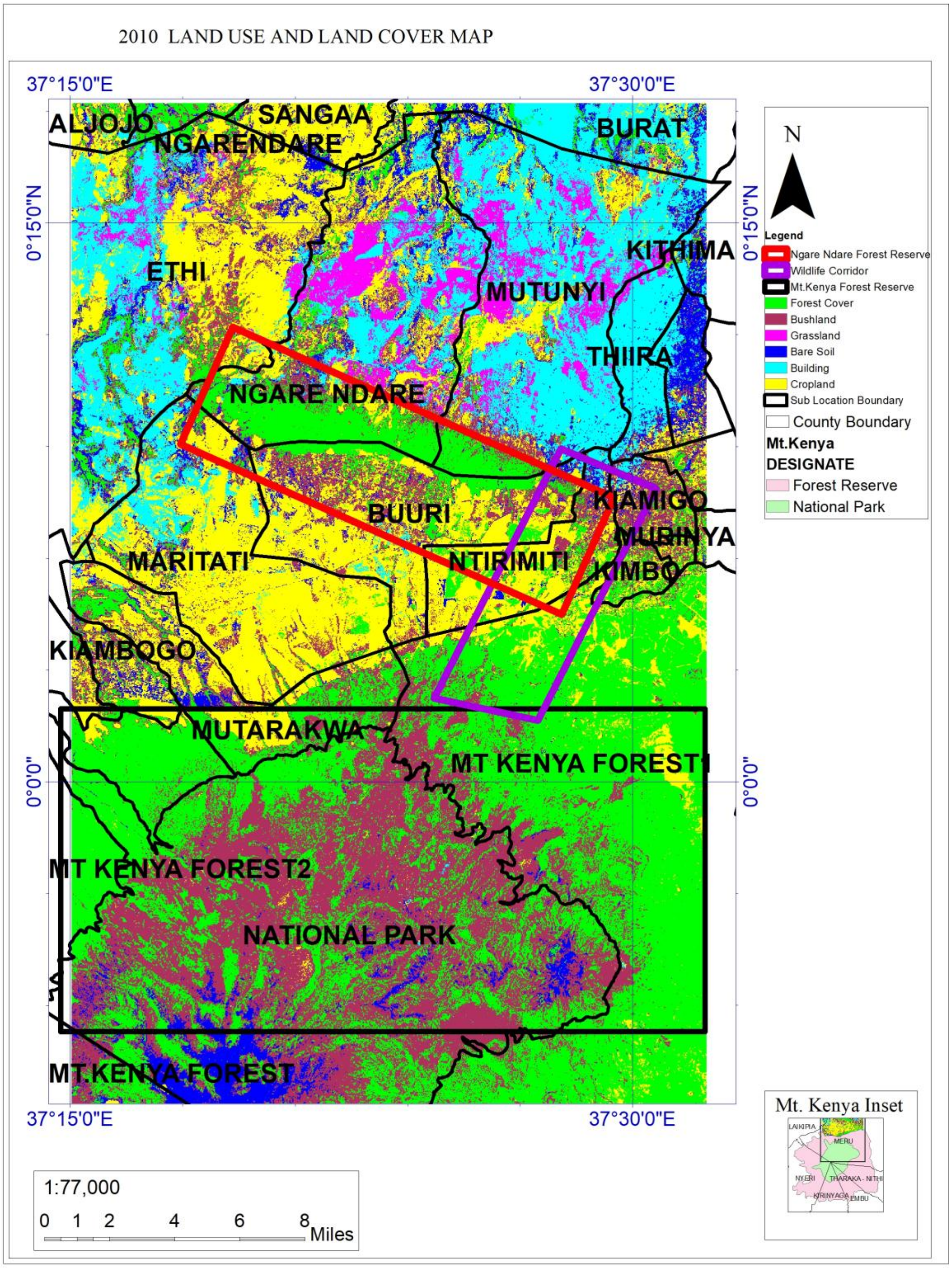

Figure 12: Land use & land cover 2010 (Source: Reseacher). .

Settlements expanded into Burat sub location, Kithima sub location, the southern part of Mutunyi sub location, Maritati sub location, Thiira sub location, Buuri sub location and

Ntirimiti sub location Grassland cover the northern and central parts of Mutunyi and Ngare Ndare sub locations. Bare grounds expanded Thiira sub location, Kithima sub location, and Mutunyi sub location. Wildlife corridor is encroached by settlement on the northern side and cropland on both the eastern and western side (Figure 12).

In terms of the shift in 1995-2010 the cropland increased by 4086 ha, the settlements gained by 13766 ha and bare grounds increased by 1302 ha. The forest cover lost by 14,044 ha, bushland lost 5014 ha and grassland declined by 106 ha as illustrated in Table 5.

Table 5: Land use and land cover matrix 1995- 2010 in hectares (Source: Researcher).

	1995							
2010	Land use and land cover	Forest	Bush land	Grassland	Cropland	Settlements	Bare ground	Row Total
	Forest	39294	7617	64	647	38	699	48359
	Bush land	13778	17808	351	2611	389	2529	37466
	Grassland	359	1140	1890	1031	920	44	5385
	Cropland	5955	7105	979	15942	2282	1366	33629
	Settlements	1542	6217	2037	7116	2909	776	20597
	Bare ground	1474	2592	172	2197	282	2977	9694
	Class Total	62403	42479	5491	29543	6821	8392	0
	Land use change	-14044	-5014	-106	4086	13776	1302	0

In 2017, the cropland covered Maritati, Buuri, Ntirimiti, Kiambogo, Mutarakwa, Ethi, and Kimbo, Kiambogo and Mt Kenya forest edges and the eastern part (Figure13). Whereas the forest covered the southern part of Ngare Ndare, Mt Kenya forest, patches in the northeastern part of Kiambogo. Patches of grassland covered northwestern part of Mutunyi, and northern part of Ngare Ndare. Settlements covered Ethi, Maritati, Southern part of Ngare Ndare, Thiira, and Kithima sub location. Bare grounds covered, Ethi, Kimbo and Kiambogo sub location. Wildlife corridor is encroached by cropland, bare ground, and settlements (Figure13).

