A SPATIAL MULTI-CRITERIA ANALYSIS OF LAND USE, LAND COVER AND CLIMATE CHANGES ON WILDLIFE ECOSYSTEMS PLANNING AND MANAGEMENT IN MERU CONSERVATION AREA

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DECLARATION AND RECOMENDATION

Declaration

This thesis is my original work and has not been presented for the award of degree in any other University.

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Recommendation

This thesis has been examined, passed and submitted with our approval as University Supervisors.

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DEDICATION

I dedicate this work to those who the term conservation triggers a concern to ensure my grandchild will enjoy the value of wildlife as we presently do.

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ABSTRACT

Protected areas are recognized as among the most effective tools that have protected the wildlife species from extinction and human induced threats. However, despite the establishment and spread of these protected areas in most parts of the world, wildlife numbers and their habitats have declined drastically due to land use land cover changes (LULCs) coupled by climate variability in the past decades. Protected areas and their buffer zones have been converted to settlement areas, grazing fields and farms by people living around these parks and reserves as a coping mechanism for declining resources at the expense of wildlife populations and their ecosystems. The study was carried out at Meru National Park (MNP) and Mwingi National Reserve (MNR) to establish changes in land use, land cover and climate variability over time and their implications on wildlife ecosystems. The study specifically sought to establish changes in land use land cover, establish climate change over time, and determine the effectiveness of the existing management plan and identifying the adaptation strategies that are being used as mitigation to climate change. To achieve these objectives, the study used remotely sensing data from Landsat satellite images of 1985 to 2015 together with physical, demographic data and questionnaires were used in post classification analysis using ArchGIS to analyze the outcome of different land use practices. The results showed a rapid decline in forest and shrub land in the study area by 14.1% and 37.8%, respectively while grassland and bareland tend to have increased to 27% and 16.2% respectively over time. From the Pearson correlation test, there was significant positive correlation between grassland and bareland ($r = 0.860$, $p=0.140$), significant negative correlation between forest and bareland ($r = -0.692$, $p=308$) and between shrubland and bareland ($r = -0.631$, $p=369$). Climate variability in MNP and MNR had impacts on wildlife ecosystems as established during by the strong negative correlation observed ($r = -0.766$, $p=0.05$). Multi-criteria decision making analysis was applied as a planning tool to establish the effectiveness of the management plans. This analysis incorporated the value measurement, goal setting and outranking. In addition to guided observations, semi structured questionnaires, and interview schedule were administered to the local community and institutions respectively to acquire relevant data on establishing the adaptation strategies for climate change mitigation by the wildlife managers and local communities in the study areas. The study established that continuous increase in human wildlife conflicts, encroachment into the Protected Areas (PAs), and low support of conservation programs by community are indicators of non effectiveness in the management plan. More so, there are various adaptation strategies to mitigate changes in climate by local community and wildlife managers. These included fencing of Protected Areas (PAs), introduction of irrigation, encroachment in protected areas and amendments of laws, policies and institutional structure. Both MNP and MNR have undergone significant changes in land use land cover over the years which have over time affected the wildlife populations and their ecosystems. These changes are likely to have been brought about by inevitable climate change which has altered rainfall distribution leading to droughts that have hindered vegetation growth. On the other hand, increasing human population by 57.4% from 1980 around these protected areas has over the years contributed towards land cover from their interaction with land through activities that are meant to provide socioeconomic livelihoods such as farming and livestock keeping. In view of these findings, the study recommends an integrated planning of protected areas in view of the changing land use land cover and climatic regimes in the study areas.

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ABREVIATIONS AND ACRONYMS

AWF	African Wildlife Foundation
GDP	Gross Domestic Product
HWC	Human Wildlife Conflicts
IBAS	Important Bird Areas
IFAW	International Fund for Animal Welfare
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KWS	Kenya Wildlife Service
LULC	Land Use land cover
MCA	Meru Conservation Area
MCDA	Multi-Criteria Decision Making Analysis
MNP	Meru National Park
MNR	Mwingi National Reserve
NACOSTI	National Council for Science, Technology and Innovations
PA	Protected Areas
PAPF	Protected Areas Planning Framework
RCRMD	Regional Centre for Resource Mapping and Development
UNEP	United Nations Environmental Programme
WEP	Wildlife Ecosystems Planning

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

The use of land to produce goods and services has been undertaken by humans around the world for over the entire years of settled agriculture (Houghton 1994 & Vitousek et al,. 1997). The use of land to yield goods and services represents the most substantial human alteration of the earth system (Ester et al., 1982; Ojima and Turner, 1994). Human use of land alters the structure and functioning of the ecosystems and it changes the distribution and abundance of wildlife in various protected areas (Defries et al., 2007; Syombua, 2013). As the human society exploit the natural resources for socio-economic gain, the biodiversity is affected to an extent of irreversible change or it takes long time to recover to productivity.

The impacts of anthropogenic activities on wildlife habitat and species vary depending on the spatial and temporal scales considered and the persistence of the activities in the landscape (Olson et al., 2004). Land use and land cover changes are important processes that influence the ecological integrity of wildlife protected areas (Noe, 2003; Mbote, 2005; Syombua, 2013).Kenya is endowed with a diversity of natural resources. These resources include wildlife which is conserved in protected areas such as national reserves and national parks. However, conservation and management of wildlife and their habitats in Kenyan protected areas and many other parts of the world continues to experience enormous challenges as a result of dynamics of land tenure, land use and climate change (Syombua, 2013; Olson et al., 2004).

Increasing human population around these protected areas continues to exert pressure on resources leading to competition, conflicts and overexploitation (Olson et al., 2004). This means that wildlife conservation areas in Kenya are slowly getting degraded and fragmented into 'Islands' of national parks and game reserves surrounded by land use activities most of which are incompatible with conservation. Existing protected areas are surrounded by various communities practicing different land use activities that include agriculture, agro-pastoralism and settlements (Smucker, 2002; Otuoma 2004& DeFries, 2007). Proficient planning is therefore crucial for enhancing the future survival of wildlife within and outside protected areas

and to enhance continuous production of ecosystem services such as forage, breeding grounds derived from such areas (Okello and Wishitemi 2006; Syombua,2013).

Problems associated with diversity, complexity and incompatibility of the above mentioned land use activities is likely to be further compounded by changing land tenure systems from the initial communal forms of land ownership to small fragmented privately owned parcels of land thereby increasing immigration and human settlement. This is likely to result to serious ecological and socio-economic consequences for biodiversity conservation. There are, for example, loss of forage, breeding areas, scarcity of water for wildlife due to reduced river water flow and human-wildlife conflicts that have probably been fueled by resource competition and loss of wildlife migratory corridor and dispersal areas.

Global climate change is another factor that has adversely affected the management of wildlife and their ecosystems (Gitay et al., 2002; Hannah et al., 2002; Schneider and Root, 2002). This is due to changes in weather patterns such as temperature and rainfall over the years. These climate changes are likely to cause variations in seasonal events that cause decline in area inhabited by wild species, ecological decline in land productivity for human needs prompting them to seek alternative sources of livelihoods from protected areas. Changes in natural ecosystems are attributed to invasive plant species, species migration, resource competition and diseases. In their study, Walther et al., (2002) reported that climate change results to shifts in species distributions often along elevation gradients; changes in the timing of life history events, decoupling of coevolved interactions, such as plant–pollinator relationships; effects on demographic rates like survival and fecundity.

Management of wildlife in the protected and surrounding areas is guided by wildlife management plans prepared to suit the conservation needs of each National Park, Reserve, Sanctuary or Conservancy. The persistent human wildlife conflicts (HWCs), incompatible land use practices and poverty of communities living around protected areas suggest that participatory planning and management of wildlife conservation in Kenya areas has not been adequately realized. This is despite numerous efforts by the conservation authorities to develop management plans for various protected areas in the country. For example, the Meru Conservation Area (MCA) management plan

developed in 2007 under the new Protected Area Planning Framework (PAPF) model (KWS, 2007) was meant to enhance the efficiency of planning initiatives and the understanding and buy-in of both managers and stakeholders.

The MCA Management Plan is intended to be a practical tool to support and guide the coordinated and integrated management of the four constituent PAs that make up the MCA. These are Meru National Park, Bisanadi National Reserve, Kora National Park, and Mwingi National Reserve which are regarded as a single ecological and administrative unit. Providing connectivity zones between these protected areas facilitates several critical conditions which includes facilitating feeding across multiple habitats types (Kozakiewicz, 1995), re-colonization of degraded patches (Thomas, 1994) reduction of inbreeding (Richards, 2000) and provision of vital interactions that sustain ecosystem health (Crooks and Sanjayan, 2006).

Resentment and opposition from local communities towards protected areas management is due to the fact that establishment of most protected areas in Kenya and other parts of the world was based on the Yellowstone model which lacked adequate consultation and approval of local communities who were traditionally associated with such areas and their resources (Machlis and Tichnell, 1985; Runte, 1997). It is in this regard that local communities around most protected areas consider their governments to have taken away their traditional land which they depended on for socio-economic and cultural purposes. There have been therefore, numerous cases of human-wildlife conflicts and low support for conservation by these communities living around protected areas (Mbote, 2005).

Conservation and management of wildlife in Kenya is guided by established institutional and legislative frameworks. The Sessional Paper No 3 of 1975 initiated the formulation of Wildlife Conservation and Management Act (CAP. 376) of 1976. It is through the implementation of this Act that led to the establishment of Kenya Wildlife Service, an independent institution to coordinate all matters pertaining wildlife in the country. Currently, the new Wildlife Conservation and Management Act 2013 and the Wildlife Conservation and Management Policy 2012, provide a framework through which conservation and management of wildlife in Kenya should be practiced amidst emerging issues such as climate change and human-wildlife

conflicts. Moreover, the implementation of Kenya's Vision 2030 has put a heavy burden on promoting wildlife conservation and environmental conservation as drivers for economic and social development. This study is motivated by the widening gap between conservation of wildlife ecosystems, changing land tenure and land use options around protected areas and low incomes of the local communities who may possibly be the beneficiaries of these conservation initiatives.

1.2 Statement of the Problem

The wildlife conservation areas are slowly getting degraded and fragmented into 'islands' of protected areas. On the other hand, increasing human population around these protected areas continue to exert pressure on the available diminishing natural resources. This problem is coupled by land use land cover that hinders continuous realization of ecosystem services required by both wildlife and human society such as provisioning, regulation, support and socio-cultural benefits. Further, the impacts of ongoing climate change on wildlife ecosystem have contributed to seasons changes, declining land productivity and changes in community ecology. Also among these is lack of inadequate proficient planning for the protected areas which have resulted to numerous human wildlife conflicts, resentment and mistrust by local communities to wildlife managers.

1.3 Purpose of the Study

The study was conducted to analyze the changes on land use land cover, climate change and their impacts on wildlife ecosystems planning in Meru National Park (MNP) and Mwingi National Reserve (MNR) of Meru Conservation Area (MCA).

1.4 Objectives of the Study

The objectives of the study were to;

1. Examine changes in land use and land cover and its impacts on wildlife ecosystems
2. Examine variations in climate and its impacts on wildlife ecosystems
3. Determine the effectiveness of the current MNP and MNR management plan in addressing human wildlife conflicts.
4. Assess adaptation strategies for climate change adopted in the study area

1.4 Hypothesis of the Study

HO_1 There are no significant changes in land use and cover over time in Meru National Park and Mwingi National Reserve

HO_2 Variations in climate over time do not have impacts on wildlife ecosystems

HO_3 The current MCA management plan is not effective in addressing human wildlife conflicts and socio-economic needs of the communities

HO_4 There are no adaptation and mitigation strategies for climate change in the study area.

1.5 Justification of the Study

This study examined the extent of changing land cover within and around the protected areas as influenced by dynamic land tenure systems and land use patterns as well as the impacts of climate change on wildlife ecosystems. The study further sought to investigate the potential for a planning decision that was to address both the need for functional ecosystems and improvement of community livelihoods. The study findings are useful in order to identify appropriate adaptation strategies for changing climate in MCA, and hence development of an integrated land use and wildlife ecosystems planning model in the study area. The study findings form part of reference material for future researchers.

1.6 Scope of the Study

The study focused on assessing the spatial-temporal changes on land use and land cover that have occurred within and around wildlife conservation areas, their effects on wildlife ecosystems and the livelihoods of local communities living around them. It also focused on the effects on continuous climate change on habitat and species occurrence from 1985 to 2015. Specifically, the study analyzed land use and land cover (LULC) activities in the study areas. The study further investigated the achievement of the current MCA management plan in addressing key challenges such as human wildlife conflicts, community participation as well as benefit sharing. The selected study areas were MNP and MNR and the adjacent community land up to 5 kilometers from the protected area boundaries. The areas occupied by the community are included because of their close interaction with wildlife and the consideration that they may also be experiencing the highest frequency and intensity of human-wildlife conflicts.

1.7 Operational Definition of Terms

Community Participation	A process and means of promoting people's involvement in conservation project, program or initiative in all phases of identification, design, planning, execution, management and evaluation
Conservation Area	An area that combines several protected areas and their surrounding dispersal areas and migratory corridors and managed as a single unit.
Dispersal Area	These are portions of land surrounding protected areas that are regularly used as refuge for wild animals in search for food, water, breeding or avoiding predation.
Effective Participation	This is the ability to act in the best way possible to provide the intended results in the conservation and management of wildlife considering socio-economic needs of the communities.
Local Community	They are people living around Meru Conservation Area who share common problems such as human-wildlife conflicts
Ecosystem Planning	This is the process of allocating resources in order to enhance conservation of wildlife and produce benefits to the communities living around the protected areas.
Protected Areas	These are areas with boundaries that have been set aside as wildlife habitat without human activities. They include Meru National Park and Mwingi National Reserves
Stakeholders	These are people who have a connection and/or legitimate interest and right with the Meru Conservation Area and contribute to its success or failure.
Wildlife Corridors	They are movement paths commonly used by wild animals when occasionally migrating from one habitat to the other.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview of Wildlife Conservation Management

Protected areas worldwide are refuge for wildlife and other forms of biodiversity, most of which are currently threatened due to anthropogenic activities and other factors. Protected areas (PAs) are among the most effective tools for protecting species from extinction and human induced threats (WWF, 2008). The world has over 100,000 protected areas of which the terrestrial one covers 12.2% of the earth surface (UNEP-WCMC, 2008). The aim of establishing these protected areas was to sustainably make use of natural resources, preservation of ecosystem services and integration of broader social development processes along with the core role of biodiversity conservation (IUCN, 1994; Alenka, 2005; Mbote, 2005; Mansourian *et al.*, 2009; IUCN, 2012).

With the vital role they play to link the communities and nature, Protected Areas (PA) should be driven by cultural values, as essential associates of biodiversity and the need to improve indigenous and local community's ability in management decisions affecting them (IUCN, 1994, Dudley *et al*, 2010). They focus not only on biodiversity goals but more so the humanity (WWF, 2008). To this end, community participation in PAs management has become an important topic in planning theory and practice (Alenka, 2005) where communities living around them should be considered in decision making. Recent trends in wildlife conservation signal a paradigm shift towards decentralized, less bureaucratic and more participatory models of protected area management which offer new opportunities for community involvement.

Initially, most of the PAs were established in non-settled areas or less populated areas otherwise known as the wilderness. However, continuous increase in human population and land use patterns has reduced the land available for wildlife conservation bringing about competition for space and resources between humans and wildlife resulting to frequent human wildlife conflicts. Human-wildlife conflict (HWC) is fast becoming a critical threat to the survival of many globally endangered species, including the large and rare mammals (MEA, 2005). The conflict occurs when wildlife requirements overlap those of human populations, creating costs to residents and wild animals (Ogada, 2011).

In view of the above, the section below discusses some major changes that have occurred in protected areas and how they have affected wildlife conservation. The purpose of this chapter is to have an in-depth understanding of the research under study in terms of the theoretical and empirical concepts and to be current in the study trends and techniques in land cover, land uses, climate change and their implications on wildlife ecosystems. Through the literature review, the several gaps that exist in this field of study will be identified.

2.2. Land Use Land Cover Changes and Its Impacts on Wildlife Ecosystems

Land use is the human modification of the natural environment or wilderness into built environment. It is mainly as a result of human activities. Whereas land cover is the observable feature that occupies the earth surface at a particular time period. (Nuwagaba & Namateefu, 2013; Musa & Odera, 2015). Worldwide land use and land cover changes are caused by changes in the way people use and manage land (Millennium Ecosystem Assessment, 2005). Changing land use and land cover patterns that have persisted in the environs of protected areas in recent years have been caused by human social and economic factors (Simms, 2006; WWF, 2008; Watson *et al.*, 2012).

Expansion and intensification of agriculture is among the most significant human interaction of the global environment (Matson *et al.*, 1997). Local communities have exploited the available land for agricultural production, livestock grazing and settlements converting the protected areas that were once surrounded by vast dispersal areas into ecological islands (Ogada, 2011). The land fragmentation, conversion and subsequent fencing have resulted to local extinction of wildlife species (Adler *et al.*, 2001; Tobler *et al.*, 2003; Worden *et al.*, 2003).

In Kenya, this fragmentation of natural habitats into isolated wildlife areas contributes to potential loss of biodiversity and reduced genetic exchange among the populations (Aboud, 2002; Mundia & Murayama, 2009). These changes have resulted to conflicts between communities depending on the natural resources to meet their daily socio-economic needs and wildlife that has been demeaned their movement corridors and dispersal areas. This in turn has had a profound impact on wildlife habitats and wildlife populations. To counter this, the Kenya Wildlife Service (KWS) has in recent

years adopted various measures to reduce cases of human-wildlife conflicts in areas surrounding protected areas, wildlife corridors and dispersal areas. This has been through fencing, increasing security surveillance and translocation of problem animals (KWS, 2007a).

In spite of the foregoing efforts, this costly approach appears not to have yielded the envisaged results in solving the problem. This is because wildlife management in protected areas is influenced by adjacent land tenure systems and land use activities as well as the social values of communities living close to these areas. For example, settlements around protected areas have contributed to majority of the PAs becoming ecological islands. These areas suffer massive degradation due to the concentration of wildlife in small areas coupled with pressure from land users surrounding them (Mbote, 2005). These changes have been further compounded by, for example, changing land tenure, introduction of activities incompatible with conservation, land subdivision and fragmentation. Savanna areas are important ecosystems for wildlife conservation. For instance, of the 54 national parks and reserves managed by KWS, 63% (34) of them are located in the savannas. However, most of them have been affected by expansion of land use activities by communities living around. For example, land that served as dispersal areas in Kitengela, Kajiado County for wildlife in Nairobi national park has now almost been completely occupied by farming, industrial, human and urban activities in the last couple of years not forgetting the current developments of Standard Gauge Railway (SGR) and the southern by pass road which are passing through Tsavo East and Nairobi National parks.

It is possible that land set up as protected areas exceeds their carrying capacity. Although most protected areas were set aside to protect the savanna's large mammal population, many other ecological habitats particularly forests and wetlands appear to have been largely ignored therefore leaving vital parts such as breeding and dispersal areas of the ecosystems outside PA boundaries. Presently, these areas that were likely to have been initially ignored have become very useful as dispersal areas for wildlife in protected areas, and also serve as movement corridors. It is possible that these areas are now held in privately owned hence reducing their access by the conservation authorities. Despite this, continuous population increase is likely to have made land

within or adjacent to wildlife corridors and dispersal areas become very valuable and high demand is being placed on it for settlement and agriculture.

It is becoming apparent that in order to maintain the integrity of PAs, new and innovative approaches among them participatory planning for wildlife corridors, and dispersal areas as well as the land use practices and activities around are sought and adopted in order to address conservation efforts both inside and outside PAs (Halladay and Gilmour, 1995; Lambin & Geist, 2003). Conservation initiatives in many protected areas are faced by challenges and numerous cases of conflicts. More often these conflicts arise between local communities living adjacent to PAs and protected area managers. This results to loss of life, property and conservation lands. The causes of these conflicts have increased in recent years due to changing land tenure and land use systems around PAs, lack of community involvement and benefit sharing (Mbote, 2005).

During the establishment of protected areas, it is possible that no attempts were made to integrate traditional land uses with conservation in order to allow viable interactions between conservation imperatives and compatible human land uses. Failure to plan has resulted in increased encroachment by humans on protected areas, thus converting them into agricultural and settlement areas, thereby pushing wildlife into smaller and degraded areas. Sustainable approaches to conservation and management of wildlife inside and outside protected areas has been adversely affected by both the failure to provide for multiple land uses and lack of proper planning for wildlife resource utilization. Considering that up to 70 per cent of wildlife in Kenya is found outside protected areas (Matiko, 2000; Mbote, 2005). Meaning that with limited land capacity, many PAs are not large enough to provide all the required space for wildlife feeding, breeding and predator escape. It is therefore important that lands outside protected areas be considered in wildlife conservation and management plans. This would allow migration of wildlife from and into parks. It would also permit local communities to engage in their traditional productive activities like cattle grazing, water, firewood and honey harvesting according to their traditional way of life alongside conservation.

2.3 Variation in Climate and Its Impacts on Wildlife Ecosystems

Climate change is one of the key threats to biodiversity conservation (Watson *et al.*, 2012) Climate change is currently a concern not only to conservationist but also across several other disciplines such agriculture and other production sectors. It has been linked to well documented changes in physiology, phenology, species distribution and in some cases extinction (Simms, 2006; Dudley *et al*, 2010; IUCN, 2012; Watson *et al.*, 2012). However, accommodating the shifts by climate change to conserve biodiversity represents one of the difficult challenges by conservation planners (UNEP-WCMC, 2008).Hence the need to integrate climate change adaptation strategies into conservation planning frameworks (WWF, 2008; Mansourian *et al.*, 2009).

The world's climate is continuing to change at rates that are projected to be unprecedented in recent human history. The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001) indicates that the global average surface temperatures increased by about 0.6^{o}c during the 20^{th} century. The Fifth Assessment Report still indicates that there is a linear tread in temperature changes across the globe by 1 to 3% $^{0}C^{-1}$(IPCC, 2013). The report further projects that in the 21^{st} century, there would be hotter and fewer cold temperature extremes as global mean temperatures increase. Much of this is likely attributed in the above referred report to increase in anthropogenic activities that lead to increasing amount of greenhouse gas concentrations. The climate change 2014 synthesis report indicated that human influence on climate system is on increase causing rise in the emissions of greenhouse gases. (IPCC, 2015). These anthropogenic greenhouse emissions have increased since the pre-industrial era, driven largely by economic and population growth (IUCN, 2012).

There is a high possibility that as temperatures increases and rainfall increases or decreases (depending on location) and therefore becomes more variable, destroying niches for existing species. As temperature and carbon dioxide (CO_2) levels change due to climate change, the optimal growth ranges for different species also change; species alter their competition dynamics, and the composition of mixed grasslands changes (Thornton *et al.*, 2007). Developing countries are considered more vulnerable

to the effects of climate change than the richer developed countries. Thus the reason for this their low capacity to adapt in the developing world (Thornton *et al.*, 2006).

Climate change will possibly add to the impact of land use change on species and ecosystems. Rising temperatures, rainfall variability, and new climatic regimes pose threats to biodiversity and human livelihoods alike. In their work Hannah, *et al.*, (2002) noted that the current conservation strategies needs to be revised to be effective in the face of future climate change. The interactive effects of land use and climate change will accelerate the loss of biodiversity, lower ecological resilience and increase vulnerability of marginalized communities. High levels of vulnerability and low adaptive capacity in the developing world have been linked to issues such as a high reliance on natural resources, limited ability to adapt financially and institutionally, low per capita Gross Domestic Product (GDP), high poverty and a lack of safety nets (Thomas and Twyman, 2005, Dudley *et al.*, 2010).

Climate variability and change stresses the rural livelihoods and especially the agro pastoral communities in various ways which includes but not limited to, reduction of harvested produce and death of livestock (Klein *et al.*, 2014). Further, the fifth report by the Intergovernmental Panel on Climate Change (IPCC) working groups I, II and III provides a detailed report on impacts of climate variability and change which includes serious and pervasive effects on the natural and social environment (IPCC, 2014). From the above it is envisaged that wildlife conservation in Kenya is facing many challenges as a result of the changes in climate. The effects are likely to be decline in wildlife population, illegal trade, unplanned human settlements leading to loss of movement corridors and human-wildlife conflicts (Wanyonyi, 2012).

With Africa occupying about one-fifth of all the known species of plants, mammals and birds in the world (Ament, 1975), it is one of the most vulnerable regions in the world to climate change (Thomas and Twyman, 2005). According to the IPCC report of 2001, human activities such as burning fossil fuels and changes in land use are modifying the global climate to affect human welfare and the environment. For instance, climate change has already affected the marine animals where coral reefs in the Indian Ocean have experienced massive bleaching with over 50% mortality (Spalding *et al.*, 2001). This damage to coral reefs has far reaching implications for

fisheries, food security, tourism and overall marine biodiversity. On terrestrial ecosystems, animal biodiversity in Africa is concentrated in savannas and tropical forests. These areas have also been affected by loss or alterations of habitats by climate change (Hulme, 1996).

2.3 Effectiveness of Protected Areas Management Plans and Human Wildlife Conflicts

Participation of the local communities living around protected areas is hindered by decreasing effective participation and the need for alternative approaches to wildlife conservation. People who are directly affected by the presence of wildlife in their lands and those who are victims of human-wildlife conflicts are given incentives that can be appreciated at individual level such as monetary compensation for losses and wildlife utilization (Bergin, 1995). Such an approach can help to obtain the support of the local community by winning them from the perceived communal benefits such as establishment of schools and health facilities in these areas which might not be well appreciated as appropriate rewards for conservation.

In seeking for more effective strategies that are more innovative and efficient, the role of local communities living in and around protected areas and other biodiversity hotspots should be recognized (Nandita, 2004). This is because natural resources, people and cultures are fundamentally interlinked (Borrini *et al.*, 2004). Since the 1972 UN Conference on the Human Environment held at Stockholm, the 1992 UN Conference on Environment and Development in Rio de Jeneiro, international and national approaches to conservation has strived to harmonize social needs and the development agenda. This means that protected areas now focus on enhancing sustainable use of natural resources, the preservation of ecosystem services and integration with broader social development processes, along with the core role of biodiversity conservation. More attention is being given to respecting cultural values as essential associates of biodiversity conservation and the need to involve indigenous and local communities in making management decisions affecting them.

The process of engaging communities as management partners should ideally begin at the stage of planning and design of protected areas (Borrini *et al.*, 2004). This should involve the effective participation of all interested parties at every stage, and also

provide meaningful responses to their concerns which encourage co-management of resources in PAs. Co-management can be based upon a negotiated, joint decision-making approach and some degree of power-sharing, sharing of responsibilities, and distribution of benefits among all institutional actors. Where the concepts of effective participation in planning and co-management have been implemented, it is possible that communities have been able to realize economic gains through utilization of resources for example which include ecotourism and promoted resource conservation that leads to reduced resource use conflicts.

2.4 Adaptation Strategies for Climate Change Mitigation

As one of the most important threats to nature, climate change challenges the way we manage the protected areas (Gross *et al.*, 2016). Climate Change include rising global temperatures, large scale melting of snow and ice, longer and more frequent droughts, changes in the intensity and timings of storms and acidification of marine environments (Stein *et al.,* 2014). As a result there is increasing response of these challenges by plants and animals being disrupted and in some cases the entire ecological region gets disrupted.

In the context of climate change, adaptation refers to human activities that are intended to minimize the adverse effects of climate change on the environment (Parmesan, 2006; The Heinz center, 2007). Further in their studies, (Root *et al.*, 2005 and Lovejoy, 2005) have explained climate change adaptation as the process of designing, updating and implementing strategies to account for the impacts of climate change to ensure the highest return over time. However, there is little doubt that on-going human forced climate change is a main contributor to biodiversity loss (Watson *et al.,* 2012). Therefore, adaptation is one of the key building blocks required for a strengthened future response to climate change (Simms, 2006).

2.5 Theoretical Framework

Theoretical Framework refers to a set of assumptions about reality that determine the type of questions the researchers ask and the answers they arrive at. This thesis is informed by the Yellowstone model theory, the people-park theory and model protected areas planning framework model theory.

2. 5.1. The Yellowstone Model

The modern concept of protected areas dates back to the Yellowstone National Park in United States of America (USA) in 1872 (West & Brechia, 1991; Runte, 1997). This was the first protected area to be established in the world following concerns by a group of environmentalist in USA that wild lands were diminishing due to threats from unsustainable human activities (Pimbert & Pretty, 1995; Stevens, 1997; Weurthner, 2015).

Following this model, early protected areas were established to preserve spectacular scenery and natural wonders from appropriation by private interests. The establishment which followed the Yellowstone model laid more emphasis on preservation than conservation (Machlis and Tichnell, 1985). Preservation ensured that wildlife was kept in their natural areas without any form of utilization or manipulation, while conservation involved some allowable form of utilization of wildlife such as hunting and tourism. According to proponents of this model, no consumptive activities were permitted in the park except tourism and recreation.

Following the introduction of this model, many protected areas were established all over the world to protect and preserve wildlife and their habitats (Stevens, 1997). However, there were shortcomings in this model since local communities were forcefully evicted or relocated from their traditional lands to give way for the creation of protected areas. This led to marginalization of most of these communities world over. In Kenya where the Yellowstone model was adopted, local communities were evicted from their lands by the British colonial government. This ignored local community traditional systems of conservation and the intervention resulted to creation of national parks and reserves (Runte, 1997). It is likely that the situation of landlessness and dependency on protected area resources still prevails to date despite the evolution and implementation of community based conservation. This has contributed to the continued marginalization of local communities living adjacent to protected areas. Their traditional conservation systems are likely to be affected.

Despite its registered success in protecting wildlife and other biodiversity from exploitation, the Yellowstone model has over the years faced some setbacks. Among them was the accelerated conflicts due to human changing land tenure and land use

regimes, rise in human population, inadequate funding for conservation activities and shortage of skilled manpower to manage these areas among other factors (Runte, 1997). It is possible that local communities that were excluded from participating in the initial planning for the establishment of protected areas and denied access to resources wrapped up in protected areas. These communities were likely not to have been compensated for the land they lost to give way for the establishment of the protected areas. It is also possible that they suffered losses from wildlife, for example, through crop destruction, death or injuries. This is likely to have resulted to outright hostility, resentment and mistrust of wildlife managers by the local community.

The possible denial of access to traditional sources of livelihood coupled with lack of involvement is likely to have compounded conflicts within and around PAs, wildlife corridors and dispersal areas. It is also possible that this situation has been aggravated by climate change, land tenure and land use practices most of which are incompatible with conservation. There is therefore a need to adopt alternative approaches of conservation that addresses human demands and that of ecosystems management. The bid to improve the Yellowstone model resulted in the introduction of other models which were perceived to emphasize community participation to promote sustainable management of biodiversity.

2.5.2 The People-Park Model

Following numerous conflicts and lack of compatibility between conservation goals and human needs, People-Parks model was developed (Stevens, 1997, Oates, 1999; Schwartzman *et al.*, 2000). This model sought to reconcile and harmonize conservation in protected areas and livelihood needs of the local community. The model not only focused on protecting wildlife resources, but also ensured that benefits of conservation were attained through resource utilization. The PPs model encompasses a community-based conservation approach which promotes local involvement in decision-making, conservation and development projects. The adoption and implementation of this model by conservation agencies such as Kenya Wildlife Service (KWS) together with the introduction of a community development fund which enhanced the establishment of communal projects such as schools, health facilities and water projects in areas inhabited by communities affected by wildlife in

Kenya. This witnessed the development of many projects among them cattle dips, schools, health facilities and water supply projects which were funded and supported by KWS under the community development and enterprise fund.

In spite of the foregoing benefits, the People-Park model has however been criticized for having a mixed record of success due to insufficient clarity in its goals and institutional constraints (Oates, 1999). For example, protected area authorities in Kenya have over the years pursued different conservation goals from those of local communities, a discrepancy that has led to conflicts. Moreover, benefits that were provided to communities such as schools, health and water were considered as communal facilities and did not benefit those directly affected by wildlife. During this period, the communities were also compensated for the loss of crops, other property and human life or injury. However, this compensation programs on crops and other property by the Kenyan government were stopped in 1991 due to mismanagement of funds, corruption and lack of transparency. Compensation for human injury and loss of human life was retained at the rates of fifty thousand Kenyan shilling and two hundred thousand shillings respectively. The funds were administered by the government through the Ministry of Forestry and Wildlife (KWS and AWF, 2008). The compensation was not effective as expected since the amount paid for losses incurred was likely considered insufficient compared to the damages or losses incurred.

Despite the above, this study envisages that human-wildlife conflicts further intensified due to increased human population and settlement around PAs thus exerting pressure in these parks and their resources in addition to loss of traditional wildlife corridors and dispersal areas. There was lack of community consultation on their priorities for the projects given to them. They were therefore implemented based on the perceived rather than the felt needs of the local communities. This factor contributed to the continuous conflicts between the community and wildlife since they felt locked out of decision making process. Due to the foregoing challenges, the Protected Areas Planning Framework (PAPF) was developed by KWS to address this gap of a missing direct community involvement and participation.

2.5.3 Protected Areas Planning Framework Model

The protected areas planning framework (PAPF) model was developed by KWS after realizing the need to ensure that protected area management plans provide effective and practical guidance and support for protected area management (KWS, 2007b). The development of this model was important in breaking the missing link between the needs of PAs and those of communities living around them as a way of promoting conservation. This model lays emphasis on the integration of various components such as ecological and infrastructure management, tourism promotion, security, community partnership and education programme in protected area planning and management as well as wildlife and biodiversity conservation. It has also strengthened KWS' internal planning capacity, and increased the utility of planning as a tool for protected area management.

Compensation for the loss of life, injuries and property has also been revised to promote partnership in conservation between the local communities and the state conservation agencies. The new compensation rates as per Wildlife Conservation and Management Act of 2013 are five million Kenya shillings for death and amount not exceeding three million shillings for injuries. Loss of property and other damages can be paid as per the valued cost (GoK, 2013).

Management plans prepared for MCA under this planning model aim at ensuring that support and participation of adjacent communities in conservation and sustainable use of natural resources is enhanced (KWS, 2007b). However, despite the implementation of various community projects around most protected areas to win local support, cases of human-wildlife conflicts, encroachments and loss of wildlife corridors are on the increase. This is a scenario that calls for comprehensive investigations on how best to link local communities and their land use systems with wildlife conservation within their lands. The PAPF model which is currently being implemented by KWS continues to face a challenge due to lack of defined community benefits and involvement structures such as direct gains from wildlife on their lands and how they can be partners in management with the conservation agents. The model further continues to suffer a blow due to changing climate, land cover and land use patterns within and around the protected areas.

2.6 Conceptual Framework

From the reviewed literature above, it is envisaged that the first three models (Yellowstone, People-park and PAPF) did not adequately address the conservation challenges faced upon their implementation, as well as their shortcomings. The Yellowstone model focused on preservation and outlawed all other utilization activities other than tourism whose revenue channeled to the central government. Therefore communities whose land alienated and people forcefully evicted could not realize the meaning and benefits of conservation. This consequently engendered hostility, resentment and mistrust ultimately leading to the indiscriminate killing of wild animals whenever they crossed into their lands, and poaching for meat and other wildlife products.

On the other hand, the People-Park model which established to solve the persistent human-wildlife conflicts did not fully realize its objectives. Although this model led to the introduction of new measures such as community education, fencing of parks, compensation for damages and establishment of projects such as schools, health facilities and water to communities around protected areas, it appears not to have solved the envisaged problems since people continued to attack wildlife and encroach on fenced areas in search of resources like water, pasture, firewood and honey. Likewise, the main challenge which likely led to the failure of this model is that the interventions implemented mainly addressed the community as a whole and not the affected individuals. For example, the schools, health facilities and water projects were perceived as communal projects and therefore served the interests of the community at large and not individuals. Monetary compensation for damages caused by wild animals possibly appeared considerably too little compared to the real value.

The other major backdrop of the model is that there is no community consultation and involvement when establishing the projects. More often, it was perceived that they would be accepted as part of the PA management. Yet from literature reviewed, it is evident that these projects addressed the perceived needs rather than the felt needs of the affected or targeted communities. Therefore, communities felt that they were overlooked and not involved in making conservation decisions.

The Protected Area Planning Framework model was established at the time when human-wildlife conflicts had intensified. The model was established amidst challenges such as changing tenure and land use patterns around protected areas which led to increased demand on the resources found in them. Land which was initially considered as communal is being subdivided into small parcels. Community livelihoods were changing from pastoralism to agro-pastoralism thereby leading to loss of traditional wildlife corridors and dispersal areas.

Although the model advocated for approaches such as stakeholder involvement and strengthening institutional and infrastructure development in protected areas, the aspect of community involvement was not well addressed from a bottom up approach. Following the shortcomings of the foregoing three models, it is therefore evident that there is a need to establish an integrated conservation model that incorporates aspects of land tenure, land use and climate change. It will also promote involvement of all stakeholders among them public conservation agencies like KWS, local communities, private conservation bodies and research institutions in the planning and management of protected areas and land adjacent to PAs as shown in Figure 1. In this conceptual illustration, drivers of conservation refers to independent variables, associated impacts are the dependent variables while sustainable approaches are the intervening variables that will bring about long term coexistence of wildlife in the protected areas and the local communities while enjoying their socio-economic values.

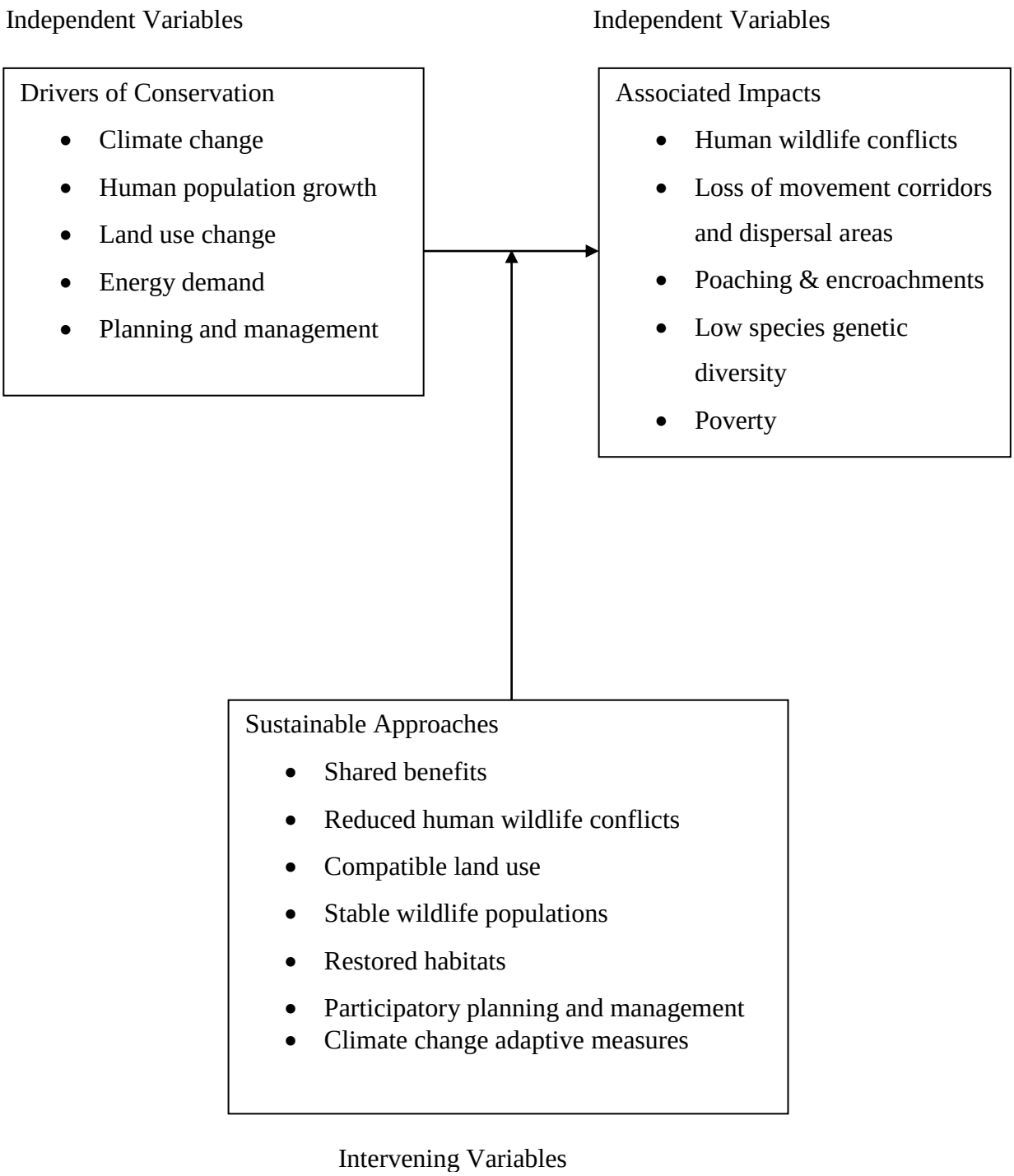


Figure 1: Conceptual Framework

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter focuses on the description of the study, data and tools used. It is sub-divided into parts based on the study area and objectives of the study. The procedure and the general methodology on how the data were processed using various datasets and tools is clearly outlined.

3.2 Study Area

The study was conducted at Meru Conservation Areas in Meru National Park and Mwingi National Reserve and the adjacent land. These two protected areas form part of the complex known as Meru Conservation Area adjoining Bisanadi National Reserve and Kora National Park.

The choice of Meru Conservation Area (MCA) as the basic unit of analysis was considered appropriate because, *inter alia*. a) MCA is one of the important wilderness areas in Kenya with diverse wildlife species managed separately by Kenya Wildlife Service, b) it portrays a classical example of a protected area network systems where there are several PAs merged together to form the MCA ecosystem. c) the area is surrounded by human communities of diverse cultural backgrounds and with differing land use practices such as agriculture, agro-pastoralist and pastoralist. Hence a potential to experience serious land use conflicts (Otuoma, 2004; UNEP & KWFT, 1988). d) like many other savannas in Kenya, areas around MCA have been undergoing major land tenure reforms since 1989 following government directive to shift the tenure systems from communal ownership to privately owned individual subdivisions.

3.2.1 Meru National Park

Located 350km east of Nairobi, the park boarders Meru, Isiolo, Kitui and Tharaka Nithi counties. It covers an area of 870 km² (Otuoma, 2004). The park was established in 1966, as a public entity managed by KWS and all the revenue collected is directed to the national treasury. The protected area is branded as complete wilderness and is popular for game viewing, camping and scenic attractions.

3.2.2 Mwingi National Reserve

Mwingi National Reserve is located in the north of Mwingi town. It was formerly known as Kitui North National Reserve and it borders Meru National Park and Kora National park. As a National Reserve, it is managed by Kitui County government and the revenue collected is expected to be used to support conservation and community development. The reserve covers an area of 755km^2 and it is selected by the Kenya wildlife service as a wilderness activity zone which allows fly camping, horseback and camel safaris as an opportunity for traditional viewing of game. However, due to poor accessibility of the area, there is no sufficient data that is available but it will be explored in the course of study.

3.2.3 Geology and Climate

The study area is a semi-arid eco-climatic zone receiving bimodal rainfall of between 380mm and 1000mm. The long rains occur between March and June while the short rains are between October and December. The temperatures range from 30^{0}C during the day to 20^{0}C at night.

The wetter North Western sector is hilly, with rich volcanic soils. The land flattens towards the East, where grey alluvial volcanic soils appear. There are numerous permanent streams, draining from the Nyambene hills and flowing in parallel between tongues of lava, south eastwards towards the Tana River, where the park is bounded by three large rivers: the Tana River to the south, Ura to the south west, Ronjeweru to the east. There are prominent inselbergs of basement rock, notably Mugwongo and Leopard rock. The average rainfall is between 300mm and 500mm. The soil consists of phaeozenis, vertisols and planosols which are well drained (GoK, 1997 & KWS, 2007a).