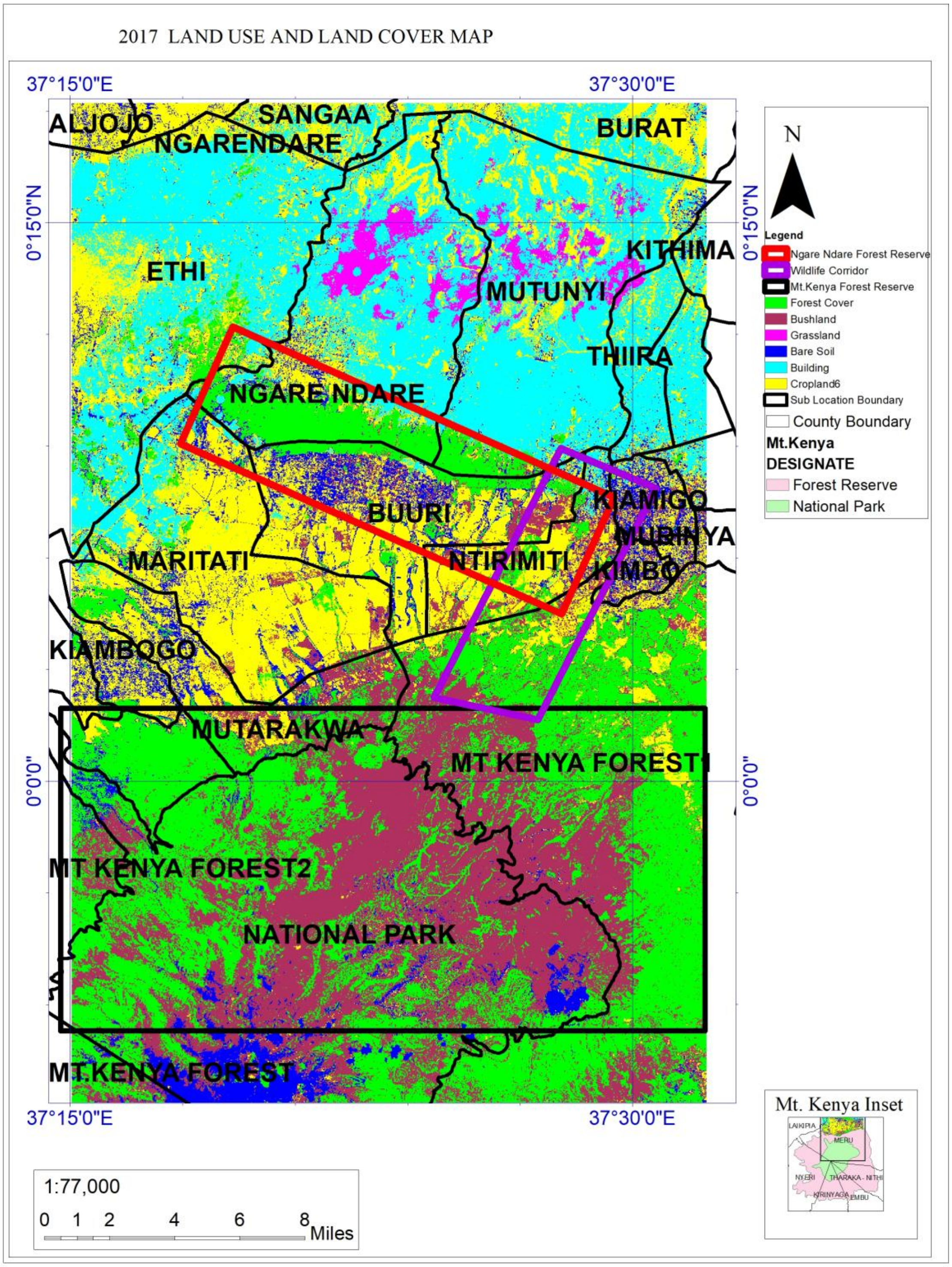

Figure 13: Land use & land cover 2017 (Source: Researcher).

In terms of the land use and cover change between 2010 and 2017, the forest cover declined by 7807 ha, bush land declined by 5035 ha and grassland reduced by 2827 ha. This was compensated by an increase in cropland by 2085 ha, settlements 12042 ha gain and 1524 bare ground gain as demonstrated in Table 6.

Table 6: Land use and land cover matrix 2010- 2017in hectares (Source: Reseacher).

	2010							
	Land use and land cover	Forest	Bush land	Grassland	Crop land	Settlements	Bare ground	Row Total
2017	Forest	29996	9340	9	1184	51	284	40864
	Bush land	12440	16869	0	2374	28	894	32605
	Grassland	16	41	1528	194	788	5	2572
	Cropland	3146	4616	405	19052	5659	3262	36140
	Settlements	1151	3372	3451	8528	13914	2519	32935
	Bare ground	1922	3401	6	2723	453	2894	11400
	Class Total	48671	37640	5399	34055	20893	9858	0
	Land use change	-7807	-5035	-2827	2085	12042	1542	

4.3.2 Image Classification Accuracy Report

The image classification accuracy was high, the overall accuracy was nearing 100% and kappa statistics was almost 1.0 as shown in Table 7.

Table 7: Image classification accuracy level in hectares (Source: Researcher).

Year	Land Use and Land Cover	Forest Cover	Bush land	Grassland	Crop land	Bare ground	Settlements	Overall Accuracy	Kappa Coefficient
1973	comission %	2.14	58.22	5.45	10.91	43.48	0.00		
	Omission%	31.61	11.24	3.70	2.00	0.00	0.00		
	Prod. Acc.%	68.39	88.76	96.3	98	100	100		
	User Acc.%	97.86	41.78	94.55	89.09	56.52	100	78.99%	0.6883
	Commission %	4.06	44.08	10.9	1.4	1.32	10.42		
	Omission	11.65	9.57	1.66	8.97	4.46	2.27		
	Prod. Acc.	88.35	90.43	98.34	91.03	95.54	97.73		
1986	User Acc.	95.94	55.92	89.1	98.6	98.68	89.58	91.03%	0.8525

Year	Land Use and Land Cover	Forest Cover	Bush land	Grassland	Crop land	Bare ground	Settlements	Overall Accuracy	Kappa Coefficient
	Commission	2.9	26.15	22.94	6.58	9.2	27.59		
	Omission	12.46	8.67	0	8.54	9.71	4.55		
	Prod. Acc.	87.54	91.33	100	91.46	90.29	95.45		
1995	User Acc.	97.1	73.85	77.06	93.42	90.8	72.41	90.10%	0.8614
2010	Commission	20.79	33.04	31.67	2.37	47.99	7.01		
	Omission	13.87	28.23	2.38	12.28	24.76	5.81		
	Prod. Acc.	86.13	71.77	97.62	87.72	75.24	94.19	85.18%	0.778
	User Acc.	79.21	66.96	68.33	97.63	52.01	92.99		
	Commission	26.03	73.9	3.76	3.56	73.38	47.41		
	Omission	16.94	43.47	3.13	33.7	22.26	8.39		
	Prod. Acc.	83.06	56.53	96.88	66.3	77.74	91.61		
2017	User Acc.	73.97	26.1	96.24	96.44	26.63	52.59	71.01%	0.5681

4.3.3 Demographic changes and land use and land cover

As the population increased over the years from 1973-2017 Figure 14. The cropland increased settlements (settlementss) and bare grounds (infrastructure) increased. This increase compensates for the land lost by forest cover, and grassland. It is projected that the population will continue to increase due to immigration and natural reproduction that will affect more on the remaining forest, and grassland (Figure 14).

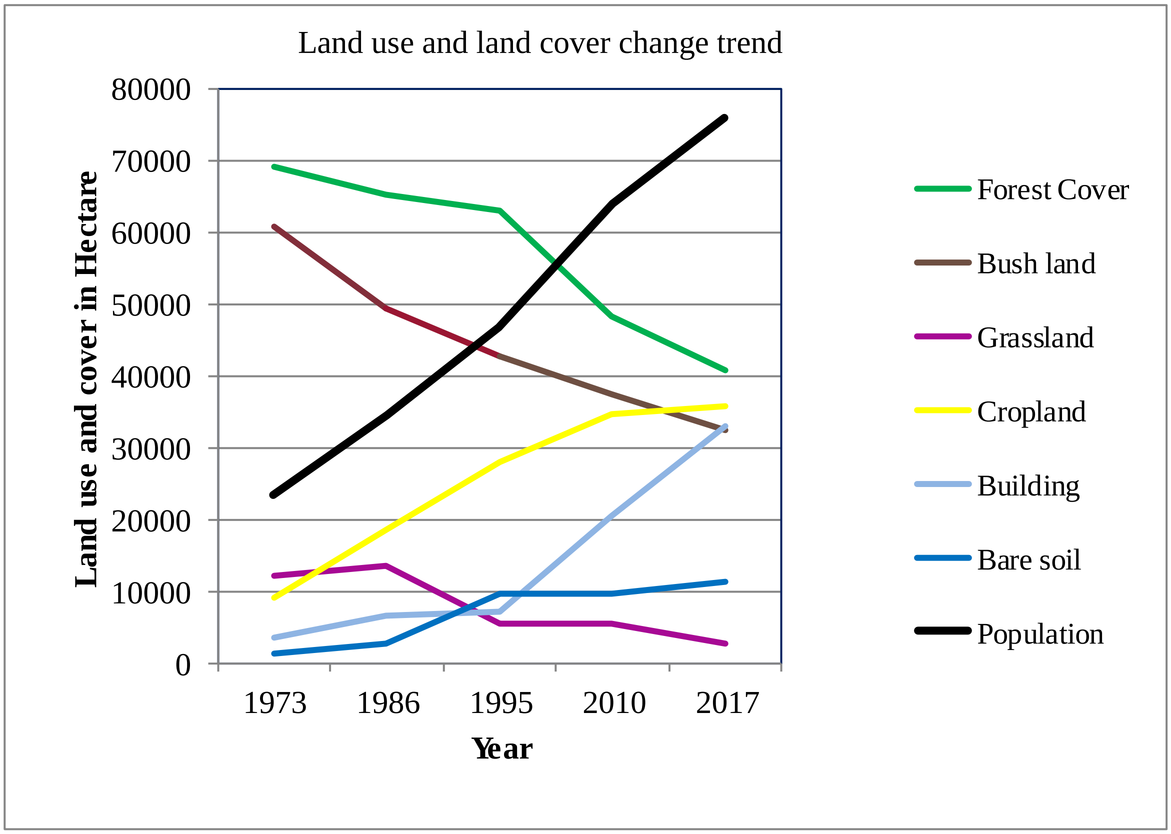

Figure 14: Land use and land cover change trend (ha) (Source: Researcher).

The decline in the forest and bush land vegetative cover is attributed to increases in immigration, population, and infrastructure development as illustrated in Figure 14 However, the increased cropland, bare grounds and settlements as observed compensated the forest, bush land and grassland vegetative loss.

Hypothesis testing - 1

To test the hypothesis there is no land use and land cover changes along the wildlife corridor. A correlation was done to show the strength and direction of association that exists between land use and cover changes with the population density as illustrated in Table 8, 9 & 10 below

Table 8: Land use and cover change statistic 1973-2017 in Hectares (Source: Reseacher).