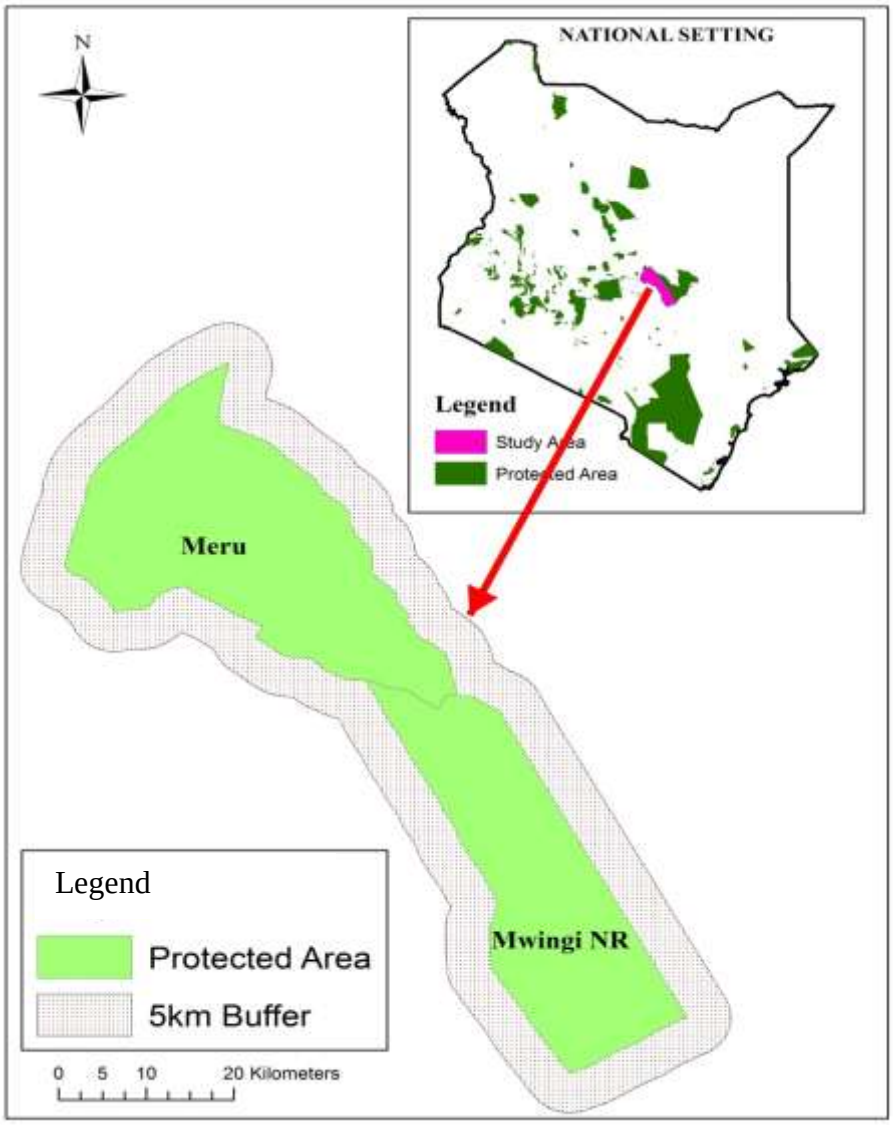


Figure 2: Map of the Study Area showing its location in Kenya (Map modified from KWS, 2014)

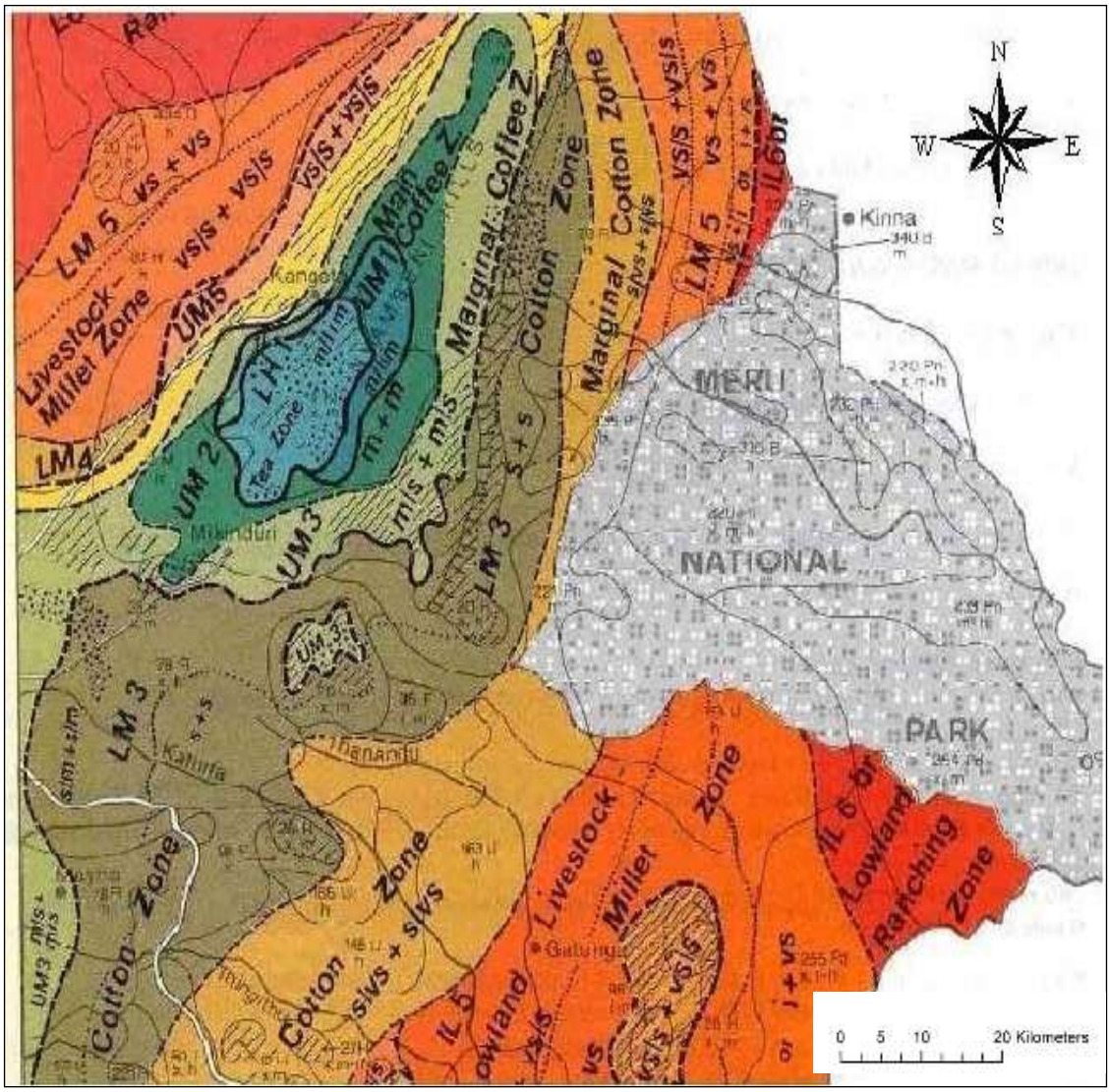


Figure 3: Agro-ecological zones around Meru National Park (Source: Jaetzold and Schmidt, 1983)

3.2.4 Vegetation

Meru National Park has a defined vegetation structure that varies across habitat types like the riverine, inselbergs, forested and typical savanna. The most common vegetation communities are the Acacia-commiphora bushland, the shrubland of Combretum, Cordia, Grewia, and open Acacia wooded grassland (Pratt and Gwynne, 1977). The vegetation types in the park can be characterized into four communities: Acacia wooded grassland, Combretum Wooded grassland, Acacia-Commiphora bushland and unique riverine vegetation consisting mainly of stands of Hyphaene and Raphia palms, and a network of Ficus trees (Ament, 1975). The later type of vegetation is found along rivers in all the vegetation types. These vegetation communities closely correspond to park geological divisions.Most of the park is

covered by bush, thorn bush and wooded grassland of varying densities with *Combretum* prevailing in the north and *Commiphora* in the south. In the extreme north there is a small remnant outliner of rain forest, the Ngaya forest. The vegetation on the ridges is Combretum wooded grassland, dominated by *Combretum apiculatum*. These grades into acacia wooded grassland to the east with *Acacia tortilis* and *Acacia senegal* on the rocky ridges, in river line thickets and dotted over open country. To the west, the Combretum merges into *Terminalia* wooded grasslands.

On the plains *Sehima nervosa, Chloris gayana, Chloris roxburghiana*, and other species of *Pennisetum* are the dominant grasses. Dense riverline forests of doum and raffia palms *Hyphaene* and *Raphia spp*. grow along the watercourses and in the swamps near the rivers. Along the Tana River is found the Tana River poplar, *Populus ilicifolia*. Other riverline trees include *Phoenix reclinata*, *Newtonia hildebrandtii, Acacia elatior* and *Acacia robusta*. The red-flowered Parasitic *Loranthus* grows on the branches of *Acacia reficiens* trees along the rivers. There are numerous riverline swamps with sedges *Cyprus sp*. and grasses *Echinochloa haplacelada* and *Pennisetum mezianum*.

In Mwingi National Reserve, the vegetation density has been declining over time mainly due to encroachment activities such as farming, charcoal burning and livestock grazing. As a result of this, the common vegetation type found are scattered species of *Acacia*, Doum palm, *Combretum* and *Terminalia* .However, this is not all inclusive since there is no detailed data on vegetation classification for the study area.

3.2.5 Wildlife

Meru national park is one of the protected areas in Kenya that is endowed with a wide diversity of wildlife species. The park has all the major big carnivores and herbivores such as Elephants, Lions, Cheetahs, Leopards, waterbucks, giraffes, Buffaloes, Rhinoceros, common Zebras, Gravy zebras, elands, Beisa Oryx, Kongoni, Lesser kudu and other plains game (IFAW and KWS, 2002). Besides these mammals, there are variety of reptiles and over 280 bird species. Meru national park is listed as one of the Important Bird Areas (IBAs) in Kenya. However, the major wildlife species commonly found moving along the corridor and dispersal areas are elephants, buffaloes, zebras and baboons.

Mwingi National Reserve has low concentration of resident wildlife due to regular disturbances on the ecosystems. However, due to the fact that the reserve is bordered by different PAs, it is frequently visited by different animals in different seasons. The most common species found are crocodiles, hippopotamus, elephants, lions, caracal, leopards, monkeys, olive baboon and several species of antelopes.

3.2.6 Human Settlement and Land Use Activities

The population around MNP is increasing with time prompting more settlements that are advancing towards the PA boudaries (Otuoma, 2004). The study area to the west of MNP consists of several administrative locations of high population density averaging 250 persons per km^2 as per the 1999 census (IFAW and KWS, 2002). Their livelihood mainly depends on subsistence agriculture and livestock keeping. There is also miraa *(Catha edulis)* farming which is planted for commercial purposes. Other crops grown include maize, green grams, bananas and vegetables. Availability of services such as water, electricity and improved road network has attracted the development of settlements at the western side of the park. Major issues in the area include human/wildlife conflicts and water use conflicts arising from irrigation activities along the rivers Murera and Ronjewero.

During the dry periods, the farmers divert the waters to their farms leaving little or none flowing to the park. There is also encroachment of livestock in the park during the dry periods for pastures. The area that was initially utilized as a corridor linking the park and the forest is no longer serving its ecological functions because of human encroachment and increased farming both of which have led to destruction of natural habitats preferred by wildlife spilling from the park. Examples of crops grown include bananas, maize, legumes, miraa (*Catha edulis*) and horticultural crops like vegetables which are sold to the local market and also to neighboring towns like Maua and Meru. However, the success of these crops up to the maturity period when ready for harvesting is not always guaranteed because of wild animals which stray into their farms and cause destruction. On some occasions residents are reported to have been injured or even killed by wild animals especially buffaloes and elephants as they try to drive them from the farms.

The land use around MNR is characterized by subsistence farming mainly by shifting cultivation and livestock keeping. Most areas of the reserve have been encroached by settlement and agriculture. However, as for the time of this study, some efforts have been made by the Kitui county government to evict the communities from the reserve.

3.3 Methods

3.3.1 Research Design

The study was conducted in form of a comparative descriptive survey evaluating the changes in land cover within and around Meru National Park and Mwingi National Reserve both of which forms part of the Meru Conservation Area Complex. Both spatial and multi-criteria approaches were used to analyze the problem. The survey method was used because it allowed for detailed investigation of the problem and comparing the findings in the two protected areas that are under different governance.

3.3.2 Sampling Technique

In sampling for natural environment, secondary data for land use land cover analysis was collected using the medium resolution TM Landsat satellite image in a time line of 1985, 1995, 2005 and 2015. The 30 years period was essential in establishing the changes in land cover and climate variables such as rainfall distribution and temperatures. Current land use types, quantifiable land cover changes over time, land tenure systems and socioeconomic data from the local community and institutions was collected using semi structured questionnaires and interview schedules respectively. Both simple random and purposive sampling techniques were used to collect the required data from the respondents (Kothari, 1985, Dawson, 2002). Pilot survey was conducted first in various sections of the park to select suitable sampling sites for the exercise.

The study area was purposively be divided into four different clusters based on the land use patterns such as crop farming, mixed crop farming, and pure livestock utilization. A total sample of 120 respondents were selected from the clusters bordering the PAs (Baibariu location in Meru County, Rapsu in Isiolo County, Ntoroni in Tharaka Nithi and Kaningo in Kitui County). The map of the study area with sampled blocks is as shown below.

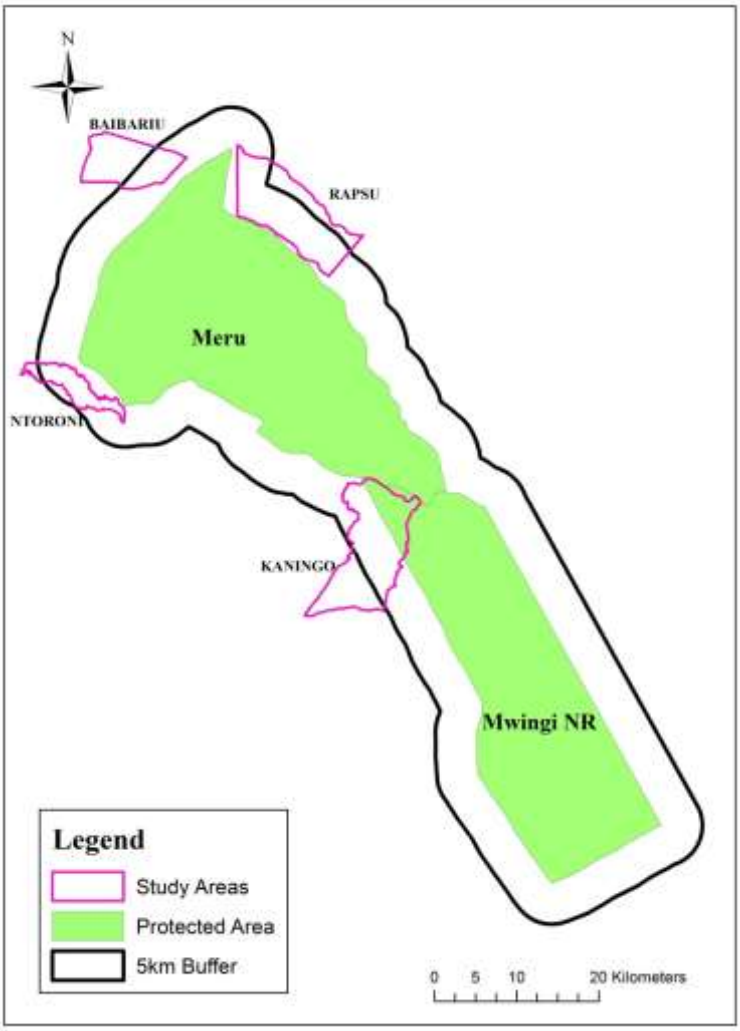


Figure 4: A Map of the study area showing the sampled blocks (Developed from Landsat Images acquired from RCMRD, Nairobi (2014))

The simple random sampling was therefore used to select the respondents for the questionnaires within each cluster. To arrive at the sample, the number of the respondents in each cluster was selected proportionally depending on their size and population density. The household heads or adult family members above 18 years were allowed to respond to the questionnaire. Key informant interviews were also conducted to the longest serving officers in the institutions such as KWS, Kitui County, agriculture, sub-county and ward administration to acquire more detailed information and to corroborate the data gathered from the questionnaires.

3.3.3 Data Collection and Analysis

To establish the land cover changes, satellite image interpretation was used as the basic tool for analysis. The use of remote sensing Landsat images to describe and

analyze wildlife-habitat relationships and general ecosystem changes has seen increased application over time by several researchers. For instance (Ondenyo, 1979; Ester *et al*., 1982; Pestena, 1986; Otuoma, 2005) have used satellite images for cover type mapping and assessment of wildlife ecosystem conditions in protected areas.

In this study, four satellite images with a span of 10 years from 1985 to 2015 were acquired for analysis as a post-classification comparison for change detection (Skole and Tucker, 1993). The analysis produced various land cover classes for analysis as driven by the study objective. For instance, the resultant classes for this study were categorized as farmland, forests, grassland, bareland (degraded) and water. The images were first classified independently into land cover categories and then compared them using Arch GIS software.

Data on socioeconomic and wildlife occurrence was analyzed using SPSS version 20 and Microsoft Excel. Frequencies of the respondents giving particular responses were summarized and the equalities tested using the *Chi-square* goodness of fit. To further find the causes of land use changes, these frequencies were summarized and Chi-square cross tabulations analysis performed to determine relationship with specific attributes. Statistical tests were considered significant if *P* values were equal to or less than 0.05 and insignificant if *P* values were greater than 0.05 (Zar, 1999). For the chi-square cross tabulations, if *P* value were equal to or less than 0.05, then a response was dependent on an attribute and independent of the attribute if *P* value was greater than 0.05. A multi-criteria decision making analysis (MCDA) was applied as a planning tool to develop a planning model for enabling collaborative acceptance for protected area management (Mendoza and Martins, 2006). This analysis incorporated the value measurement, goal setting and outranking. The analysis further helped in highlighting the need for participatory planning and the potential to multiple resource use as an option for biodiversity conservation. The analyzed data was presented inform of narratives, maps, graphs, charts, tables and models.

3.4 Validity and Reliability

The approval of the questionnaire by the supervisor and experts at Chuka University gave more validation throughout the research process and all kinds of ambiguities are eliminated. The sampled areas formed a representative sample of the entire

population. Reliability is a measure of extent to which a research instrument yields consistent results after repeated trials. The questionnaires were pilot tested in three blocks where a total of 30 samples were taken. Cronbach's Alpha method was then used to test the reliability. (Mohsen and Reg, 2011). These sample instruments were keyed using SPSS and analyzed to realize a coefficient (α) of 0.795. This therefore shows that the data was reliable.

3.5 Ethical Considerations

During the study, ethics was adhered to by ensuring that the information given by the respondents was treated in uttermost confidentiality and was only used for the study purpose as they were assured in the introduction letter shown in Appendix I. The researcher also avoided disturbance of wildlife in the protected areas as well as destruction of vegetation by following the provided guidelines for operating in the protected area. Further, the researcher acquired the required research permit from National Commission for Science, Technology and Innovation (NACOSTI), Kenya Wildlife Service (KWS), national government, local administrators (Chief, DOs) and the county government as indicated in appendices VIII, IX, X, XI and XII.

CHAPTER FOUR
SPATIAL-TEMPORAL CHANGES IN LAND USE LAND COVER AND IMPACTS ON WILDLIFE CONSERVATION

4.1 Introduction

This chapter examines the land use land cover changes that have taken place in MNP and MNR and their surroundings between 1985 and 2015 with an emphasis on human induced changes that have altered wildlife habitats. Investigation of land use land cover changes have been used in this study because they are indicators of potential environmental problems such as habitat loss, species decline and watershed degradation. Increase in human land use activities (such as agriculture) reduces both the quality and quantity of habitat for wildlife (Odenyo, 1979; Kozakiewicz, 1985). Therefore understanding the relationship between various land use changes was necessary to establish appropriate remedial measures for environmentally sustainable economic and social policies.

4.2 Data Acquisition and Sampling

Landsat TM satellite images were acquired from Regional Centre for Mapping and Resource Development (RCMRD), Nairobi. ArcGIS was used as the basic tool of analysis in this objective. The other source was Primary data which comprised of guided field observations on land use systems at selected points in different land use classes for ground truthing, identification of wildlife species and their distribution, land degradation and encroachments, marking the coordinates using Global Positioning System (GPS), taking photographs, questionnaires and key informant interviews.

Medium resolution Landsat TM images for the periods 1985, 1995, 2005, and 2015 were acquired from the Regional Centre for mapping and Resources development (RCMRD) in Nairobi, Kenya to identify and delineate different land use land cover types in MNP, MNR and their adjacent areas. The images (LandSat TM 30m resolution) were all taken for the dry month of August. The difference in ground resolution was assumed negligible for this study because the total area converted at a landscape scale (1/50,000) is what was measured in the study.

Land cover changes were assessed by use of Landsat TM images of medium resolution, topographic maps of the MCA that comprises MNP and MNR as well as ground validation using GPS for geo-referencing. Field observation and existing data by KWS was useful in assessing the impacts of the land cover changes on wildlife through observing the species occurrence, distribution and population, and reported incidences of human wildlife conflicts and encroachments.

4.2.2 Data Analysis and Presentation

Land use land cover (LULC) analysis was achieved through acquisition, interpretation and analysis of the Landsat TM images using the ArcGIS and IDRISI. The Landsat TM image of 1985 was geo-referenced against a topographic map at a scale of 1/50,000 using a number of control points that were determined during the field visit. This was followed by image to image registration by geo-referencing the satellite images of 1995, 2005 and 2015 against the geo-referenced image of 1985. This ensured that the pixel grid of 1995, 2005 and 2015 conformed to the geo-referenced image of 1985 to enable pixel by pixel comparison of the image. The images were then analyzed for various land use types while changes in land classes were mapped and quantified. Land use land cover changes were analyzed using descriptive statistics to show the variations from 1985 to 2015. This involved calculation of the size of areas under each land use for the years 1985, 1995, 2005 and 2015 using the database query module in Arc Map. The areas were then transferred to excel for computation of land use changes over time. Pearson correlation coefficient (r) statistical analysis was performed to determine linear association between different land use changes in MNP and MNR. The figure 5 illustrates the general procedure that was used in the analysis.