Land use and cover	Forest	Bush land	Grassland	Cropland	Settlements	Bare ground
1973	69164	60996	12240	9160	3556	1155
1986	65479	49470	13534	18633	6608	2547
1995	63180	42763	5493	28136	7020	9679
2010	48359	37466	5385	34770	20597	9694
2017	40864	32605	2572	35895	32935	11400

Table 9: Population density (Source: KNBS)

Year	1979	1989	1999	2009
Pop density	28.46	38.06	69.06	88.86

Table 10: Land use and cover association with the population density 1973-2017 (Source: Researcher). .

Land use/cover type	**Pearson Correlation**	**Sig. 0.05**	**Result**
Forest	-0.94	0.02	Strong negative correlation
Grassland	-0.95	0.07	Strong negative correlation
Bush land	-0.96	0.00	Strong negative correlation

Land use/cover type	**Pearson Correlation**	**Sig. 0.05**	**Result**
Cropland	0.98	0.01	Strong Positive correlation
Settlements	0.89	0.04	Strong Positive correlation
Bare grounds	0.97	0.01	Strong Positive correlation

Pearson correlations showed that forest had declined at -0.94-bush land -0.96 and grassland -0.95. Natural vegetation cover is negatively correlated through the years in relation to population density. While the bare ground had a strong positive correlation between 0.97, cropland 0.98 and settlements 0.89 increases at a positive correlation. This affirms the description that natural vegetation cover is greatly in decline while cropped, bare grounds and settlements cover are greatly on the rise.

4.3.4 Drivers of land use and cover changes

Farming has increased over the years from 1973 to 2017. This is facilitating massive land cover changes. Forest cover and grassland have declined and as a result, the cropped land, settlement and infrastructure development (bare grounds) have increased. The factors contributing to the land use and land cover are population increase. The population density is strongly correlated to land use and land cover changes Table 10.

The cropland, settlements, and infrastructure development are increasing as the population increases while the land cover (forest, bush land, and grassland) are decreasing as the population increase. The government policy of resettlement during the 1980's led to immigration into the Ntirimiti and Subuiga areas that have contributed to the current high population. Moreover, the macroeconomic policy facilitates the land use and land cover change. Horticulture crops have a ready market for export and fetch the farmers' high returns. This influences the community members to open up more land for cultivation so that they can produce more crops for both commercial and subsistence purpose.

In addition, from the survey majority (76%), of respondents cited population increase as a major contributing factor to land use change followed by inadequate land 19% and 5% cited the need for more land to increase productivity thus resulting into increased profit. The respondents that cited inadequate land as a driver argued that due to increase in the population, the land subdivision was high hence small pieces of land and this influenced them to encroach into the corridor in order to open up more land. This study found that population growth; the quest for land ownership and motivation to make more income from those lands puts pressure on land use change and land cover change.

Hypothesis testing - 2

To test the hypothesis that 'there are no significant drivers of land use and land cover changes in the wildlife corridor, a non-parametric chi-square test was used as shown in Table 11 and Table 12. The study found out that at 0.05 significance level and four degrees of freedom, the calculated chi-square value was 21.38 while tabulated value was 9.49. Hence null hypothesis was rejected due to inadequate information the alternative hypothesis was adopted. Thus, the drivers that are population increase need for high returns and inadequate land are statistically significant for land use and land cover change.

Table 11 : Drivers of land use hypothesis test (Source: Researcher).

Drivers of land use						
			Drivers of land use			Total
			Population increase	more profit	No land	
Extent of land use change	1-5	Count	92	5	13	110
		Expected Count	83.9	4.9	21.2	110.0
	6-10	Count	1	0	1	2
		Expected Count	1.5	.1	.4	2.0
	0	Count	10	1	12	23
		Expected Count	17.5	1.0	4.4	23.0
Total		Count	103	6	26	135
		Expected Count	103.0	6.0	26.0	135.0

Table 12: Chi-Square Results

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.378[a]	4	.000
Likelihood Ratio	18.119	4	.001
Linear-by-Linear Association	19.835	1	.000
N of Valid Cases	135		

4.4 Viable Options for Conservation and Management of the Wildlife Corridor

Mt. Kenya to Ngare Ndare wildlife corridor is a narrow passage surrounded by a matrix of the settlement, infrastructure, and cropland as illustrated in Figure 15. Thus following are the possible conservation and management strategies that can be employed to restore the wildlife corridor.

Create a buffer zone around the wildlife corridor and fence using the native vegetation in order to control encroachment and encourage the interior species. In addition, the geofencing can be used where the wildlife is collared and whenever they stray out of the wildlife corridor a text message is sent to the local warden with GPS coordinate of that wildlife location. The farmlands can be fenced using the beehives, the bee sound keeps wildlife away and in case of an attempt to stray, a swarm of bees can attack, scaring the wildlife away. Moreover, farmers can grow the chili pepper around the fields and this repels the wildlife. This will help reduce the human-wildlife conflicts. Moreover, the chili pepper becomes an alternative source of income. There is need for introduction of woodlots and bush land along the farm edges in order to maintain natural vegetation strips. This will help in wildlife corridor repair.

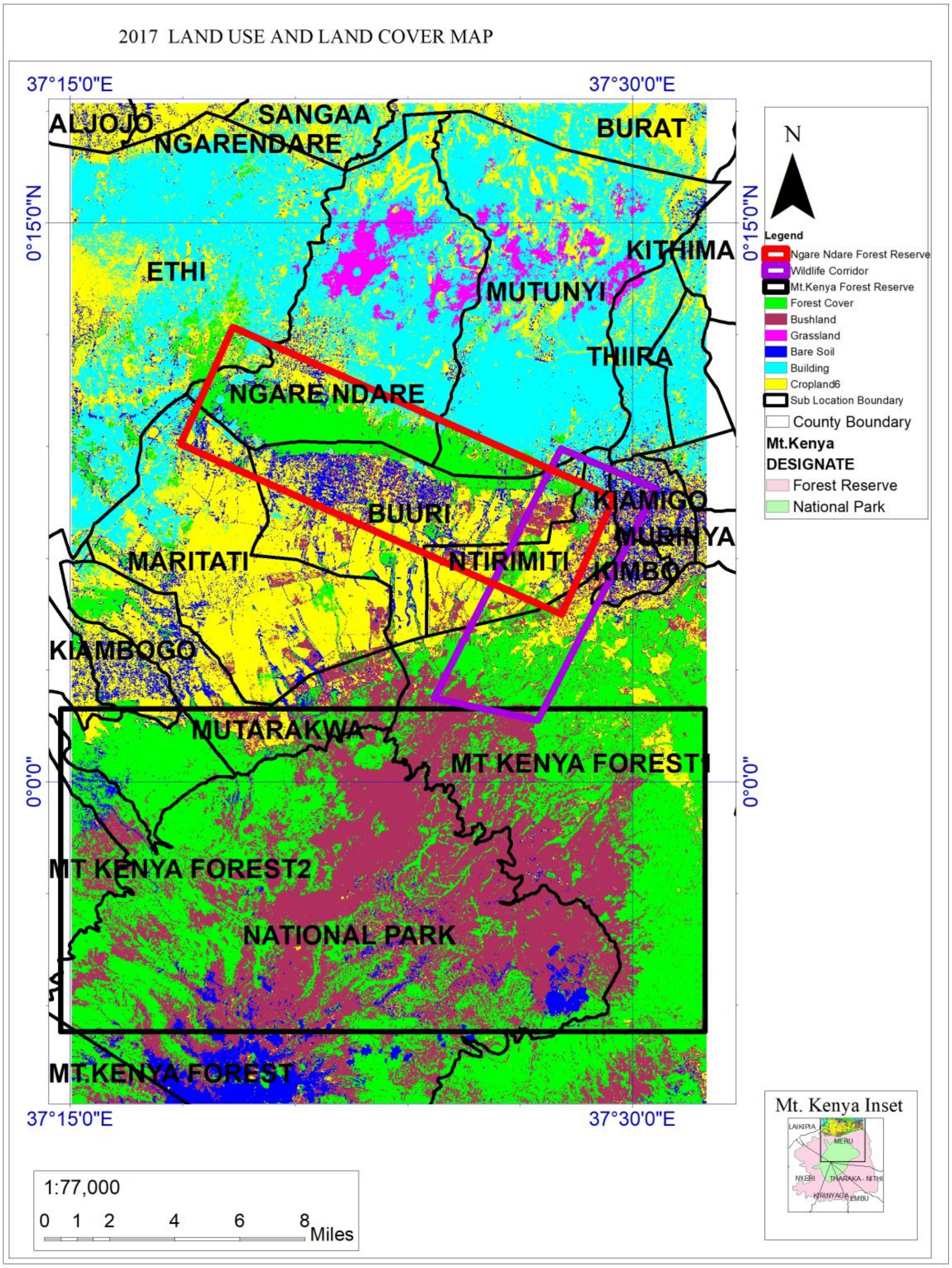

Figure 15: status of the wildlife corridor 2017 (Source: Author).

The local community can engage in ecotourism activity, for example, camping, hiking, and offer hospitality services to the tourist hence earning an income. Through doing this, they are able to raise funds without engaging into wildlife habitat destructive livelihood sources.

However, there is a need to ensure community participation in the wildlife corridor conservation and management, since the local community lives with the wildlife there is a need for them to be knowledgeable about conservation issues. It was observed from the survey that 89% of the respondents were not knowledgeable about the conservation matters. Hence, the need for active community involvement in conservation and wildlife management.

4.5 Discussion

The land in Ntirimiti and Subuiga was historically government-owned land; people were resettled there and later became individually owned. During 1980's land demarcations was done and individual land ownership was encouraged as a motivation for agricultural production (Smucker, 2002). Individual land ownership encourages heterogeneous land use activity. From the 1970-1980 period, people have continued to immigrate into Ntirimiti and Subuiga areas. High immigration of people from Katheri, Meru town, Githongo, Egoji and Abuthuguji was in response to increasing quest for land. The immigration is observed to be continuous and will progressively increase over the years which in-turn is likely to have impacts on land use and land cover. According to Olson *et al*, (2004), when space for settlement becomes small, people open up more land hence changing land cover from forestland, bush land, and grasslands to cropland, settlements, and bare grounds.Increase in population leads to land sub-division that drives land use and land cover change.

In addition, in the survey agriculture was the major source of livelihood. The mainland use activity was small-scale farming where they grew cabbage, potatoes, onions, carrots. This was practiced due to small sizes of land and need for high income. According (Omiti & Mccullough, 2009) horticultural crops like tomatoes, kales cabbage and onions are grown by small-scale farmers for subsistence and commercial purposes in Kenya and contribute 23% of the export. A study by Ogechi & Hunja (2014), also found that small-scale farmers are likely to cultivate in marginal areas hence land use and land cover changes.

The wildlife corridor provides the migratory route for wildlife from one habitat to another. Wildlife moves from Mt. Kenya forest Reserve to Lewa Wildlife Conservancy in the wet season and from Lewa to Mt. Kenya during the dry seasons via the Ngare Ndare forest reserve. As the wildlife use the corridor sometimes, they stray into the neighboring cropland causing crop destruction. However, the human being encroaches into the forest, bush land, and grassland in search of grazing fields, the collection of fuel wood and farmland for cultivation. This results in the human-wildlife conflicts A study by Waithaka (2010), found that human-elephant conflict in Kenya is significant to land use and land cover change. This study found that the small-scale farmers were knowledgeable about the movement of wildlife across the conservancy and forests but crop destruction from grazing is still a challenge.