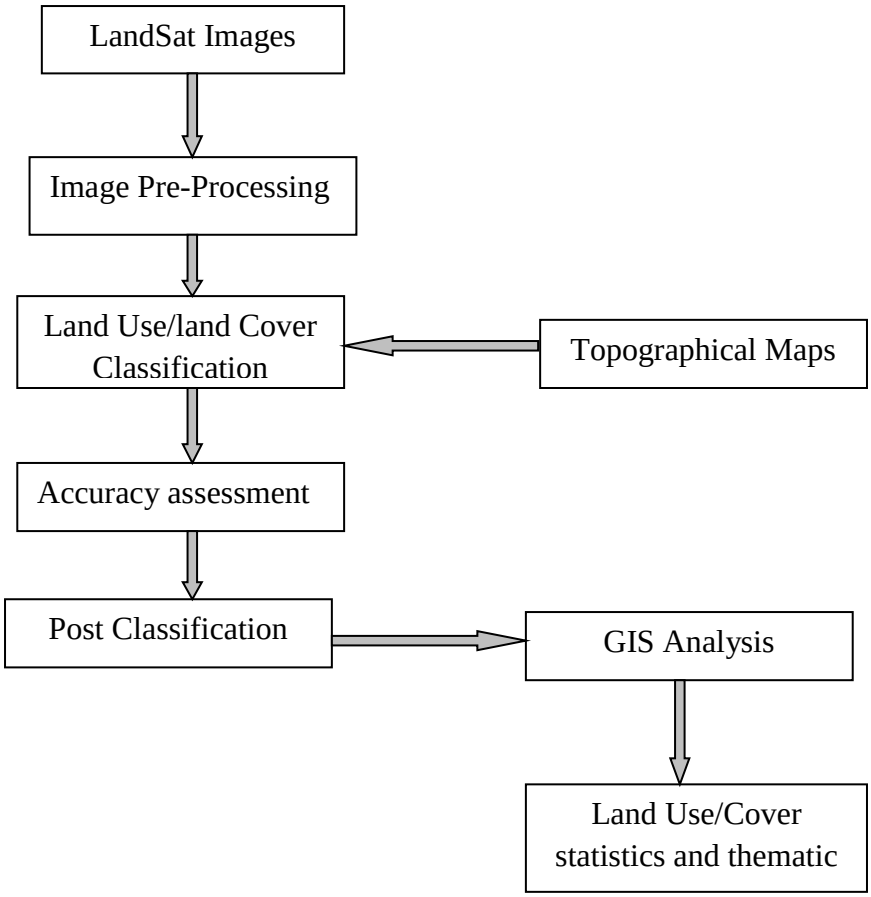


Figure 5: Study Approach Adopted in Land Use Land Cover Classification

4.3 Results and Discussion

4.3.1 Population Growth and Land Use Activities

The findings established that there has been a dynamic growth in human population around MCA since late 1980s. This was after security operations were improved by KWS to drive away the bandits and pastoralists who had earlier on invaded the protected areas for wildlife hunting and livestock grazing (Smucker, 2000; KWS, 2014). This improved the security situations thereby attracting many immigrants into the area. For instance, the population of people in southern of Ntoroni MNP in Tharaka rose from 391 households in 1980 to 717 in 2000. While the current population in study block according to 2009 census stand at 917 households which is an increase of 57.4%. Upon investigation on the duration of stay and method of land acquisition, it was established that majority (79%) of the households that occupy the buffer zones were migrant who came to the area in search for more land for agriculture and livestock keeping. Majority of these had moved from agriculturally rich areas of Meru, Nyeri, Murang'a and Kiambu. The main affected areas of MCA

were the northern and southern buffer zones which led to permanent settlement due to higher rainfall gradient where 45% had either purchased or leased the land.

Investigation on the form of land ownership established that 48(40%) of the respondents reported that the land they live in is under private tenure, 52(43.3%) reported that the land is under communal ownership while 20(16.7%) of the respondents reported that they knew the land to be under public ownership since individuals do not have title deeds as proof of absolute ownership. This investigation further observed that due to lack of title deeds as a security of land tenure, majority of the respondents had built temporary structures for fear of eviction or re-allocation of the land to another individual when land adjudication was done. The information from the location leaders tallied with that of the respondents that the land is under adjudication and the title deeds are yet to be issued.

Results of this study supports the previous findings by KWS and AWF (2008) that communities have not only utilized the buffer areas adjacent to the parks, but have further occupied the land that was initially set aside as movement corridor for wildlife from MNP to Ngaya forest. In MNR, local communities have extended their shifting cultivation, charcoal burning and livestock grazing inside the reserve. It regularly takes the intervention of KWS to evict and arrest those found carrying out such illegal activities, an issue that has continued to harbor resentment by the residents and fueling human-wildlife conflicts.

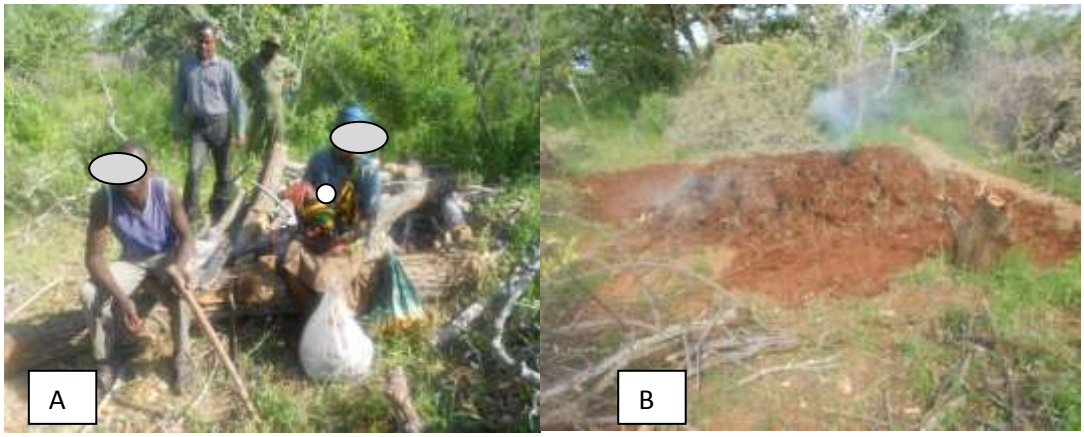


Figure 6: (a) Members of Community Around MNR Arrested for Logging and (b) Charcoal Burning in the Reserve

From the study findings, 34(28.3%) of the respondents were agriculturalist occupying mainly the Baibariu block on the western part of MCA, 43(35.8%) were mixed farmers practicing livestock keeping and subsistence farming at Ntoroni and Kaningo blocks while 41(34.2%) were pastoralist occupying the Rapsu block on the northern border of MCA. Other category that represented the 2(1.7%) of the respondents was engaged into business in the locally upcoming centers or those who were not specific on their reporting.

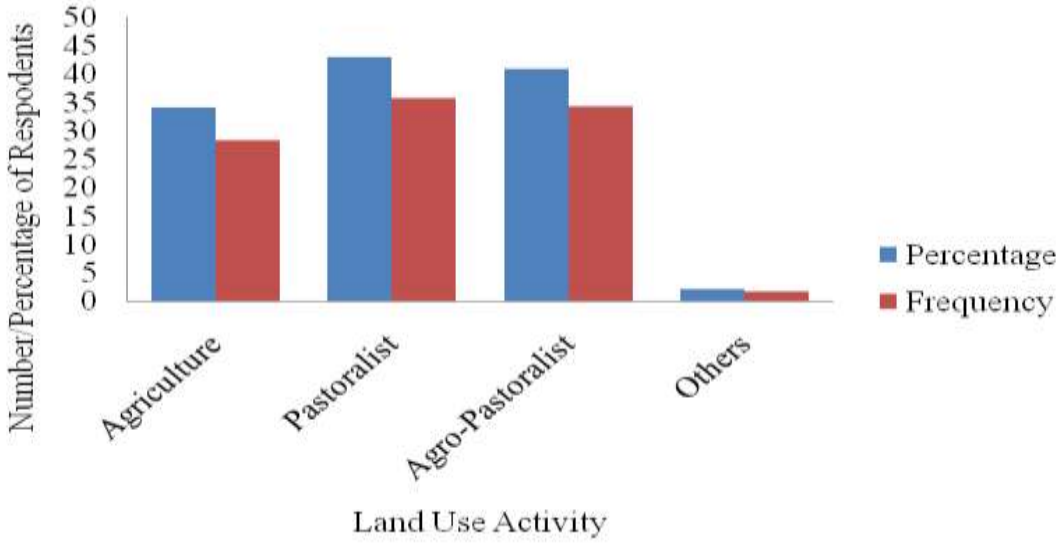


Figure 7: Land Use Practices by Respondents around the Study Area

Increasing agricultural activities have been extended to as far as the boundaries of protected areas and reclamation of wetlands for horticultural farming as shown in the figure 8 below which were taken at the western border on Meru National Park.

Figure 8: Wetland Reclaimed Tomato Farming at the Boundary of MNP and at the Planned Meru-Ngaya Corridor

4.3.2 Land Use and Land Cover Classification

Classification of different satellite images was guided by specific land use land cover (LULC) categories as shown in table 3 below.

Table 1.
Description of Image Classification Classes of Land Cover in MCA

Land Cover Class	Description
Bareland	Refers to areas with no vegetation cover, cultivated agricultural land, built up areas and livestock degraded areas
Forest	Denotes areas with high density of trees. It is both homogenous and heterogeneous.
Grassland	Represents areas of land with more grass cover and a few scattered trees such as acacia Combretum and Doum palm.
Riverline vegetation	Refers to the dense vegetation that was observed growing along the rivers that flow across the protected area.
Shrubland	Areas comprising of arid land with short vegetation scattered and surrounded by short grass
Water	Areas of open water sources within the protected area such as springs, swamps and rivers.

The analysis of LULC changes revealed substantial transformation in MCA ecosystem over the 30 year study period. For instance, the grassland and bareland are the land cover categories that were found to have significantly expanded in area respectively from 48659Ha and 28065Ha in 1985 to 76923Ha and 46048Ha in 2015, accounting for approximately 9.9% and 6.1% increase in these land cover change. This could be an indication of agricultural activities that are encroaching towards the protected areas which were formerly available as wildlife corridors and dispersal areas. It is also an indication that there is a significant change in the forestland and shrubland which have reduced respectively from 46667Ha and 152353Ha in 1985 to 40255Ha and 107587Ha in 2015 accounting to 2.3 and 15.7% decline resulting to bareland and grassland. The result of image classification as per the period is as shown in figure 9.

The analysis of the classified images produced the area in kilometer squared (Km^2) for each LULC class over the study period and the percentage (%) of each land use category as indicated in Table 2.

Table 2.

LULC Characteristics in the Study Area over Time

LULC Class	y1985 (Km^2)	% cover	y1995 (Km^2)	% cover	y2005 (Km^2)	% cover	y2015 (Km^2)	% cover	% change
Forest	46677	16.4	45792	16.1	75888	26.7	40255	14.1	-2.3
Shrubland	152353	53.5	207470	72.3	138449	48.6	107581	37.8	-15.7
Grassland	48659	17.1	6665	2.3	29773	10.5	76923	27	9.9
Riverline	8247	2.9	750	0.3	14278	5.1	12677	4.5	1.6
Water	727	0.3	538	0.2	7034	2.3	1244	0.4	0.1
Bareland	28065	10.1	23513	8.3	19306	6.8	46048	16.2	6.1
Total	284728	100	284728	100	284728	100	284728	100	0

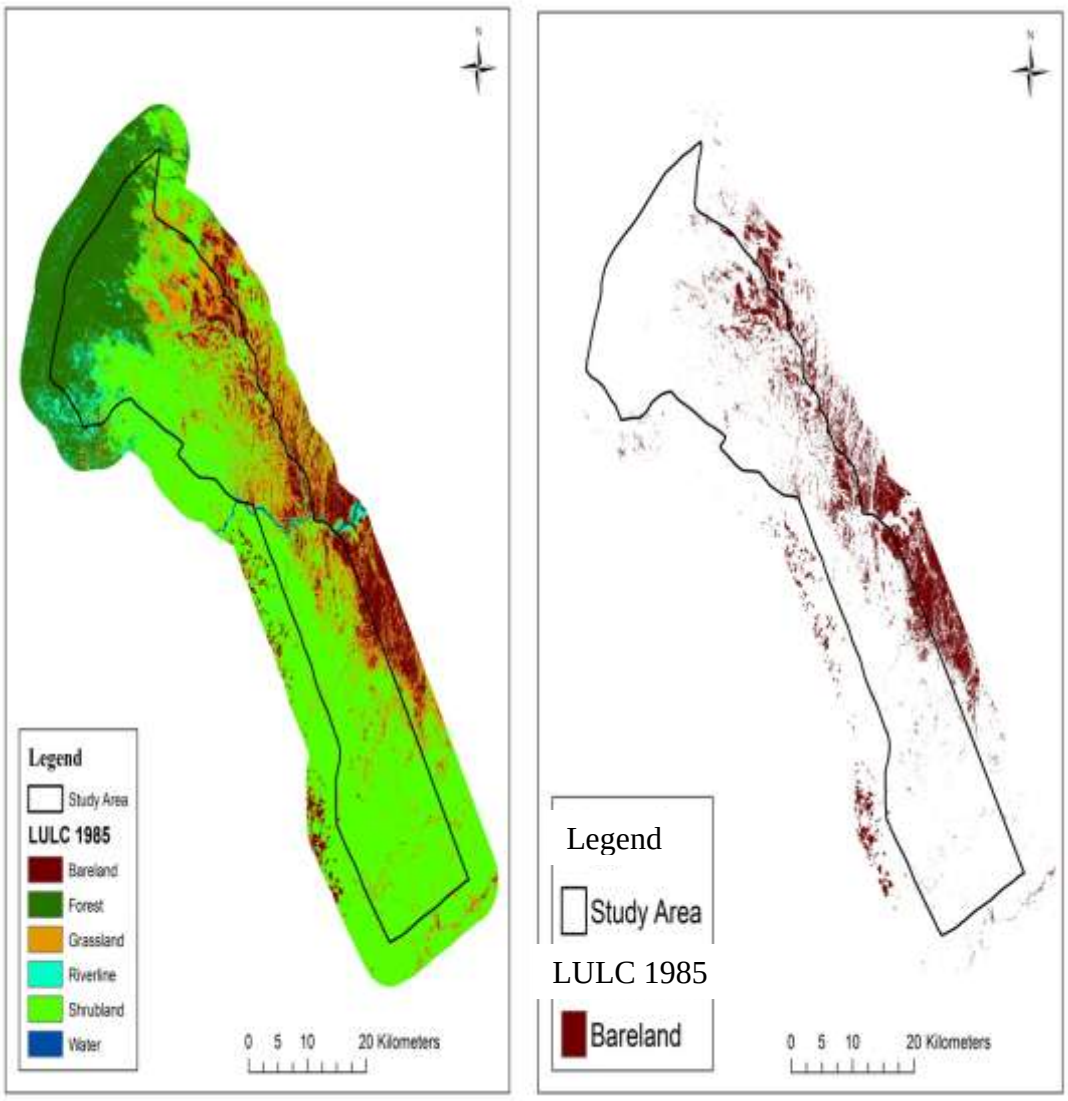


Figure 9: Image for 1985 showing (a) all the LULC classes (b) Degraded areas (Developed from Landsat Image data acquired from RCMRD, Nairobi, 2014)

The figure 9 (a) above represents the results of the 1985 image classification into six different land cover land use classes. As per this period, the study shows that the total land cover for forest was 46677Km^2, shrubland was 152,353Km^2, grassland covered 48,659Km^2, riverline vegetation was 8247Km^2, water was 727Km^2, and bareland was 28,065Km^2. While figure (b) shows the image where all other LULC classes have been isolated to remain with the bareland which according to this study represents the human activities such as farmlands, settlements and grazing areas.

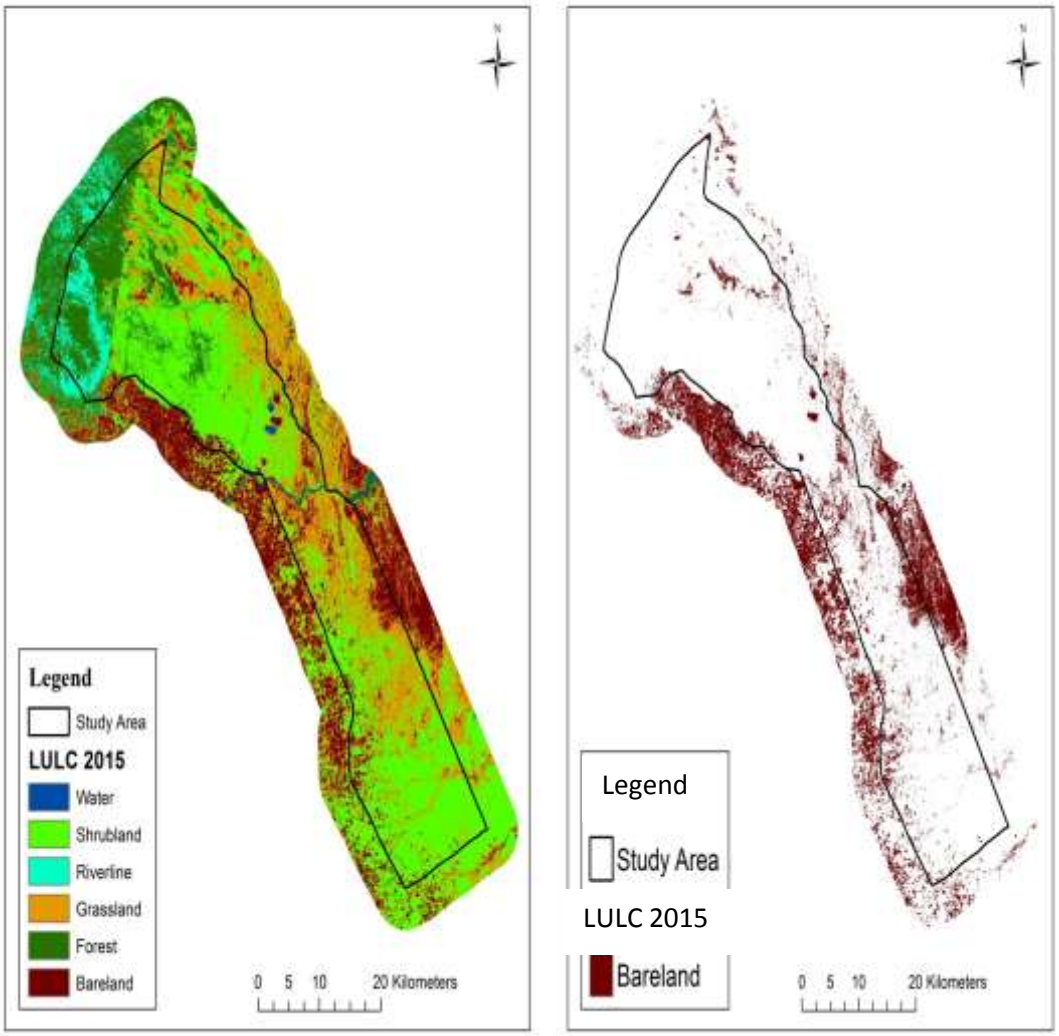


Figure 10: Image for 2015 showing all the LULC classes and Isolated bareland (Developed from Landsat Image data acquired from RCMRD, Nairobi, 2014)

Figure 10 represents the results of the 2015 image classification which revealed significant change in the six land use land cover categories. For the entire study period, the forest cover had reduced from 16.4% cover to 14.1%, while bareland had increased from 10.1% cover to 16.2%. Other land uses that shown a significant change were grassland with +9.9%,

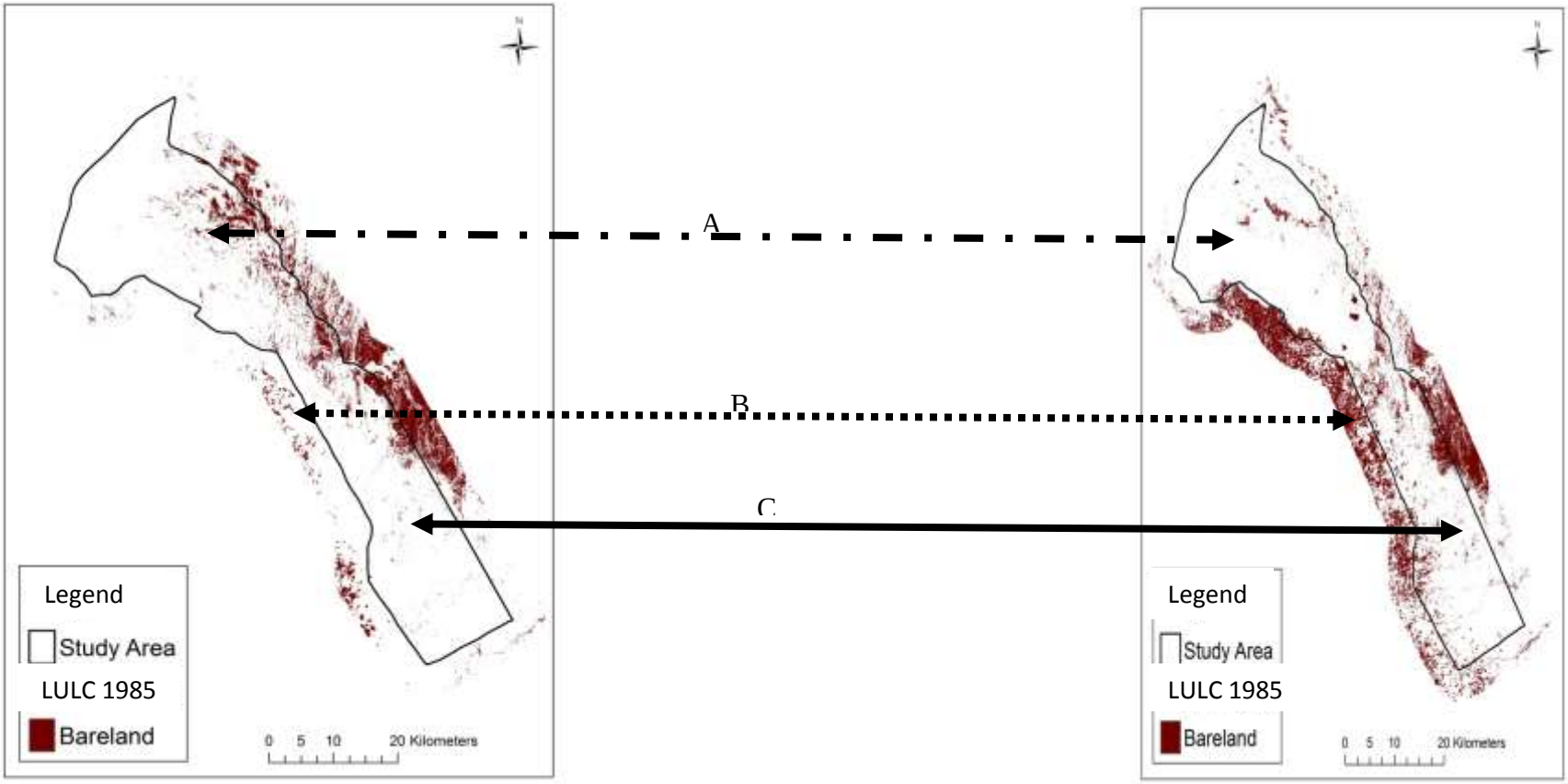


Figure 11: Comparison of Land Use Changes from 1985 to 2015

The classified images in Figure 11 show the changes in different LULC for the 30 year period from year 1985 to year 2015. The LULC class represented as bareland increased from 28065km^2 in 1985 to 46048km^2 in 2015 which account for the 6.1% change from 10.1% in 1985 to 16.2% in 2015. The study associated the changes that occurred in both MNP and MNR and their surrounding land to the ongoing anthropogenic activities such as farming, livestock grazing, charcoal burning and human settlements. The colored section A pointed by the arrow above, shows some disturbances of the habitat inside Meru National Park (MNP) in 1985 which was attributed to the past disturbances that were experienced in the park during the 1970s to late 1980s where many species of wildlife mainly elephants and rhino were killed by bandits.

During this time, there was high insecurity in the park and it is reported that the pastoral community from the northern boarders had invaded the protected areas. However, this has significantly improved over time as shown by the 2015 image. Due to improved security in the protected areas, community consultation, fencing and improved management strategies, cases of livestock encroachment in Meru National Park (MNP) has been prohibited. The arrow B shows the land cover and land use changes that have occurred in the buffer zones and dispersal areas of both Meru National Park (MNP) and Mwingi National Reserve (MNR). The human activities have increased from low population in 1985 to high human settlements and farming as shown in the darker pattern in the 2015 image. Further, the arrow C represents the changes in land use and land cover in Mwingi National Reserve (MNR) from 1985 to 2015. As indicated in the image, the vegetation disturbances have been increasing significantly in the reserve over the years. This is associated with observed and reported cases livestock encroachment in dry spells, charcoal burning and farming in the reserve.

As the human population increased, it posed a profound effect on land use, land cover and wildlife around the Meru Conservation Area (MCA). Different community groups had varying forms of interaction with the land. For instance, it was established that 28.3% were practicing pure agriculture, 34.2% were agro-pastoralists and 35.8% were pure pastoralists. The increase in farming activities contributed to the change in vegetation cover as well as degradation due to overstocking and overgrazing. The

implications of these changes include loss of wetlands which have been reclaimed for farmland, loss of dispersal areas and corridor to Ngaya forest due to expanding farms towards the Park boundaries and encroachment of pastoral communities in the Protected Areas for forage and water during the dry season particularly in the Northern buffer of Meru National Park and Bisanandi National Reserve. In addition to human population increase, variation in seasonal temperature and rainfall over time have resulted to changes in land cover hence contributing to decline in wildlife ecosystem potential in Meru Conservation Area (MCA). The changes in land cover such as forests to grassland or bareland have thus reduced the ability of the ecosystem to support viable wildlife populations leading to death or migration of species.

It is noted that land cover changes may occur as a result of natural factors such as fire, drought and climate variations. However, the changes may be temporary and irregular and the ecosystem tends to recover from them. But the most destructing land cover changes are as a result of human alterations which have high degree of resistance and consistency that minimize chances of ecosystems to recover. For instance, farming and grazing activities around MCA have significantly contributed towards changes in the land cover where once forested areas have been converted to open grassland or worse of bare grounds that are rarely covered due to excess degradation.

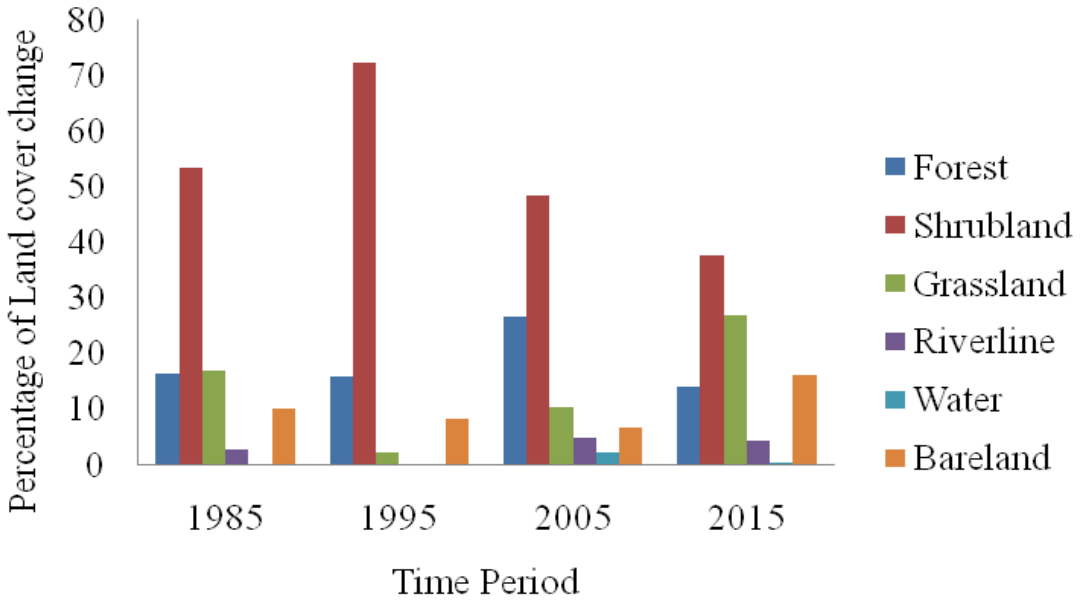


Figure 12: Showing Changes in Land Use Land Cover Classes over Years

The data on LULC was subjected to person corelation coeficient to establish the linear relationship between different classes as shown in the table 3 below.

Table 3:
Correlations between various LULC classes in Meru National Park and Mwingi National Reserve

		Forest	Shrubland	Grassland	Riverline	Water	Bareland
Forest	Pearson Correlation	1					
	Sig. (2-tailed)						
Shrubland	Pearson Correlation	-.073	1				
	Sig. (2-tailed)	.927					
Grassland	Pearson Correlation	-.361	-.898	1			
	Sig. (2-tailed)	.639	.102				
Riverline	Pearson Correlation	.473	-.913	.648	1		
	Sig. (2-tailed)	.527	.087	.352			
Water	Pearson Correlation	.964*	-.296	-.153	.651	1	
	Sig. (2-tailed)	.036	.704	.847	.349		
Bareland	Pearson Correlation	-.692	-.631	.860	.269	-.481	1
	Sig. (2-tailed)	.308	.369	.140	.731	.519	

*. Correlation is significant at the 0.05 level (2-tailed).

There was positive correlation between forests and water (r = 0.964, Df =2, P = 0.036), riverline and water (r = 0.651, Df =2, P = 0.349), bareland and grassland (r = .860, Df =2, P = 0.140). on the other hand, a significant negative correlation occurred between forests and bareland (r = -0.692, Df =2, P = 0.308), shrubland and bareland (r = -0.631, Df =2, P = 0.369), grassland and shrubland (r = -0.898, Df =2, P = 0.102) and between bareland and water (r = -0.481, Df =2, P = 0.519).

Figure 13 shows represent the trend in changes of different LULC categories from 1985 to 2015. From the graph, there is a positive linear trend in which forests, grassland and shrubs are increasingly changing to bareland in the study area over time.

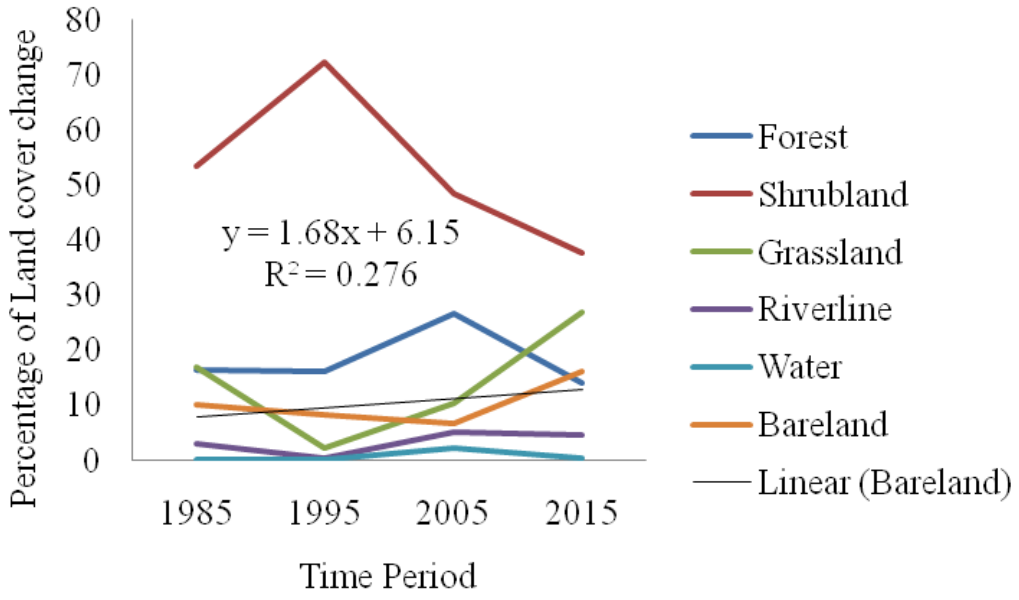


Figure 13: The linear trend in change of land to bareland from 1985 to 2015

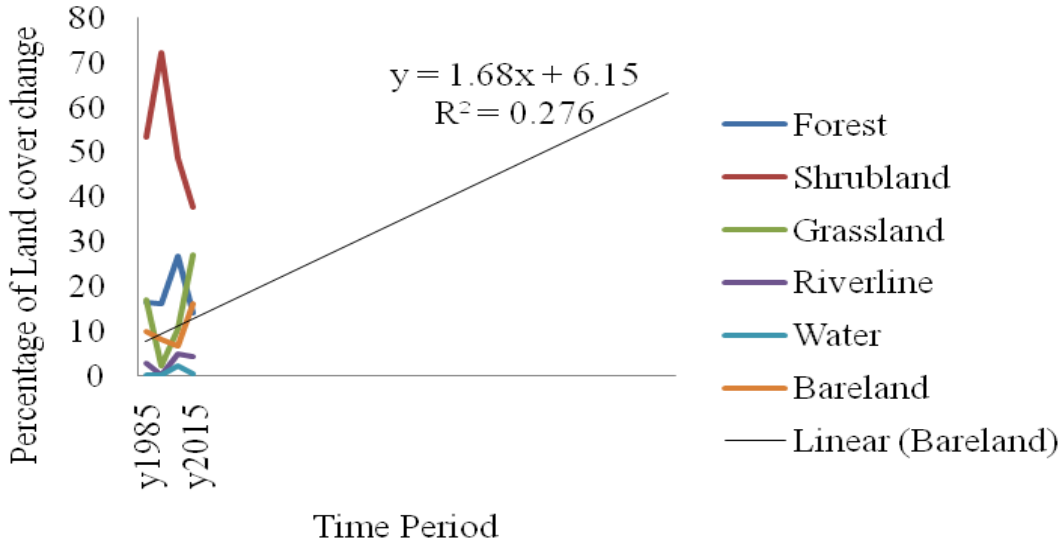


Figure 14: Projection of expected positive trend in change of land to bareland in the next 30years

The findings of the study agree with those of Caviglia and Sill (2005) and Liyama *et al.*, (2008) who observed that continuous increase in human population contributes significantly (r^2=0.276) to land cover changes particularly in areas that have for a long time been protected due to their rich natural resource potential such as parks and reserves. The study established that these particular areas do not easily recover since the demand for grazing and cultivating land is increasing with the expanding human settlements around the protected (PA) hence putting wildlife and their ecosystems at

jeopardy with no hope of recovering. This is a similar scenario that was experienced in MNR where the communities living around the reserve have intensified grazing charcoal burning and subsistence farming.

The implication of this is that potential and preferred habitat for wildlife has been destroyed over time leading to migration of many wildlife species to neighboring MNP and KNP where there is less encroachment. Esikuri (1998) agrees to these findings by noting that landscapes such as vegetation cover are modified by land use activities. Such modifications can lead to an increase or decrease in habitat quality and quantity for various species of wildlife native to an area (Dublin and Hamilton, 1987, & Maitima *et al.*, 2009). The expansion and intensification of agriculture in the western boundary of MNP at Baibariu block is now recognized as one of the most significant human threat to wildlife dispersal and movement to other ecosystems such as Ngaya forest, Mt. Kenya, Samburu and Laikipia. The farming has extended up to the boundaries of the park leaving no space for wildlife movement.

The foraging behavior by elephant may have contributed to the decline in the forested areas and shrubland to expanded grassland and bareland within the protected areas. This is after it was observed from the study that there was significant destruction of trees and shrubs by the elephants resulting to an ecological succession. Another cause that accounts for the observed change in the land cover is the frequent ecological disturbances such as fires that are either introduced by the management to control pest and diseases or that which was found to be caused local communities accidentally when they invade the protected area to harvest honey.

4.4 Conclusions

From the study findings, it is evident to make a conclusion that the human population around MNP and MNR has increased over time due to improved security in the area by the presence of KWS rangers who have managed to drive away the bandits who had invaded the protected areas illegally killing wildlife. The communities have not only utilized the buffer areas adjacent to the PAs, but have further occupied the land that was initially set aside as movement corridor for wildlife. The continuous changes in different land use land cover classes have been accelerated by human activities such as farming, livestock grazing and settlements. The land use and land cover in

MNP and MNR has changed over time showing a positive and significant correlation between different land use classes. These changes have affected distribution and abundance of wildlife species due to transformation of their habitat. Continuous changes in land use and land cover has altered wildlife ecosystem to an extent that they are not able to easily recover due to increasing demand for grazing, farming and settlement land by humans.

CHAPTER FIVE
VARIATIONS IN CLIMATE OVER TIME AND ITS IMPACTS ON WILDLIFE ECOSYSTEMS

5.1 Introduction

Protected areas should remain a cornerstone of global conservation efforts. However, the double impacts of climate change and biodiversity loss are major threats to achieving the sustainable development goals (SDGs), especially those relating to environmental sustainability, poverty alleviation, and food and water scarcity (The Heiz Centre, 2007). In this case, this study agree with the finding by Lopoukhine *et al.,* (2012) that inclusion of local community in protected area planning and management comes in right time when it is of realization that national parks and reserves are changing into islands amidst the sea of changing land cover and land use activities coupled with climate change. This view is further supported by previous reports of IPCC, 2012; IPCC, 2013; IPCC, 2014 that climate change is expected to cause serious disruptions to earth's ecological systems, resulting in an overall loss of biodiversity and a reduction in the goods and services provided to humans. Further, (Lovejoy,2005 and Adger, 2006) established the importance of biodiversity to wildlife and human well-being and the irreversibility of its loss and the depletion of biodiversity to be one of the most important environmental threats that humanity faces.

According to Jaetzold and Schmidt (1983) and Otuoma (2004), the entire study area which is under MCA is classified to be in a similar ecological region (AEZ VI), Arid to Semi Arid receiving annual rainfall amounts ranging between 300-500mm annually. The study based on the fact that availability of food in arid and semi arid areas and the distribution of wildlife population in the protected areas is a function of rainfall amount and distribution pattern. It is hypothesized in this study that climate variability has impacts on wildlife ecosystems in MNP and MNR. Since not all wildlife species could be studied under the present endeavor, the African elephant (*loxodonta africana*) was selected as the evaluation species. The elephant was used because inter alia, 1) it is highly visible and easily counted during census 2) it is water dependent 3) it is very mobile and known to cause conflicts outside the parks when resources are missing and 4) their data is readily available since they have been highly studied. The approach is supported by Esikuri (1998) who argues in his study of

African elephants that capacity of savanna areas to support elephant population is influenced by rainfall patterns, availability of water and human land use activities.

5.2 Methodology

Under this objective, the study site description and research design have been discussed in chapter three.

The study made use of the available rainfall data and elephant's census data in Meru national park and Mwingi National reserve from 1990 to 2016. Primary data was acquired by use of questionnaire and interview schedule from the local communities and leaders respectively. Four clusters were purposively selected around the protected areas based on the land use patterns of each individual community group. In each of the four clusters, a total of 30 questionnaires were administered. Direct observation was also employed on identification of wildlife distribution and abundance, current land use types, park degradation and encroachments. Photographs were employed to capture data using digital camera. This helped in the classification of land uses in the area and as evidence of actual practices taking place.

The acquired rainfall and animal population data was analyzed using SPSS. Pearson correlation coefficient test was carried out to establish the strength of a linear relationship between climate variables and wildlife. The responses from the questionnaire were analyzed and presented inform of percentages. The photographs taken were presented as figures in the study to illustrate the situation on the study area.

5.3 Results and Discussion

The Rainfall pattern in MNP and MNR is bi-Modal with the long rains running from mid March to mid May while the short rains are experienced from October to December. The rainfall data available for MNP and MNR was from 1988 to 2016. This was the secondary data that was regularly recorded by the research department from the weather stations located within the protected areas. To support this secondary data, questionnaires were administered to the local communities and key informant to evaluate if they were aware of the current scenarios in climate variability and whether they could associate the variations in rainfall patterns in the area to

changing climate. The survey also determined the implications of these changes on wildlife species and human livelihoods.

Upon investigation on whether climate change has contributed to decline in rainfall amount, 69.2% of the respondents supported while 30.8% disagreed that decline in rainfall amount was affected by climate change. However, upon validation from the existing data collected from the park, it was established that there has been a significant decline in the amount of rainfall received in the area from 1990 to 2014 from 1509mm to 335mm respectively. The figure below shows the trend rainfall amount received in the study area as it was recorded over the study period.

Figure 15: Trend in rainfall amount over the study period in Meru National Park

The findings revealed that there has been constant decline in the amount of rainfall that is received per annum. From these study findings, it is argued out that human land use activities in MNP and MNR have been affected further by climate variations where as observed, the changes in the amounts of rainfall have over the years resulted to prolonged drought and poor crop harvests. The outcome of these has influenced people to carry out illegal activities such as grazing, charcoal burning and farming inside the protected areas as an adaptation strategy to the changing climatic regimes. These activities which are practiced both within and outside protected area boundaries provided alternative sources of livelihood to humans at the expense of changing wildlife habitats. A Pearson correlation coefficient test confirmed a strong significant

negative correlation between rainfall amount and wildlife population in both MNP and MNR ($r = -0.766$, $N=7$, $P<0.05$).

This test shows climate change has had impacts on the wildlife ecosystems. Reduced amounts of rainfall and seasonal variations may have contributed to poor growth of preferred forage and domination of drought tolerant non palatable species of grass. In other cases, the land has been converted into bare land exposing loose soils to agents of soil erosion due to overgrazing and browsing. Some of the rivers such as Kathithi which flows across the park to Tana River were found to be dry especially during the seasons of prolonged drought. All these factors compel the wildlife to move and concentrate in areas that are closer to water, hence contributing to habitat degradation, competition, higher rate of predation and diseases or worse of death, hence reducing the population.

Further, low rainfall amount received in MCA in the recent years averraging to 350mm has resulted to prolonged drought which have had an adverse effects on wildlife. For instance, the recent drought experienced in 2009 and 2013 contributed to numerous death of wildlfe and compelling others such as elephants to migrate to other ecosystems like Mt. Kenya, Samburu and Laikipia (KWS, 2014). The figure below shows wildlife decline as a result of changes in rainfall amount that has in turn affected wildlife population in the study area. However, as established in the study, the wildlife population was low in the period of 1990-2000 due to insecurity that was experienced in the area.

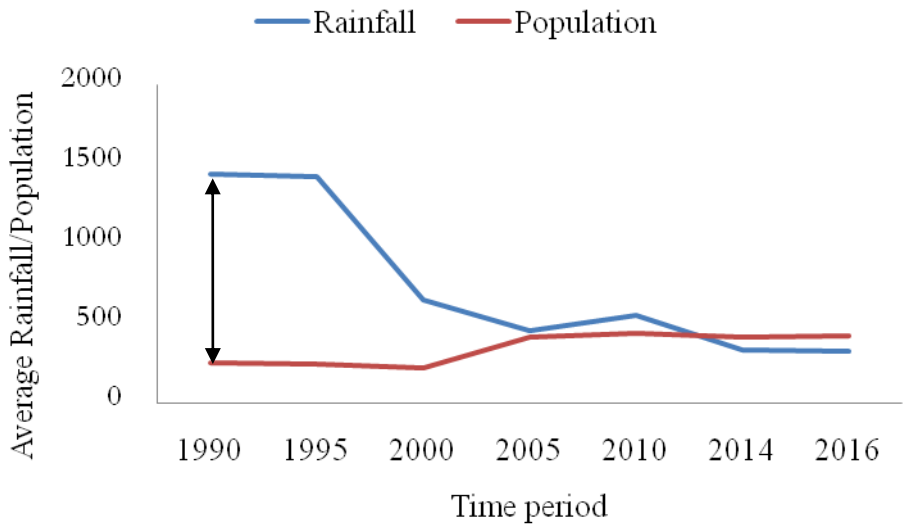


Figure 16: Relationship between Rainfall and wildlife Population in the study area

The study findings further established as a result of changes in rainfall amounts, charcoal burning and livestock encroachments became a main threat especially in MNR which is managed by the Kitui County government and KWS. This was identified as a response strategy for frequent and prolonged droughts. However, MNP was not affected by encroachment since there was an electric fence and regular patrols by the KWS rangers.