Land use and land cover changes have been observed to be dynamic from 1973-2017, the forest cover, bush land, grassland cover have declined over the years at 0.94, 0.95 and 0.96 respectively while the cropland, settlementss and bare grounds in form of infrastructure have increased at 0.98, 0.89 and 0.97 respectively. According to Olson *et al*, (2004), when space for settlement becomes small, people open up more land hence changing land cover from, forestland, bush land, and grasslands to cropland. Land use and land cover are strongly correlated to population density Table 10 for example cropland had a strong positive correlation of 0.98. Moreover, a study by (Willkomm, *et al*, 2016) showed similar land use and cover change patterns in the Mt. Kenya region. According to Willkomm, cropland had increased in the area and mostly dominated by small-scale horticultural farming in eastern and southern part of the Mt. Kenya region. In addition, in his study he revealed a decrease in forest and scrubland cover that was lost to cropland. Land use and land cover are strongly correlated to population density from the findings. The total population within Ntirimiti and Subuiga has been growing due to immigration into the area. High population density has led to the land subdivision that contributes to land use and land cover changes. From the 1970-1980 period, people have continued to immigrate into Ntirimiti and Subuiga areas The immigration is observed to be continuous and will progressively increase over the years which in-turn is likely to have impacts on land use and land cover. According to Dessie & Kleman (2007) on a study of pattern and magnitude of deforestation in the South Central Rift Valley Region of Ethiopia, the size of farmlands in fragments continues to increase due to land sub-division thus an increase in landscape fragmentation. Similarly, in Ntirimiti and Subuiga population was cited as contributing factor to land use and land cover change. Land tenure too contribute to land use and land cover changes because with the individual land ownership, the land use decisions are made at a personal level hence heterogeneous land use activity. According to Okello (2005), conflict of interest can lead to informal land use depending on the land tenure arrangement. He found out that the land tenure system is likely to affect land use change and cover destruction resulting from conflict since most of the lands were, acquired from the government. However, there is a high likelihood of cover destruction prior to acquisition and ownership transfer from the government through the settlement scheme (impact of public policy on fragmentation). In addition, poverty and quest for high returns facilitate land use and land cover changes, this was confirmed by the respondent who cited need for income and subsistence needs as driving factors to land use and cover changes. According to Maitima *et al*, (2010), poverty and motivation to generate a source of income have increased small-scale farming that has negatively impacted good land use practices. This study found that the motivating factor of small-scale land use was mainly to support an increase in income and food supply for subsistence. The mainland use activity was small-scale farming where they grew cabbage, potatoes, onions, carrots. This was practiced due to small sizes of land and need for high income. A study by Ogechi & Hunja (2014), also found that small-scale farmers are likely to cultivate in marginal areas hence land use and land cover changes.

Since the wildlife corridors lies along the settled area, cultivated and infrastructure development area a number of option could provide harmony co-existence and help preserve the wildlife corridor The community living adjacent to wildlife corridor should engage into sustainable land use activities and or use alternative sources of livelihood for example beekeeping that can fetch them good income as well as favour the wildlife habitat to thrive. The beekeeping will not only provide them a source of livelihood but will also prevent the wildlife from straying into the farmland. A study by (King *et al*, 2011) in northern Kenya proved that bees could scare away wildlife from straying into the farmlands. The local community can engage in ecotourism activities that earn them a livelihood source. Moreover, they can grow chili pepper that fetches high income; the chili pepper is non-palatable to wildlife.

Local community members need to know the best and sustainable land use practices, for instance, the employed of agro-forestry. According to Williams & Schirmer (2012) in their study, they found out that awareness of the land use and land cover change is critical to sustainable conservation. This study found that the majority of the respondents are not aware of sustainable land conservation measures. Moreover, agroforestry will promote the wildlife survival as well as improve the land productivity.

CHAPTER FIVE - SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This section provides the summary of the study; particularly the findings of the study on the respondents' characteristics; and the land use and cover changes along the wildlife corridor between 1973 and 2017. The summary section also gives an outline of findings of the drivers of land use, land cover changes, and additionally summarizes the viable options to the conservation of land and mitigation of land changes. This section gives the conclusion and a few recommendations based on the findings of this study.

5.1 Summary

With respect to the respondents' characteristics, the majority of the respondents: were male (54%); age above 40 years (70%) and are more likely to engage in the farming practice. In addition, most had the primary educational level (52%) and at least 5 persons in their household (98%), pointing out that there is a high potential for the wildlife to have less size of land left for their use. The study found that the main source of livelihood is agriculture followed by livestock keeping especially using small-scale farming methods in fragmented areas. And this has continued to draw many migrants into the area and thus pointing out that at a point in time the increased settlement causes resource degradation.

This study found that the forest cover, grassland and bush land vegetation cover has been reducing at a commendable level from 1973 through to 2017. The statistical test indicated that the decline is at (-0.94,-0.95 & -0.96 Pearson statistic) for the forest, grassland and bush land vegetation cover respectively. This decline is compensated by an increase in the cropped cover, settlements and bare soil that has continually increased over time statistically at 0.98, 0.89 and 0.97 Pearson statistic respectively. From the satellite image classification, the Kappa statistics is close to one and percentage accuracy closer to 100% of overall imagery accuracy was statistically significant. The study found that forest, grassland, and bush land vegetative decline is inevitable.

In addition, statistically, at the 0.05 alpha level, the drivers of land cover changes were population growth, the quest for land ownership/use and motivation to make more income from those lands. These were influenced by the purpose for land use, the motivation for land use and the overall ecosystem of wildlife ecology. The major land use activity was observed to be small-scale farming that means that there is a high likelihood of unsustainable land use due to cultivation in marginal areas. The motivation for these small-scale farming was for an increase in income and food supply for subsistence, and more often the farmers' practices negatively affect good land practices. The study found out that the wildlife corridor is used by wildlife as they move across conserved areas like Lewa to Ngare Ndare and Mt Kenya forest. However, wildlife has a severe impact on local livelihoods such as crop damage and this result, in the illegal killing of wildlife.