Further, the disturbances as a result of climate variability has had impacts on wildlife ecosystems and human society as established in the study. According to the MNP community warden, reported cases of human wildlife conflicts increased by 16% from 2000 to 2015. These findings could be attributed to the changes in vegetation cover compelling wildlife to move to disperal areas that have since been settled or cultivated. Figure 17 below shows the distribution of livestock as a result of encroachment in MNR and other PAs in MCA unlike in MNP where there are only few observed cases.

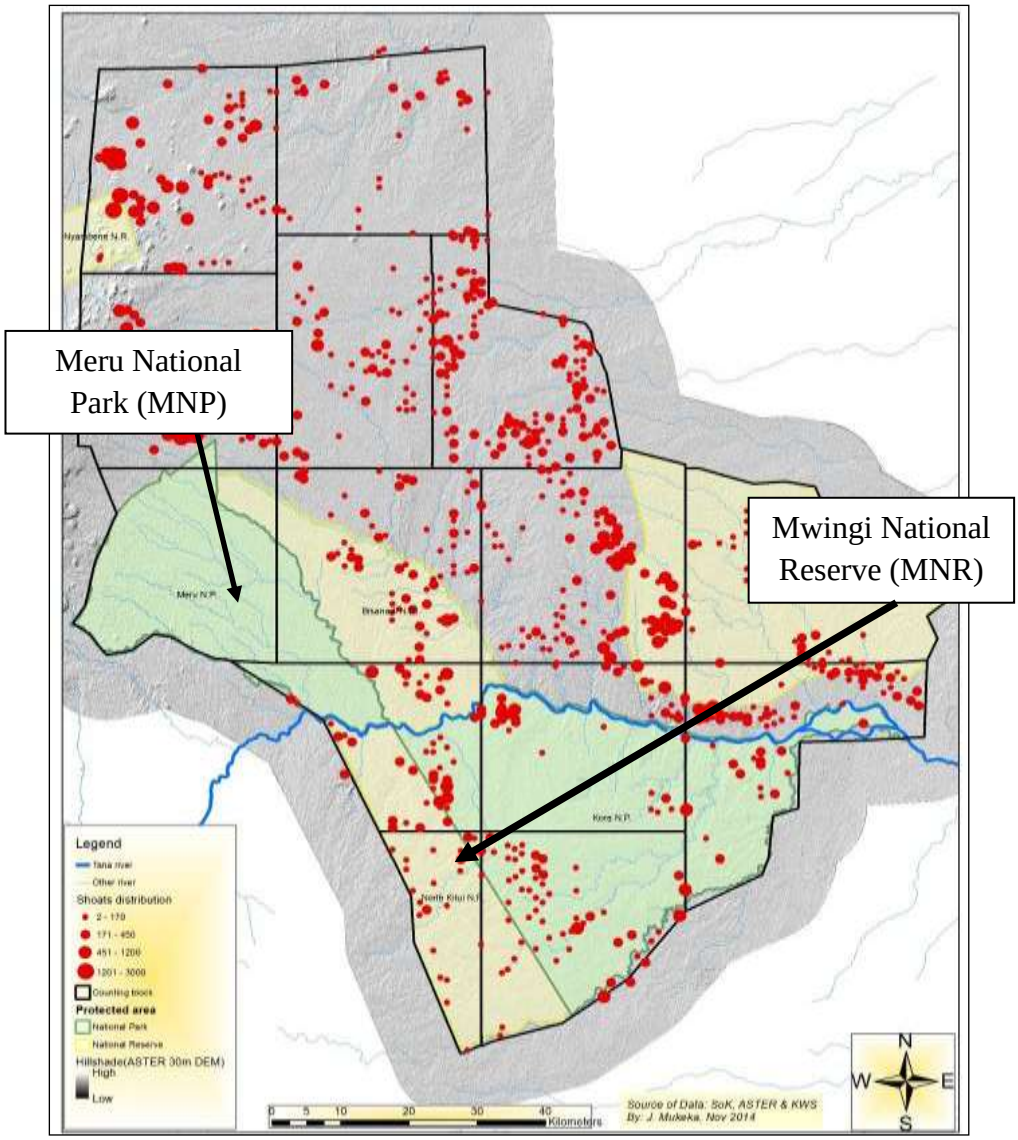


Figure 17: The distribution of Livestock in Mwingi National Reserve during the dry season (Source: KWS, 2014)

From the figure above, it is observed with the dots that cases of sheep and goats (Shoats) encroachment was highly reported at Mwingi national reserve as compared to the adjacent Meru national park. This is attributed to the variation in the governance systems of the two protected areas. Meru national park is managed by Kenya wildlife service (KWS) while Mwingi national reserve is managed by Kitui County as a trustee.

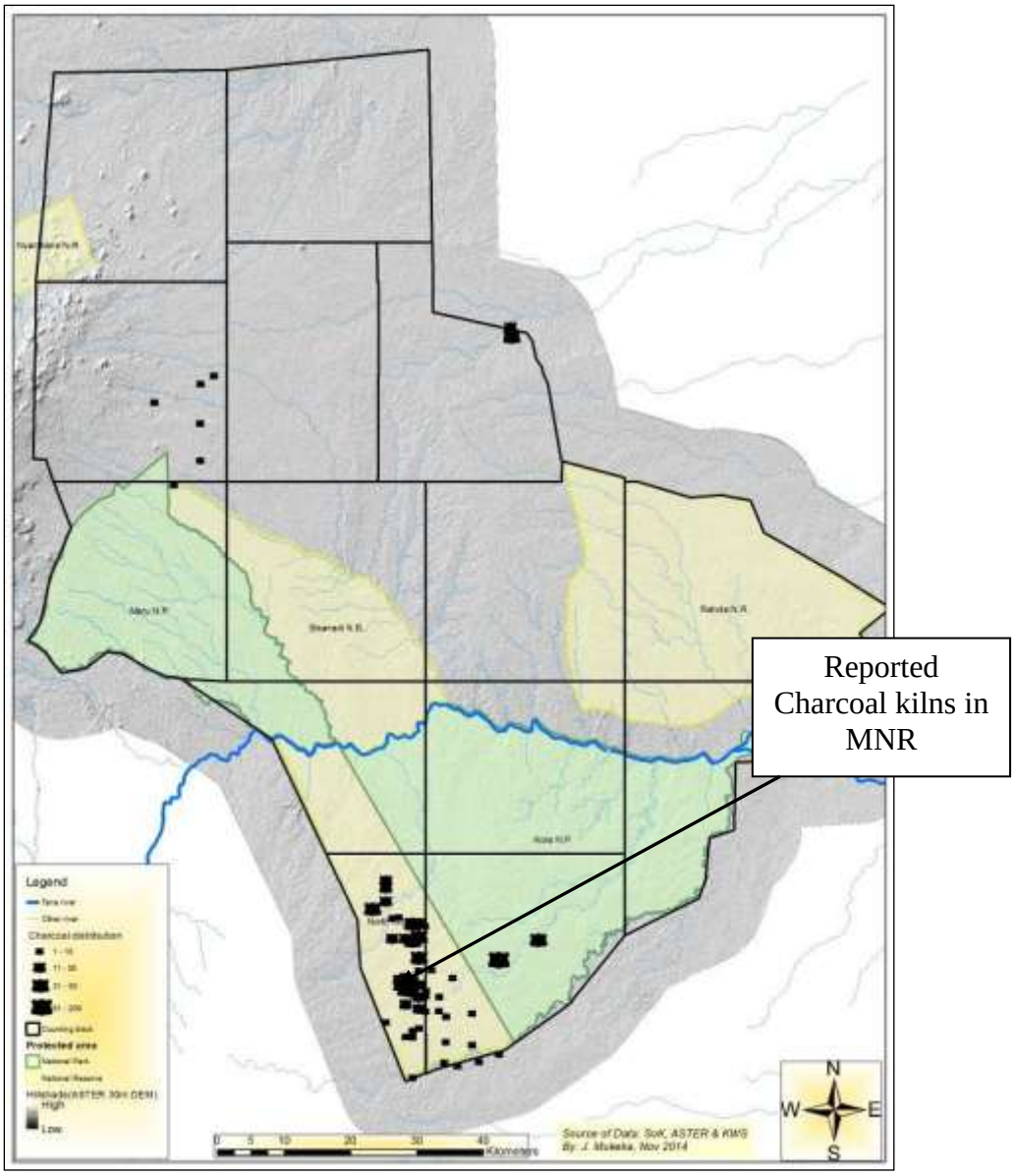


Figure 18: The distribution of charcoal burning Areas in MCA (Source: KWS, 2014)

During the study, the respondents reported that there has been regular crop failure as shown in the Figure 19 prompting them to alternatives such as charcoal burning, and other income generating ventures.

Figure 19: An interviewee explaining about frequent crop failure around Mwingi National Reserve (MNR)

Figure 20: A) women making ballast at Kaningo gate of MNR for construction of a rangers post as an alternative source of income. B): women fetching water at the dry rivers adjacent to the reserve

On the western part of the MCA, communities have intensified the use of water for irrigation from the rivers such as kathithi which is one othe rivers that waters MNP. The increase in water abstraction results to drying up of such rivers as shown in the photo below that was taken in the study area.

Figure 21: Water Diverted from Kathithi River to Irrigate Miraa by Farmers

This has cotributed to human-wildlife conflicts as the animals get outside the PA in search of water. However, the changing trend in climate results to continous drought it is anticipated these swamps and rivers may dry up due to land use pressure on the upstream catchment areas. These findings agree with the study by Nyaoro (1999) that conflicts on water resources will tend to rise with increase in demand while the volumes in rivers declines.

Figure 22: a). Abstraction of Kathithi River Upstream b). Dry Kathithi River as it Enters the Park Downstream

Upon further investigation, the study established that reported cases of human wildlife conflicts were higher 87% during the dry spells as compared to wet seasons 13%. This is because most of the species such as buffaloes, elephants, baboons were found to move out of the park boundary in search of forage. In view of these findings, the increasing rates of conflicts are an outcome of the vulnerabilities brought about

climate change that is impacting on human livelihood and wildlife. This study observation agrees with that by Gupta *et al* (2017) that conflicts could increase vulnerability, lessen opportunities for adaptation and reduce support for species management. In their study, Okello and Kiringe (2004) found that communities living adjacent to protected areas are highly prone to such threats, which may occasionally hinder their support to conservation.

5.4 Conclusion

From the findings, it is noted that climatic variations in the study area have resulted to changes in vegetation cover and facilitated alternative land use options by local communities as coping strategies which have negative impacts to wildlife conservation. Wildlife populations on the other hand have declined in both MNP and MNR due these changes. For instance, annual census for the elephants population in MCA shows that their numbers have been decreasing over time, a factor which is associated with changes in habitat and disturbances by humans. Interestingly, vegetation along the rivers and wetlands outside the PA boundaries has increasingly been destroyed for farming. The livestock keeping community in Rapsu, Kaningo and Ntoroni blocks on the other hand have been found to drive their livestock into the park during the dry spells in search of water and fodder. However, since climate change is an ongoing phenomenon, it is considered in this study that the protected area managers and other conservation agents should establish mitigation measures that will reduce the effects of climate change as well as providing alternative land use options that are environmentally sustainable.

CHAPTER SIX

EFFECTIVENESS OF THE EXISTING MERU NATIONAL PARK AND MWINGI NATIONAL RESERVE MANAGEMENT PLAN

6.1 Introduction

Reconciling biodiversity conservation goals with social and economic issues is a strategy for conservation success. This is supported by the definite and mandate of PAs by IUCN (1994) that effectiveness of a PA is realized when all stakeholders including the local communities forms part of the management team and are able to realize the benefits of conservation. However, it is worthwhile to note that many PAs have followed the conventional and exclusionary approach of 1872 Yellowstone model (Pretty and Smith, 2004; Adrade and Rhodes, 2012). And as a result, many PAs have failed to integrate other important factors such as socio-cultural and political issues in biodiversity conservation, an approach that has triggered adverse social impacts on local communities, disrupting their traditional ways of living and control of natural resources (Dudley *et al.,* 2003; Daniels *et al.,* 2012, Jenifer, 2014). This has in return continued to undermine wildlife protection policies through conflicts between the protected area authorities and the communities (Okello and Wishitemi, 2006; Ogada, 2011; FAO, 2015).

Some communities still withhold their association from the PAs because the management denies them access to natural resources that supported their livelihood as well as little consultations and inadequate compensation during acquisition of these lands sets aside as PAs (Jim and xn 2002; Antony,2007). In other studies, (Macsia (2003); Pretty *et al.,* 2004, Gelcich *et al.,* (2005), Kiria *et al.,* 2014) noted that local communities are more likely to comply and commit themselves to long term conservation strategies when their knowledge and opinions are incorporated in the PA decision making process. For example, a study conducted by Stein (2014) revealed that in Bwindi impenetrable forest Uganda, several anonymous fires were set up after the national park was established burning up 5% of the forest. Further, Watts and Faasen (2009) observed that in Tsitsikamma National Park, South Africa, local communities practiced illegal activities as a form of retaliation to command –and-control conservation policies.

Under this objective, the study sought to establish the effectiveness of the existing MNP and MNR management plans in promoting wildlife conservation as well as addressing the needs of the local communities. The PAPF model which was developed by KWS in 2007 provides the framework under which the current MCA management plan operates. As the study reveals, the plan was predestined to enhance effectiveness in PA management through reduced HWC, improved biodiversity conservation, increased tourism activity to boost local economy and increased wildlife security.

6.2 Methodology

Under this objective, the study site description and research design have been described in chapter three.

The existence of a functional management plan in any protected area is an indicator of good governance in a park or reserve where the management engages all stakeholders including the local communities not only to conserve wildlife but more so improve the socioeconomic well being of the communities. Multi-criteria decision making analysis was applied as a tool to establish appropriate planning matrix for the wildlife ecosystems. Semi structured questionnaires; guided field observation and interview schedule were administered to the local communities living around the protected areas up to a distance not exceeding 5 kilometers from the PA boundaries and institutions to acquire relevant data. The survey method was selected for it allowed for detailed investigation of the research problem in a short time through purposive and simple random sampling.

The main parameters that were tested in this study were acquired from the existing MCA management plan. These included involvement of the community in park planning and management, access to socio-economic benefits by the community, as well as approach to human wildlife conflicts.

6.3 Results and Discussion

The study established that 87% of the communities living around the PAs are frequently prone to human wildlife conflicts. Of these, 95.8% confirmed that there are wild animals which are found outside the PA boundaries. The most commonly

mentioned being baboons (65%), elephants (42%), buffaloes (8%) and others (5%). These animals were frequently mentioned as the ones that contribute to common forms of conflicts such as crop destruction (70%), loss of livestock (22.5%), human death and injuries (3.3%) and other forms of conflicts (4.2%).

Table 4.

Common Forms of Conflicts in the Study Area

Conflict Type	Frequency	Percentage
Crop Destruction	84	70.0
Human Death and Injuries	4	3.3
Loss of Livestock	27	22.5
Others	5	4.2
Total	120	100.0

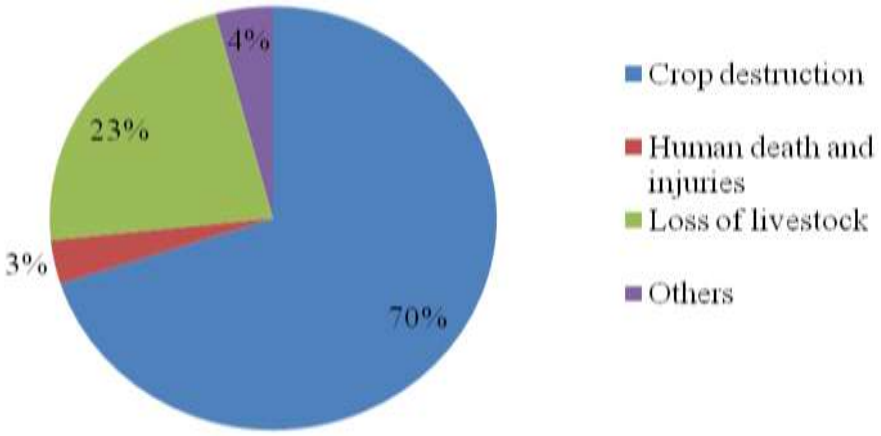
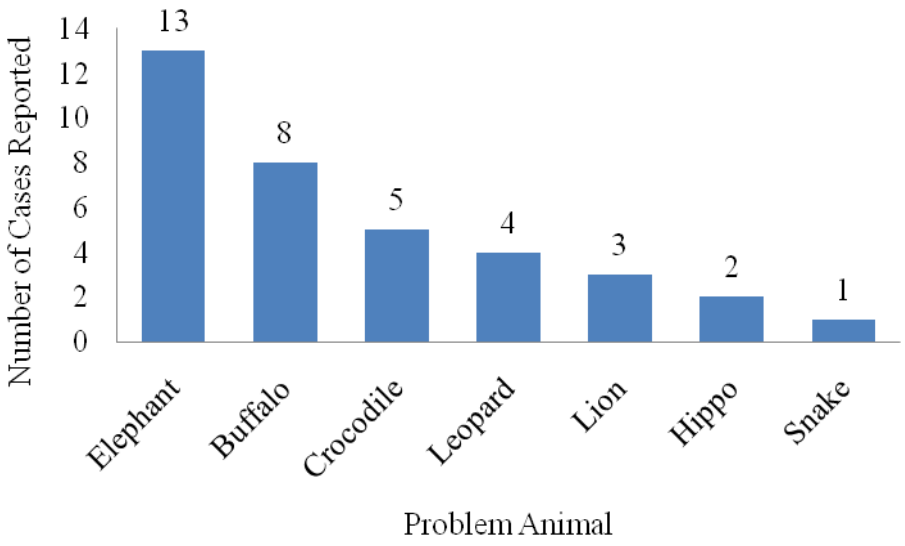


Figure 23: Common Conflicts Reported in the Study Area



(Source: KWS, 2010)

Figure 24: Conflict Cases Reported as Per Animal Species in MCA from 2000-2007

Upon investigation on the reaction of the communities to the conflicts, 50.8 % reported that they guard the farms and livestock, 39.2% reports to KWS, 7.5% did nothing against the problem while 2.5% reported to kill the problem animal.

Table 5.
Action Taken by Community After Conflicts around Meru Conservation Area

Action	Frequency	Percentage
Kill animal	3	2.5
Report to KWS	47	39.2
Guarding	61	50.8
Nothing	9	7.5
Total	120	100.0

On the other hand, investigation from the community on the intervention by KWS towards the conflicts, majority of the respondents 77.5% reported that they did nothing despite reporting to them, 20% reported that they occasionally drive away the problem animals while only 3% reported to be compensated after the conflict.

Table 6.
Help Received from KWS after Conflict to Communities in Meru Conservation Area

Help	Frequency	Percentage
Compensation	3	2.5
Driving animals Away	24	20.0
Nothing	93	77.5
Total	120	100.0

Increase in Human Wildlife Conflicts (HWC) has been attributed to poor management by KWS (69.2%), increased human population around the PAs (17.5%), sub-division of land (10.8%) and dislike of people for wildlife.

Table 7.
Causes for Increased Human Wildlife Conflicts

Cause	Frequency	Percentage
Poor management by KWS	83	69.2
Increased human population	21	17.5
Sub-division of land	13	10.8
People don't like wildlife	3	2.5
Total	120	100.0

Upon inquiry whether the local communities were aware of the existing MCA management plan, 25.5% strongly disagreed, 58.3% disagreed, 9.2% had no opinion, 5% agreed and 1.7% strongly agreed that they were aware of an existing management plan for the conservation area. Majority of the respondents (63.3%) disagreed that they were not involved during the preparation of the management plan which should have been a participatory process for them to contribute their ideas and make them co-managers of the resources. Upon inquiry on their involvement in management plan preparation, 22.5% strongly disagreed, 63.3% disagreed, 6.7% had no opinion, 2.5% agreed and 5% strongly agreed. On regular involvement in decision making, 18.3% strongly disagreed, 61.7% disagreed, 5% had no opinion, 5.8% agreed and 9.2% strongly agreed that they were actively involved in day to day decision making in the protected area.

On whether the intensity of human wildlife conflicts has reduced since the inception of the management plan, 49.2% strongly disagreed, 42.5% disagreed, 5.8% of the respondents agreed they have reduced while 2.5% had no opinion.

Figure 25: Part of Electric Fence Destroyed by the Community at Ntoroni in Tharaka near Ura gate

Figure 26: Part of Electric Fence Destroyed by Elephants in Meru National Park as they move to the dispersal areas

Investigation carried out to establish whether the local communities were realizing any socio-economic benefit from the protected area revealed that, the establishment of the MCA management plan has promoted the utilization of the resources by the local communities.

Findings showed that of the total respondents, 45% disagreed that the management plan has addressed the socio-economic values of the local communities, 15.8% strongly disagreed, 7.5% had no opinion about the query whereas only 29.2% agreed and 2.5% strongly agreed that the socio-economic values and expectations of the local communities have been addressed by the management plan.

Table 8.
Ranking of Protected Area Effectiveness by Respondents in Meru Conservation Area

Indicators	Strongly disagree	Disagree	Uncertain	Agree	Strongly agree	Total
Local community participate in management and planning process	31 28.5%	70 58.5%	11 9.2%	6 5.0%	2 1.7%	120 100%
cases of human-wildlife have reduced	59 49.2%	51 42.5%	3 2.5%	7 5.8%	0 0%	120 100%
MCA plan has addressed social-economic values	19 15.8%	54 45.0%	9 7.5%	39 25.2 %	3 2.5%	120 100%
MCA plan has addressed cultural values	76 63.3%	24 20.0%	6 5.0%	11 9.2%	3 2.5%	120 100%

The responses in this section were acquired using an outranking method where likert scale was used to weigh the attitude of the respondents on a 5- point scale. The responses were ranked from number 1-5, Where 1 represented, strongly disagree, 2- Disagree, 3- Neutral/No opinion, 4- Agree and 5- Strongly agree. The conclusion is based on the scores.

The main areas that were subjected to attitude test included awareness of the local community of an existing management plan and their involvement in planning process, occurrence of conflicts and the realization of benefits. The evidence presented in this section suggests that low tourism activities in entire in both MNP and MNR may have made the communities not to appreciate the economic value of wildlife. This is because they are not able to establish tourism-based ventures that can provide incentives for conservation. As a National Park, Meru provides little opportunities for resource utilization by the community as compared to Mwingi National Reserve which according to its category allows for resource use and revenue

sharing since it is should be managed as a community resource by the County government of Kitui. However, the communities in MNR also have not benefited from any revenue from the national reserve since the county government has not developed effective management structure despite the drafting and passing of the Management Plan in 2007.

It was observed that the numerous cases of encroachments experienced in Mwingi National Reserve is attributed to non effective management by the Kitui county government in regard to the mandates of a National Reserve. The government has invested little effort in involving the community in the planning and management of the National Reserve. For instance, the study established that most of the community members (73.2%) in the study area of Kaningo were not aware of the protected area management plan. An indication that they are barely involved in the decision making.

On the other hand, although both PAs are experiencing threats posed by human activities, Meru National Park has experienced less anthropogenic impacts within its boundaries as compared to the adjoining Mwingi National Reserve which is supposed to be managed by the Kitui County as a trustee for the community. This is evidenced by the outcome of the satellite image analysis of 2015 as shown in figure 11. Therefore, due to the failure by the County to effectively manage the reserve as per the management plan, communities found a freedom to practice activities that have continued to alter the wildlife ecosystems.

The results of the study failed to portray the expectations of the Protected Areas as effective management areas that have a broad array of positive and negative socio-economic, cultural, ecological and political impacts on local communities. The frequent complaints and lack of commitment for conservation by the local communities was an indicator of the presence of the protected area does not meet their expectations. The design and day to day management of these parks should be in such that they are able to meet ecological and human needs. These findings are consisted with those of Hockings *et al*, (2006), that success is often predicted on local support for conservation, which is strongly influenced by the perceptions of the impacts that are experienced by local communities and opinions of management and governance.

It is expected that PAs should not only protect biodiversity but more so to be centers for alternative livelihood, social, cultural and educational benefits. However, information from the ground revealed that MNP and MNR are centers of conflicts due to poor dispute resolution mechanism by the PA management, poor community and stakeholder participation, and limited access to resources and benefit sharing. Majority of the communities (62.4%) living around protected areas still harbor claims that they were not consulted neither compensated during their establishment. Their relationship with protected area management has been marred with conflict since the communities pursue ways of continuing to enjoy the benefits of the PA which they believe is their right that has been denied. However, to counter this resentment and mistrust by the local community, protected area managers should cultivate all the efforts to ensure that the local communities are part of the protected area planning and management to enhance efficiency of the management plans and existing policies.

The study reviewed that communities living around MNP and MNR do not fully support conservation programs since they believe they are not involved in planning and making management decisions. 15.8% strongly disagreed and 45% disagreed that MCA management plan has addressed the socio-economic needs of the communities, while 7.5% had no opinion whereas 29% strongly agreed and only 2.5% agreed. There was a further claim by the community that they were not adequately compensated for the land lost during establishment of the two PAs. For instance, respondents interviewed from Ameru and Tharaka community living around MNP at Kanjoo and Ntoroni areas respectively reported that during recent construction of the perimeter electric fence, parts of their land was taken over by KWS where vital resources such as access to water, grazing land and honey was cut off. Destruction of the installed electric fence by the community as shown in Figure 24 was an evidence to indicate that no compensation was done by KWS for the land lost to PA neither was there alternatives provided for the resources and livelihood lost. This could become a recipe to increasing cases of conflicts and withdrawn support for conservation by the local communities. In Mwingi National Reserve, communities also harbor resentments due to forceful eviction and penalties they are subjected to as a result of encroachment to the reserve for grazing, cultivating or charcoal burning.

With majority of the respondents having accepted that crop destruction by wildlife is inevitable, they have resulted to "doing nothing" after the regular destructions, and have accepted that wildlife is to destroy the crops and they only live by hope that the subsequent season might be better. This is to mean, they only survive on hope that the current season might different from the previous and that baboons, monkeys and elephants will not revisit their farms. This is a situation that has positively contributed to persisted poverty in these areas as portrayed by the visible living conditions observed during the study. Further, the assumed lifestyle of guarding the property in the farms can lead to a probability of socio-economic impacts such as low education levels in the communities, marital break-ups and diseases.

Figure 27: A House Fitted on a Tree for Guarding the Farm against Wildlife at Kathithi area bordering Meru National Park

The study reveals that effectiveness still lacks in MNP and MNR despite the use of the PAPF model (KWS,2007b) to prepare the MCA management plan since many PAs still follow the same exclusionary top-down management approach. From the study findings, there is dissatisfaction by the communities who feel they were not consulted in plan preparation as well as its implementation on day to day basis. The KWS has also failed to consider their social, economic and cultural needs. This the evident from persistence poverty amongst the communities as revealed by the poor housing and living conditions observed during the field study.

Further, it was observed that over time, the continuous resentment and numerous conflicts is a sign of reduced effectiveness of these PAs biodiversity conservation. Nevertheless, communities at both MNP and MNR, reported that they appreciate the presence of the PA and are willing to be involved in day to day management activities. Reports from the community warden revealed that the management is positively involving stakeholders such as local administration (chiefs, sub-chiefs, village elders, nyumba kumi), county government, national government agencies such KFS, Livestock, Vetinery, Agriculture), Community Based Organizations (CBOS), Non-Governmental Organizations (NGOs) and newly established County Wildlife Compensation and Conservation Committee (CWCC) on issues of compensation, management of the water catchment areas, encroachment into the park as well as poaching.

6.4 Conclusion

From the findings conclusions can be made that the expectations of the management plan have not been realized since human-wildlife conflicts still exists, communities are still encroaching into the park and also practicing land use activities that affect wildlife ecosystems through pollution and reduced river flows downstream. Effectiveness of the PA management systems can be assessed and acknowledged by the local communities and other stakeholders who interact with the regular management routine. Lack of total support to conservation efforts by all stakeholders affects PA management effectiveness. These experiences show that when local communities are excluded from PA management and their needs and aspirations ignored, it becomes extremely difficult to enforce conservation policies. This should trigger the Protected Area managers to establish some advancement for community involvement to enhance their compliance to the provided conservation policies and goals. The current Wildlife Conservation and Management Policy of 2012 and the subsequent Wildlife Conservation and Management act of 2013, if well implemented, provides a suitable avenue to effectively promote community participation in conservation and management of wildlife due to its provisions such as compensation for life and property, wildlife utilization as well as inclusion in management.

CHAPTER SEVEN
ADAPTATION STRATEGIES FOR CLIMATE CHANGE MITIGATION IN MERU NATIONAL PARK AND MWINGI NATIOAL RESERVE

7.1 Introduction

In the context of climate change, adaptation refers to human activities that are intended to minimize the adverse effects of climate change on the environment (Permesan, 2006; The Heinz Center, 2007). In their studies, (Root et al., 2003; Hannah et al 2005 and Lovejoy, 2005) have explained climate change adaptation as the process of designing, updating and implementing strategies to account for the impacts of climate change to ensure the highest return over time. In order to establish whether there is any effort by the wildlife management and the community on climate change mitigation, the study sought to identify existing adaptation strategies for climate change mitigation in Meru Conservation Area.

7.2 Methods

Under this objective, the study site description and research design have been discussed in chapter three

The study used questionnaires, observations, interview schedule and the available secondary data to establish existing adaptation strategies for climate change in Meru Conservation Area. A checklist of the likely intervention was provided in the questionnaire for the respondents to identify and tick appropriately those that are in use. The interview schedule was given to the key respondents who included the KWS personnel, county officers in charge of environment in Kitui County and other local leaders.

Both simple random and purposive sampling techniques were used to collect the required data from the respondents (Kothari, 1985, Dawson, 2002). In this case, the study area was purposively divided into four different blocks based on the dominant ethnic community group living adjacent to the protected area. This included the Rapsu, Baibariu, Ntoroni and Kaningo where the dominant tribe was Borana, Ameru, Tharaka and Kamba respectively, who were expected to have different socio-cultural interactions and land use patterns. After selecting the clusters, simple Random

sampling technique was then used to select 30 respondents for administering the questionnaires within each cluster, making a total sample of 120 respondents.

7.3 Results and Discussion

From the study, 57.5% of the respondents were in agreement that they have initiated adaptive measures for climate change, 14.1% disagreed that there are no adaptation strategies in place and significant number 28.4% did not have any knowledge on climate change. Although there was lack of adequate data on climate change adaptation strategies since majority of the residents had little knowhow, various observations in the study area could be attributed to attempts for adaptation strategies for changing climate regimes as applied by wildlife managers and local communities. These were grouped into similar categories as discussed below.

7.3.1 Strategies towards Land Protection and Management

This refers to all the efforts that are directed towards changing land cover, loss of dispersal areas and corridors.

Findings from the study show that areas that were initially used as wildlife movement corridors and dispersal areas have been replaced by human settlements and farmlands. This is possibly due to the increasing demand for food to meet the growing populations. Another outcome of the changing climate on humans and wildlife is the increase in human wildlife conflicts. The study found out that communities living around Meru National Park and Mwingi National Reserve are worst affected perhaps as a result of regular invasion of their property by wildlife. From the study findings, increase in human wildlife conflicts is attributed to significant changes in land use and land cover around the protected areas where much of the area that was initially serving as either dispersal areas or movement corridors for wildlife has been converted to farmland or settlement. Free movement of wildlife has been further worsened by the erection of the electric fence round the protected areas. In this study, it was observed that wildlife finds their way out of the established fence to the adjacent land during both dry and wet seasons hence causing further conflicts. According to the study findings, much of the conflicts experienced in the areas included human injuries and death, livestock and crop destruction. The local

communities retaliates these attacks by placing snares to kill or harm the wildlife. Animals such as baboons were reported to contribute to majority of conflicts (54.2%) at all seasons in relation to other major reported such as elephants (35.0%), buffaloes (6.7%). Baboons have been reported by the community to be highly problematic since they are not contained by the electric fence. As a result of this, most of the residents especially those in the agricultural and agro-pastoral zones of Baibariu, Ntoroni and Kaningo respectively have adopted to guard their farms all day and nights to chase these primates from destroying the crops.

Occasionally, once the baboons succeed to invade the farms, the farmers reported that they rarely reported these incidences to KWS since no action would be taken. The elephants and the buffaloes broke the electric fence and occasionally invaded the farms especially during the dry seasons. To control these, farmers also guard the farms and prepare other devices to scare them away. According to the respondents, the guarding exercise is a tedious cycle that begins from the planting to the harvesting periods. It was perceived from the study findings that this may have negative impacts to the society such separation of the family unit by either mother or father by regularly keeping guard over the animals day and night. This may contribute to social challenges such as family separation, in addition to diseases such as pneumonia, malaria and Sexually Transmitted Infections (STIs).

In the event of invasion of the farms by the elephants or buffaloes, the residents claimed they normally report the incidences to KWS whose their response is not guaranteed. The intervention by KWS upon such incidences included driving away the problem animal and compensation but only for human injury or death that have been under consideration for such compensation. However, the enactment of the new law, ‘Wildlife Conservation and Management Act, 2013 has provided for the property compensation subject to the approval by the county wildlife compensation and conservation committee (CWCC). For the residents in the pastoral areas of Rapsu block, the common problem animals are the carnivores such as lions, hyenas and leopards which prey on their livestock. Since there is minimal crop farming, these areas have been favored as buffer zones and alternative migratory routes by wildlife.

Another adaptation strategy is increasing the amount of protected area (Adger *et al.*, 2003). Providing more land for conservation and establishment of protected area networks is also another action that has been used by management in MCA as an adaptation towards changing climate. For instance, through the PAPF model, several protected areas such as Meru National Park (MNP), Kora National Park (KNP), Bisanandi National Reserve (BNR) and Mwingi National Reserve (MNR) were joined together as one management unit known as Meru Conservation area (MCA). This move was to effectively enhance conservation of biodiversity through creating a protected area network. Wildlife can move freely from one protected area to the other hence increasing their home range, providing more options for breeding areas as well as preferred forage. In the adjacent land to MCA, communities have also been mobilized to establish conservancies as a direct means of wildlife utilization and providing space for dispersal.

Establishment of controlled areas was done by the research department in Meru National Park (MNP). This is where enclosed parcels of land within the park were set aside as controlled areas. These areas are meant to be free from wildlife interference and provide a representation of the vegetation structure as it is in the ecosystem. This helps in improving the management of the existing wildlife areas to maximize resilience.

7.3.2 Strategies towards Species Management

Another strategy that has been adopted by wildlife managers is by building attention on the endangered species such as Elephants, Rhino and Gravy Zebra where various strategies have been developed by KWS and other stakeholders (McNeely and Schutyser, 2003, UNEP, 2006). These strategies recognize the fact that there are changes in the habitat as influenced by climate change and therefore provide guideline through which the survival of the target species can be enhanced amidst these challenges of climate change. Translocation exercise have been carried out in MNP in the year 2005 to restock wildlife species whose population had reduced due to threats such as insecurity and drought in the previous years. Various species such as elephants and rhinos were brought in to the PA.

In addition to translocation, it was established that the research department organizes for controlled burning of vegetation especially grass in selected blocks so as to increase palatability of forage by encouraging growth of fresh grass, eradicate pest and invasive species as well as to remove accumulated litter that may cause accidental fires.

7.3.3 Strategies Related to Planning and Management

The establishment of the participatory framework that targeted to improve the involvement of other stakeholders including local communities in the conservation and management of wildlife in MCA by KWS in the year 2007 is hereby acknowledged as an adaptation measure towards changing land cover, land tenure systems and climatic regimes. The strategy further provides for involvement of the communities through their participation in decision making in the protected area. As a result of this, the study established that the management of MCA through the community wildlife service department has initiated formation of functional groups in the communities surrounding MCA.

Members of the groups are trained on the importance of wildlife and the need to protect and conserve their habitats. In return, these groups are supported by KWS to establish income generating ventures such as bee keeping, tree nurseries among others. The community groups also provide members for community policing, move to help control incidences of poaching and other wildlife related crimes around the PAs. However, lack of tangible benefits from community involvement call for the need to revise the existing management plan so as to cater for emerging issues and changes in legislations for effective participation.

Further, MCA management is taking steps to help improve the compatibility of cultural practices and land-uses surrounding the MCA with the areas conservation, and to ensure that MCA-adjacent communities are directly benefiting from the area's natural resources.

7.3.4 Strategies Related to Legislative and Legal Framework

The revised Wildlife Conservation and Management Policy 2012 and the subsequent Wildlife Conservation and Management Act of 2013 is hereby recognized by this

study as a strategy that contributes towards changing land use, land tenure, land cover and climate changes in within and outside wildlife protected area boundaries. The act provide for establishment of wildlife conservation and compensation committee at the county levels to enhance effective participation of the communities in wildlife management. It also provides a robust structure that will ensure compensation of human life, injuries and property are compensated to curb the increasing human wildlife conflicts and drive the communities to support conservation initiatives. Further the act provides for stiff punitive measures against wildlife offenses. This targeted to mitigate crimes such as poaching which has contributed significantly to decline in wildlife species.

Other provisions of the law that are adaptive to changing trends in climate, land use and land cover includes the permit for wildlife utilization where individuals and communities can be able to drive economic benefits by engaging in activities such as game farming and conservancies. By this engagement, it perceived that there will be reduction in human-wildlife conflicts, increase in ecosystems management as well as enhanced support for wildlife by the then economically empowered communities.

7.4 Conclusion

This study set out to determine the possible adaptation strategies for climate change in MNP and MNR. The results have therefore revealed that both the local communities and wildlife managers have developed varying strategies that enable them to counter ongoing changes in ecosystem as a result of climate change. Developing adaptation strategies is a planning approach for sustainable management of wildlife resources that help wildlife, ecosystems and human communities that rely on natural resources to adjust to the effects of the changing climate. Therefore, it is worthwhile to note that since climate change is lending protected areas to be more costly to run, there is need for investment in conservation actions that will provide benefits to the people and nature over the long term.

CHAPTER EIGHT
SUMMARY, CONCLUSION AND RECOMMENDATION

8.1 Summary

The main goal of the study was to establish the spatial-temporal changes on land use land cover and climate changes and their impacts on wildlife ecosystems as well as the livelihood of the surrounding communities in MNP and MNR. The study results were analyzed as per the various objectives that guided the study.

From the study findings, investigations of the first objective revealed that there has been a significant change in land use and land cover in MNP and MNR over the study period. Forest cover declined from 16.4% to 14.1%, the shrub land decreased from 53.5% to 37.8%, there was an increase in grassland from 17.1% to 27% while settlement, grazing and farmlands as represented in the study as bareland increased from 10.1% to 16.2%. These changes, according to the study findings have been contributed mainly by anthropogenic activities within and around the protected area boundaries. Although both MNP and MNR are under MCA, the study established that comparatively Mwingi National Reserve was the most affected by human encroachment leading to the loss of preferred wildlife habitat and consequently low wildlife populations. On the other hand, the effects of humans on LULC in MNP were high around of the Park where communities had encroached into the areas initially utilized by wildlife as movement corridors and buffer zones.

The second objective of the study was to establish variations in climate over time and its impacts on wildlife ecosystems in MNP and MNR. The study was successfully carried out by using rainfall data recorded in the study area over time and elephant population as the indicator species. The analysis of this data has subsequently established a strong correlation between decline in rainfall and wildlife populations. Decrease in rainfall in the protected areas has affected the vegetation growth, water availability and hence change in preferred habitat for wildlife. The resultant of these changes as established in the study was decreasing wildlife populations over time, increase in human invasion into the PAs in such of water and fodder for their livestock and human wildlife conflicts. Upon comparing the two protected areas, the density and distribution of wildlife was higher in MNP as compared to MNR. Frequent invasion of the reserve by communities for charcoal burning, farming and

livestock grazing had created disturbances to wildlife hence resulting to their migration to the neighboring Kora National Park or Meru National Park with only few numbers of giraffe, antelopes and baboons being the only common wildlife in the reserve.

The third objective was to determine the effectiveness of the current management plan for MNP and MNR in addressing the increasing cases of human wildlife conflicts. The evidence presented in this study suggest that indeed the current management plan has not been effective to address both wildlife conservation needs and the needs and expectations of the communities living around the protected areas, who bear the cost of conservation by maintaining wildlife in their land. The indicators that were used in the study to test for effectiveness included intensity of conflicts, community participation and benefit sharing. The study established that there were many cases of human wildlife conflicts that were increasing over time, majority of the community reported that they were not involved in planning and management activities in the PAs and there were insignificant benefits from the PAs. Therefore, the outcome of these findings shows that the current plans by KWS for MNP and MNR were not effective in addressing both the need for wildlife conservation and human livelihoods.

The fourth objective was to evaluate and document existing adaptation strategies for climate change mitigation in the study areas. Together, the study provide important insights that the ongoing changes in climate and associated impacts have prompted the local communities and wildlife managers in MNP and MNR to develop strategies that are targeted to ensure continuous survival of wildlife and support to livelihoods. Among the adaptation measures that were identified by the study includes the election of fence around MNP to control conflicts, regular pest control programs, community awareness and capacity building by KWS, shifting to irrigation of crops by farmers, advancing of the settlement and farms close to the PAs, encroachment into the PAs by local communities and also adjustments of laws and policies to suit the current trends.

8.2 Conclusion

In conclusion, both Meru National Park (MNP) and Mwingi National Reserve (MNR) have undergone significant changes in land use land cover over the years which have over time affected the wildlife populations and their ecosystems. These changes have

been brought about by inevitable climate change which has altered rainfall distribution leading to droughts that have hindered vegetation growth. On the other hand, increasing human population around these protected areas has over the years contributed towards land cover from their interaction with land through activities that are meant to provide socioeconomic livelihoods such as farming and livestock keeping.

Good planning and a total paradigm shift in space management are necessary in Meru Conservation Area (MCA) for sustainable management and conservation of wildlife. From the findings, the management plan for MNP and MNR is not effective in addressing wildlife conservation needs and socio-economic expectations of the communities. This can be examined through protecting the rights of indigenous peoples and their access to resources on which they depend. This study further established that effectiveness of a protected area management plan is realized when it is able reach the goals and objectives set for the biological conservation, economic development, social sustainability or cultural heritage of the protected area. Among the Exceptional Resource Values that make MCA unique is the diverse cultural communities living around and that their role in protecting the biodiversity notably the water catchments that feeds the rivers flowing through the parks and the land that doubles up as the dispersal areas or movement corridors for the wildlife. As established in the study both the wildlife managers and the communities have devised adaptive measures to cope with the changing land use, land cover and climate variability.