Viable options for wildlife conservation and management in the wildlife corridors, awareness on wildlife corridor conservation and local community engagement in conservation has not been well championed as the land use and land cover change continues to increase. This study found out that majority of the respondents were not aware of sustainable land conservation measures that are critical to sustainable conservation. However, there is a need to create buffer zones through effective management and control of grazing; and settlements an underpass along Ntirimi-Kibirichia road to enhance wildlife conservation. The viable means of livelihood and sustenance for the majority of the world's population is mainly agriculture, this, in the nearest future will be threatened by the level of rainfall, precipitation, and river dynamics if measures to sustainably harness the products are not put-in-place.

5.2 Conclusions

The study found out that there has been a drastic decline of forest, bush land and grassland covers. While the cropland, settlementss and the bare soils have increased over the years from 1973 to 2017. The land use and land cover changes along the wildlife are contributed by population increase. The human activities are the major factors contributing to partial or complete blockage of wildlife corridors. The population increase results in the rise in cropland; settlements and bare soils land use. While the population is negatively correlated with the forest, grassland and bush land cover. In addition, the study found out that majority of the respondents were not aware of the conservation measures and strategies.

Study findings confirm the results found out by the government during the mapping of wildlife corridors and dispersal areas. The report indicates that human activities are the major causes of wildlife dispersal routes blockage as found out in this study Similarly high land subdivision that results into individual land ownership and heterogeneous land uses were observed in this study and it was also cited in the report on dispersal routes by the government of Kenya. Inadequate knowledge of conservation measures was also indicated in the report as a contributing factor to wildlife corridor loss. This because people lack information on the conservation strategy that needs to be practiced. Thus, land use and cover changes are the key contributing factors to wildlife corridor partial or complete blockage.

The land use and land cover changes are traditional information that known to rural settlement along the wildlife corridors (Okello, 2005; Kioko & Okello, 2010). This information, especially those that are statistically significant and known to the inhabitants, is capable of conserving land cover and mitigating the effects of change in land use. The population globally, in Kenya, and across the wildlife corridor is expected to increase as part of an anticipation of the 2 billion mark in 2015 (Bongaarts & Sinding, 2011). Such population outburst through massive migration, commercialization and resource scarcity will challenge the currently overwhelmed land use if sustainable measures are not put-in-place to increase vegetative land cover and reduce the further reduction of natural cover

5.3 Recommendations

5.3.1: Wildlife Corridor Management

a) Fencing wildlife corridors and installing monitoring systems.

b) Construction of artificial pathways where infrastructure development for example roads or railway cuts across a wildlife corridor.

c) Wildlife corridors development should be integrated with development planning for example settlement, roads, and railways.

d) Create public awareness about the wildlife corridor conservation and management.

e) Promote participatory community involvement in the conservation of wildlife corridor.

f) Recommends the development and promotion of payment for environmental services.

g) Encourage compensated for loss incurred for example crop destruction, loss of livestock and human injury caused by the wildlife.

h) Incorporate family planning into the conservation policies.

5.3.2 Land Use Management

a) The government ministries need to be integrated for example the Ministry of Environment and Forestry, Ministry of Tourism and Wildlife, Ministry of Lands and Physical Planning and Ministry of Agriculture and Irrigation during conservation policymaking.

b) Advocate for the use of Integrated Agricultural Development.

c) Encourage the use of alternative sources of livelihood for example beekeeping, chili pepper farming, and eco-tourism.

d) Incorporation of wildlife development into the land use planning.

5.3.3 Further Research

This study did not investigate all the characteristics of the wildlife corridor, impacts of land use and land cover changes on all the wildlife corridors. Hence proposes that a further research needs to be done on all the migratory corridors. Moreover, there is the need for more investigation on the community attitudes towards wildlife corridor conservation and management so that their perceptions can be taken into consideration during decision-making. This is very important because the community members are the one who owns the land that needs to be leased for wildlife corridor protection. In addition, more research should be done on the best suitable payment services that should be enacted to motivate the community living adjacent and taking part in the wildlife conservation.

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APPENDIX

EVALUATION OF LAND USE CHANGES BETWEEN MT KENYA AND NGARE NDARE WILDLIFE CORRIDOR

HOUSEHOLD QUESTIONNAIRE

NOTE: The information that you will give here will be used strictly for academic purposes and will be treated with high confidentiality. Your assistance will be greatly appreciated

SECTION 1

1. **Respondent No__**
2. County:____
3. Sub-County:____
4. Location:____
5. Village name:____
6. GPS location of Household:
   X-coordinates _____________Y-coordinates________________
   Elevation ________________
7. Approximate household distance from the park/reserve boundary (Km)____________

PART 1: HOUSEHOLD (HH) CHARACTERISTICS

Social Economic

1. Gender: Male □ Female □
2. Age Category: □20-29yrs □30-39yrs □ 40-49yrs □ 50-59yrs □ 60-69yrs □Above 70yrs
3. Marital Status □Single □ Married □ Divorced □ Widowed
4. Highest education attainment:□ No formal education □ Primary certificate □ Secondary certificate □ College certificate □ College Diploma □ College/University 1st Degree □ Master's Degree □ Doctorate Degree
5. Total number of people in your household including you______

6. The source of livelihood □ agriculture □ livestock keeping □ Employment □ hunting □ business □ charcoal making (objective 2)
7. The original homeland______
8. The year settled here: □ before 1970 □ 1970-1980 □ 1980-1990 □ 1990-2000 □ 2000-2016 (objective 1)
9. The reason for migrating to the area □ Agriculture □ livestock keeping □ Settlement □ employment □ others please specify (objective 2)

Farm characteristic

1. The size of your farm □ 1-2 Acres □ 3-5 Acres □ 6-10 Acres □ >10 Acres

2. The nature of land tenure of the household □ government land □ rented □ family □ others specify; ________

3. The historical land acquisition □ self-allocation □ government settlement scheme,

□ rented land □ bought land if bought specify from whom______ □ Not sure, □ others (specify) ___________

Land Use

1. Household land use activities □Grazing □Large Scale farming □Small Scale farming □fuel wood □ ecotourism (objective 1)

2. What motivates the land use activity ___________?

____ (objective 2)

3. Has the land under use been □ increasing □ decreasing over the years? (Objective 1)

4. Reasons for the change above___________

____ (objective 2)

5. The extent of the land size change in acres__________ (objective 1)

Climate Change

1. Any changes in river volume □ yes □ no .Explain___________

____ (objective 2)

2. Any change in rainfall patterns □ yes □ no .Explain___________

____ (objective 2)

Wildlife Corridor conservation and Management

1. The knowledge about the wildlife corridor □ yes □ no (objective 3)

2. Are there any wild animals around this area □ yes □ no?

3. Give areas where wild animals are found___________

____

____

___________ (objective 3)

4. How is there movement of wild animals'

____?

____ (objective 3)

5. What affect the movement of these animals from one area to another?

____ (objective 2)

6. What measures or actions can be done to facilitates wild animal movement (objective 3)____

7. The human wildlife conflicts experienced in the area

____ (objective 2)

8. The impact of the presence of wild animals in this area to you□ Positive □ negative Explain your response above ___________ (objective 3)

9. Your recommendation to the government on wildlife corridors management explain

____ (objective 3)

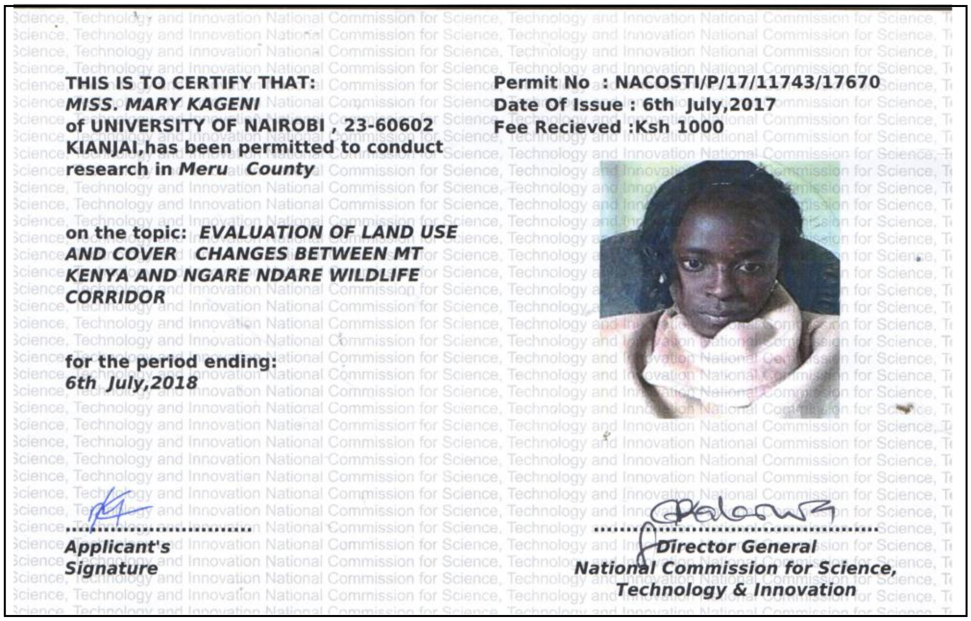
FIELDWORK PHOTOGRAPHS

Wildlife corridor and its use, by the wildlife and for research.

Human encroachment

Land Use Activity along the wildlife corridor

Research Permit.



THIS IS TO CERTIFY THAT:
MISS. MARY KAGENI
of UNIVERSITY OF NAIROBI , 23-60602
KIANJAI,has been permitted to conduct
research in *Meru County*

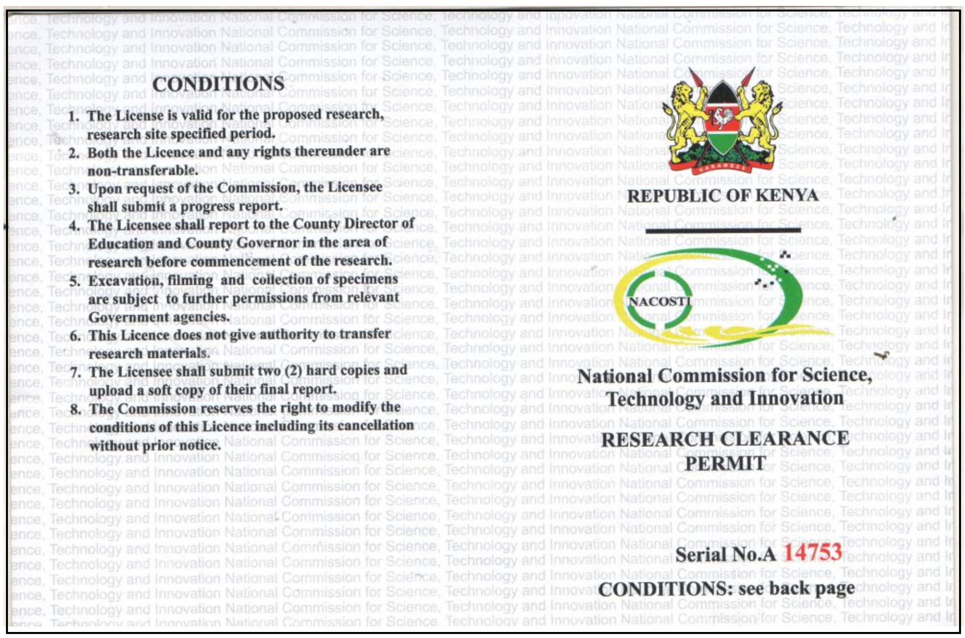
on the topic: *EVALUATION OF LAND USE AND COVER CHANGES BETWEEN MT KENYA AND NGARE NDARE WILDLIFE CORRIDOR*

for the period ending:
6th July,2018

Permit No : NACOSTI/P/17/11743/17670
Date Of Issue : 6th July,2017
Fee Recieved :Ksh 1000

Applicant's Signature

Director General
National Commission for Science, Technology & Innovation



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