8.2 Recommendation

From the study findings the following recommendations are suggested

i. There is need for application of geospatial technologies in the analysis of land use land cover and related effects to help in the future planning and monitoring of the Meru Conservation Area.

ii. There is need for mapping out vulnerable areas in both Meru National park and Mwingi National Reserve for detailed conservation effort that enable wildlife managers to learn from previous management activities and to respond quickly and creatively to the challenges posed by climate change.

iii. There is need to recognize global climate change as a factor in wildlife conservation and therefore develop adaptation strategies that promote sustainable management of wildlife resources and those that enable communities to adjust to the effects of changing climate.

iv. The current management plans should be revised and incorporate participation of local communities to enhance transparency and support for their effective management.

v. There is need to establish mechanism to promote the introduction of alternative ventures that will provide economic returns to the community so that they can appreciate the value of wildlife conservation as an adaptive measure.

vi. Compensation for losses incurred by wildlife should be given in the shortest time possible to restore community confidence that the government equally values their property as it is to wildlife to realize community support for wildlife.

vii. The is need for further studies to establish the viability of the proposed integrated conservation model as shown in Figure 28 below.

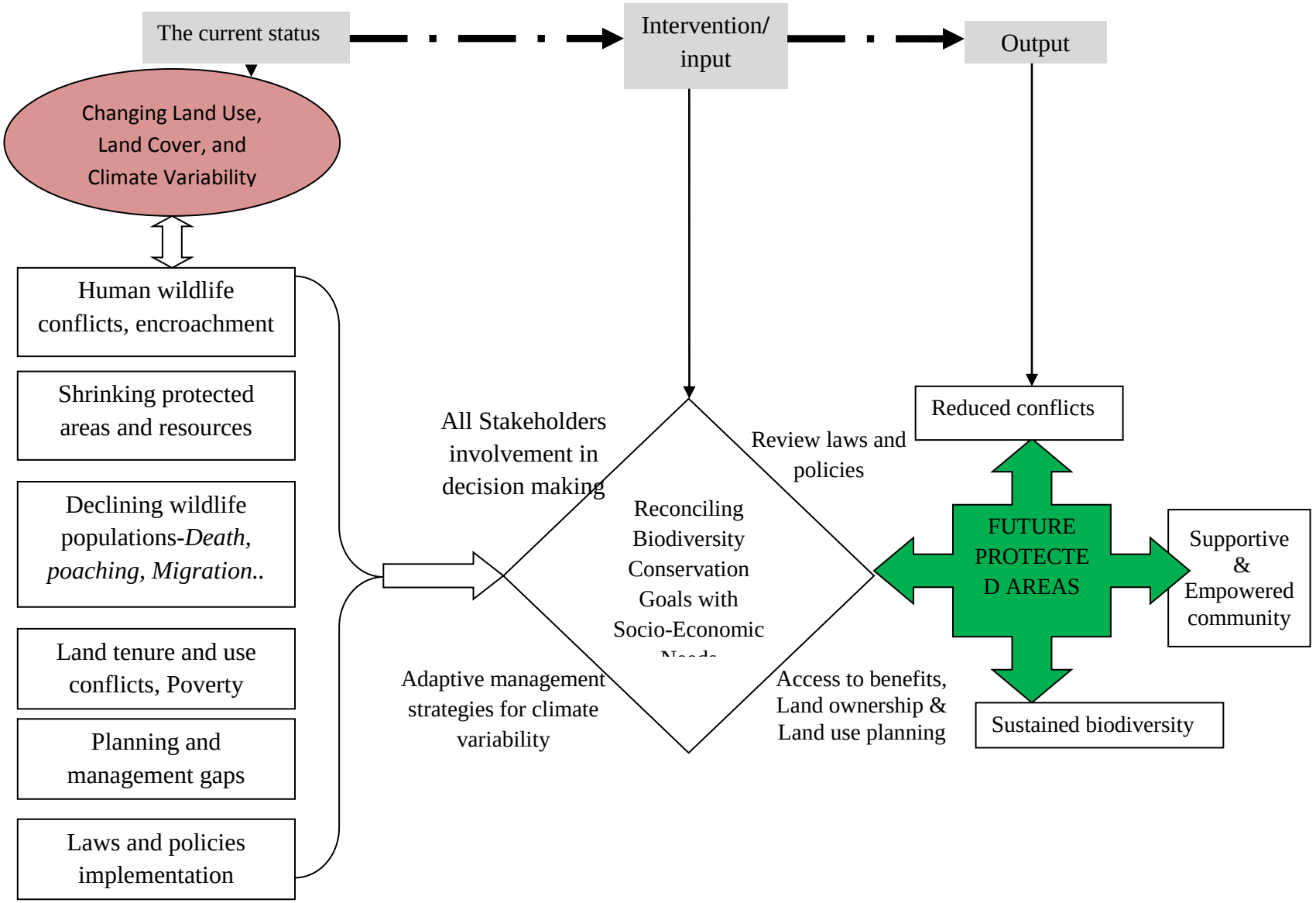


Figure 28: A Schematic representation of the proposed integrated planning framework

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APPENDICES

APPENDIX I: SELF INTRODUCTON LETTER

Edwin Muchomba Kiria
Department of
Environmental Studies
and Resource
Development
Chuka University
26-05-2015

RE: LETTER OF SELF INTRODUCTION

I am a student at Chuka University pursuing a PhD degree in Environmental science. My research topic is; **ANALYSIS OF LAND USE AND CLIMATE CHANGES ON WILDLIFE ECOSYSTEMS PLANNING IN MERU CONSERVATION AREA: A SPATIAL MULTI-CRITERIA EVALUATION.**

In the course of my study, I will use questionnaires to the local communities living around the protected area and interview schedule to the key informants who will include KWS officers, County officers and other local leaders.

The information acquired from the respondents will be treated with confidentiality and only for study purposes.

I therefore request for your support and cooperation during this time.

With kind regards

Edwin Kiria
0721 227 686

APPENDIX II

QUESTIONNAIRE FOR LOCAL COMMUNITY

PREAMBLE:

Dear respondent,

This study aims at analyzing changes in land cover and climate as well as the effectiveness of the current Meru Conservation Area (MCA) management plan in addressing human wildlife conflicts and socio-economic needs of the communities. The study is being carried out by Edwin Kiria, a Graduate student in the department of Environmental Studies and Resource development, Chuka University. The responses will be treated with utmost confidentiality and will be used solely for the purpose of the study. Your co-operation is much appreciated

SECTION A: PERSONAL DETAILS (*Tick where applicable*)

1. SEX: Male ☐ Female ☐
2. AGE: (In years) (12-20) (21-30), (31-45), (46-60) (60-above)
3. RESIDENCE: (Block) ……..…….
4. EDUCATION LEVEL
   (a) Never Attended School ☐) Primary ☐ c) Secondary☐ d) Post ☐ Secondary
5. What is your family size?
   a) (1-4) b) (5-7) c) (8-10) d) (11 and above)

SECTION B: LAND USE AND LAND TENURE SYSTEMS

1. What is the form ownership of this land that you live in?
   a).Private ☐ b) Community/trust ☐ c) Public ☐ d) Don't Know ☐
2. What is the approximate size of your land?
   a) (<1acre) b) (1-2acre) c) (2-5 acre) d) (>5 acre)
3. For how long have you been living in this land?
   a) (1-10 yrs) b) (10-20 yrs) c) (20-30 yrs) d) (above 30 yrs)
4. How did you acquire the land?
   a).Inherited ☐ b).Bought ☐ c).Other ☐
   If other, state……
5. What is your main economic activity?
   a).Agriculture ☐ c).Agro-pastoralist ☐

b).Pastoralist d).Others

If others, state……..

6. a. Are there wild animals that visit the areas outside the national park/reserve?

   Yes ☐ No ☐

   b. If yes, state the three most common.....

7. Do these animals cause any conflicts to you and the rest of the community?

   Yes ☐ No ☐

8. If yes, in 7 above, state the type of conflicts caused.....

   a). Crop destruction ☐ b) Human death ☐ c) Injuries ☐ d) Livestock killing ☐

9. What action do you take after the conflict?

   a) Kill the animal ☐ c) Did nothing ☐ e) Guarding ☐

   b) Report to KWS ☐ d) Fenced ☐

10. a Do you get any help from KWS in preventing wildlife invasion ☐ Yes ☐ No

    b If yes, what help do they give?

    Damage compensation ☐ Driving animals away ☐ Fencing ☐

    Others……

11. What do you think is the cause for increasing human-wildlife conflicts in these areas?

    a) Poor management by KWS ☐ b) Increased wildlife population ☐

    c) Sub-division of the land ☐ d) People don't like wildlife ☐

    e) Others ……..

SECTION C: EFFECTIVENESS OF THE MANAGEMENT PLAN (*Tick where applicable)*

12. Do you know there is a management plan for the MCA? Yes ☐ No ☐

	The question	**Feedback**
A	The local communities are aware of the existing MCA management plan	1 2 3 4 5

B	Local communities were involved in the preparation of MCA management plan	1 2 3 4 5
C	Local communities are actively involved in the day to day management and decision making in MCA	1 2 3 4 5
D	As a result of the MCA management plan, the communities are now getting benefits of conservation	1 2 3 4 5
E	Cases of human wildlife conflicts have reduced since the initiation of MCA plan	1 2 3 4 5
F	The MCA management plan has promoted wildlife utilization among the local community living around the protected areas	1 2 3 4 5
G	The current management plan is receiving full community and stakeholder support	1 2 3 4 5
H	The management plan has addressed the social values of the community and supports community projects, water catchment and binding communities together	1 2 3 4 5
I	The plan has addressed cultural values such as protecting sacred sites for local communities	1 2 3 4 5
	Key: **1**- I strongly disagree , **2**- I Disagree, **3**- Neutral/No opinion, **4**- I agree , **5**- I strongly agree	

SECTION D: CLIMATE CHANGE

13. a. Are you experiencing the impacts of climate change? Yes ☐ No ☐

14.	Strongly disagree	Disagree	Strongly Agree	Agree	Don't Know
a. Climate change has impacts on wildlife ecosystems and population					
b. Climate change has led to increased/reduced temperatures					
c. Climate change has led to increased/reduced rainfall					
d. Climate change has led to reduced land production					
e. There are measures to mitigate climate change					

15. If agree/strongly agree in 15e. above, state the mitigation measures that have been adopted by community

	Adaptation strategy	**Tick**
A	Practicing compatible land use practices around the park	
B	Awareness creation to communities and conservation programs	
C	Practicing conservation agriculture for better returns	
D	Creating wildlife movement corridors and dispersal areas to prevent conflicts	
E	Establishing wildlife based enterprises for additional economic returns	
F	Reducing livestock numbers in households to use available resources	

Thank you (Asante Sana)

APPENDIX III

INTERVIEW SCHEDULE FOR KEY INFORMANTS

PREAMBLE:

Dear respondent,

This study aims at analyzing changes in land cover and climate as well as the effectiveness of the current Meru Conservation Area (MCA) management plan in addressing human wildlife conflicts and socio-economic needs of the communities. The study is being carried out by Edwin Kiria, a Graduate student in the department of Environmental Studies and Resource development, Chuka University. The responses will be treated with utmost confidentiality and will be used solely for the purpose of the study. Your co-operation is much appreciated

Name of Officer: ……

Organization/Institution:…….

Responsibility: ……...

1. What are the main socio-economic activities practiced the local community around the protected area?

   ……

   ……

   ……

2. How do you think these activities affect conservation and management of wildlife?

   …….

   ……

   ……..

   ……

   …….

3. Are there incidences of human wildlife conflicts? Yes☐ No ☐

   If Yes, which are the most common ……

   ……

   ……

4. What are the reasons behind the increase in the rate of conflicts

   ……
   ……

5. How has your institution helped to solve these conflicts?

   ……

   ……
   ……

6. a). Has the application of PAPF model improved the management approaches of wildlife ecosystems? Yes No

   b). If Yes, state the realized benefits of this model in Meru Conservation Area so far……
   ……
   ……
   ……

   Do you know there is a management plan for the MCA? Yes ☐ No ☐

	The question	**Feedback**
1	The local communities are aware of the existing MCA management plan	1 2 3 4 5
2	Local communities were involved in the preparation of MCA management plan	1 2 3 4 5
3	Local communities are actively involved in the day to day management and decision making in MCA	1 2 3 4 5
4	As a result of the MCA management plan, the communities are now getting benefits of conservation	1 2 3 4 5
5	Cases of human wildlife conflicts have reduced since the initiation of MCA plan	1 2 3 4 5
6	The MCA management plan has promoted wildlife utilization among the local community living around the protected areas	1 2 3 4 5
7	The current management plan is receiving full	1 2 3 4 5

	community and stakeholder support	
8	The management plan has addressed the social values of the community and supports community projects, water catchment and binding communities together	1 2 3 4 5
9	The plan has addressed cultural values such as protecting sacred sites for local communities	1 2 3 4 5
	Key: **1**- I strongly disagree , **2**- I Disagree, **3**- Neutral/No opinion, **4**- I agree , **5**- I strongly agree	

7. a. Are you experiencing the impacts of climate change? Yes ☐ No ☐

8.	Strongly disagree	Disagree	Strongly Agree	Agree	Don't Know
a) Climate change has impacts on wildlife ecosystems and population					
b) Climate change has led to increased/reduced temperatures					
c) Climate change has led to increased/reduced rainfall					
d) Climate change has led to reduced land production					
e) There are measures to mitigate climate change					

9. If agree/strongly agree in 15a above, state the mitigation measures that have been put in place by your organization

	Adaptation strategy	**Tick**
A	Enforcing policy reforms	
B	Changes in conservation activities and programs	
C	Encouraging participatory management of park resources	
D	Put measures for reducing Human-wildlife conflicts	
E	Establishing protected area networks and corridors	
F	Promoting wildlife utilization by local communities	

Thank you!

APPENDIX IV

OBSERVATION CHECKLIST

The following are some of the variables that will be checked during the field visits;

a) Forms of land ownership and land use patterns
b) Human settlements and population increase
c) Wildlife habitat structure
d) Wildlife populations
e) Decline in forest and water resources
f) Intervention measures by KWS, community and other stakeholders in protected area conservation and management

APPENDIX V

FIELD GPS COORDINATES

Physical Location	Northings	Eastings	Altitude	Land use/land cover
Murera Gate	00 266. 60	038 129. 56	762	Development of shoping centre
Kathithine pry	00 263. 94	038 117. 81	778	Farming activities immediately after fence
Kathithine river	00 260. 11	038 112. 84	780	Dry river bed. Farming activities along the river
Malaene	00 298. 60	038 098. 42	854	Farming activities immediately after fence
Kina duba	00 303. 19	038 112. 60	815	Livestock grazing and farming--Ngaya corridor
Inside park 1	00 218. 04	038 192. 35	675	Grassland with sparse shrubs
Inside park 2	00 166. 09	038 218. 85	598	Mulika river--riverline vegetation
Inside park 3	00 163. 04	038 206. 52	605	Past bwathelongi river--acacia woodland
Inside park 4	00 167. 16	038 192. 69	619	Kina hqs--dried acacia in grassland
Inside park 5	00 111. 86	038 193. 39	601	Woodland
Ura Gate	00 241. 40	038 065. 43	669	Ura river..riverline vegetation
Makutano	00 148. 70	038 070. 89	678	Settlement and farming
Kanjoro	00 060. 29	038 005. 67	743	Farming

APPENDIX VI

SUMMARY OF THE QUESTIONNAIRE DATA IN SPSS

FREQUENCIES VARIABLES=Sex age Residence education family size ownership size duration acquisation occupation movement conflict conflicts animals action help type cause plan involvement present benefits reduced utilization support intervention climate change impacts temperatures rainfall production mitigation adaptation
/ORDER=ANALYSIS.

Frequencies

Notes

Output Created		29-JAN-2016 10:26:10
Comments		
Input	Data	D:\PhD\Raw data pre-study.sav
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Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Sex age Residence education familysize ownership size duration acquisation occupation movement conflict conflicts animals action help type cause plan involvement present benefits reduced utilization support intervenction intervention2 climatechange impacts temperatures rainfall production mitigation adaptation /ORDER=ANALYSIS.
Resources	Processor Time	00:00:00.11
	Elapsed Time	00:00:00.20

[DataSet1] D:\PhD\Raw data pre-study.sav

Frequency Table

sex of respodents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	57	47.5	47.5	47.5
	female	63	52.5	52.5	100.0
	Total	120	100.0	100.0	

age of respodents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	21-30	23	19.2	19.2	19.2
	31-45	43	35.8	35.8	55.0
	46-60	38	31.7	31.7	86.7
	60>	16	13.3	13.3	100.0
	Total	120	100.0	100.0	

residence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Block A-Baibariu, Meru	30	25.0	25.0	25.0
	Block B-Ntoroni,Tharaka	30	25.0	25.0	50.0
	Block C-Kaningo,Kitui	30	25.0	25.0	75.0
	Block D-Rapsu,Isiolo	30	25.0	25.0	100.0
	Total	120	100.0	100.0	

Education Level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never attended school	35	29.2	29.2	29.2
	primary	63	52.5	52.5	81.7
	secondary	22	18.3	18.3	100.0
	Total	120	100.0	100.0	

Family Size

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-4	47	39.2	39.2	39.2
	5-7	70	58.3	58.3	97.5
	8-10	3	2.5	2.5	100.0
	Total	120	100.0	100.0	

Type Of Land Ownership

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Private	48	40.0	40.0	40.0
	Communal	52	43.3	43.3	83.3
	Public	20	16.7	16.7	100.0
	Total	120	100.0	100.0	

Size Of Land

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 1acre	8	6.7	6.7	6.7
	1-2 Acre	54	45.0	45.0	51.7
	2-5 Acre	39	32.5	32.5	84.2
	> 5acre	19	15.8	15.8	100.0
	Total	120	100.0	100.0	

Duration Of Stay

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-10 Yrs	42	35.0	35.0	35.0
	11-20 Yrs	53	44.2	44.2	79.2
	21-30	25	20.8	20.8	100.0
	Total	120	100.0	100.0	

Method Of Land Aquisation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Inherited	35	29.2	29.2	29.2
	Bought	41	34.2	34.2	63.3
	Acquired	30	25.0	25.0	88.3
	Rented/;Eased	14	11.7	11.7	100.0
	Total	120	100.0	100.0	

Ocupation of Respondents		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agriculture	34	28.3	28.3	28.3
	Pastoralist	43	35.8	35.8	64.2
	Agro-Pastoralist	41	34.2	34.2	98.3
	Others	2	1.7	1.7	100.0
	Total	120	100.0	100.0	

Wildlife Movement

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	115	95.8	95.8	95.8
	No	5	4.2	4.2	100.0
	Total	120	100.0	100.0	

Do Animals Cause Conflict?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	116	96.7	96.7	96.7
	No	4	3.3	3.3	100.0
	Total	120	100.0	100.0	

Common Forms Of Conflicts

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Crop Destruction	84	70.0	70.0	70.0
	Human Death And Injuries	4	3.3	3.3	73.3
	Loss Of Livestock	27	22.5	22.5	95.8
	Others	5	4.2	4.2	100.0
	Total	120	100.0	100.0	

common problem animals

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	baboons	65	54.2	54.2	54.2
	elephants	42	35.0	35.0	89.2
	buffaloes	8	6.7	6.7	95.8
	others	5	4.2	4.2	100.0
	Total	120	100.0	100.0	

		Frequency	Percent		
Valid	yes	20	16.7		
	no	100	83.3		
	Total	120	100.0		

type of help

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	compensation	3	2.5	2.5	2.5
	driving animals away	24	20.0	20.0	22.5
	nothing	93	77.5	77.5	100.0
	Total	120	100.0	100.0	

any help from KWS

Valid Percent	Cumulative Percent
16.7	16.7
83.3	100.0
100.0	

what is the cause of increase in conflicts

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	poor management by KWS	83	69.2	69.2	69.2
	increased human population	21	17.5	17.5	86.7
	sub-division of land	13	10.8	10.8	97.5
	people dont like wildlife	3	2.5	2.5	100.0
	Total	120	100.0	100.0	

community are aware of existing MCA plan

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	31	25.8	25.8	25.8
	Disagree	70	58.3	58.3	84.2
	neutral/no opinion	11	9.2	9.2	93.3
	agree	6	5.0	5.0	98.3
	strongly agree	2	1.7	1.7	100.0
	Total	120	100.0	100.0	

Local Communities Were Involved In Plan Preparation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	27	22.5	22.5	22.5
	disagree	76	63.3	63.3	85.8
	Neutral/no opinion	8	6.7	6.7	92.5
	agree	3	2.5	2.5	95.0
	strongly agree	6	5.0	5.0	100.0
	Total	120	100.0	100.0	

community are actively involved on day to day decision making

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	22	18.3	18.3	18.3
	disagree	74	61.7	61.7	80.0
	neutral/no opinion	6	5.0	5.0	85.0
	agree	7	5.8	5.8	90.8
	strongly agree	11	9.2	9.2	100.0
	Total	120	100.0	100.0	

community are now getting benefit as a result of new plan

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	28	23.3	23.3	23.3
	disagree	45	37.5	37.5	60.8
	neutral/no opinion	8	6.7	6.7	67.5
	agree	15	12.5	12.5	80.0
	strongly agree	24	20.0	20.0	100.0
	Total	120	100.0	100.0	

cases of human-wildlife have reduced		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	59	49.2	49.2	49.2
	disagree	51	42.5	42.5	91.7
	neutral/no opinion	3	2.5	2.5	94.2
	agree	7	5.8	5.8	100.0
	Total	120	100.0	100.0	

MCA plan has promoted utilization among local communities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	25	20.8	20.8	20.8
	disagree	64	53.3	53.3	74.2
	neutral	11	9.2	9.2	83.3
	agree	18	15.0	15.0	98.3
	strongly disagree	2	1.7	1.7	100.0
	Total	120	100.0	100.0	

MCA plan is receiving full community and stakeholder support

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	55	45.8	45.8	45.8
	disagree	34	28.3	28.3	74.2
	neutral/no opinion	11	9.2	9.2	83.3
	agree	20	16.7	16.7	100.0
	Total	120	100.0	100.0	

MCA plan has addressed social-economic values

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	19	15.8	15.8	15.8
	disagree	54	45.0	45.0	60.8
	neutral/no opinion	9	7.5	7.5	68.3
	agree	35	29.2	29.2	97.5
	strongly agree	3	2.5	2.5	100.0
	Total	120	100.0	100.0	

MCA plan has addressed cultural values		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	76	63.3	63.3	63.3
	disagree	24	20.0	20.0	83.3
	neutral/no opinion	6	5.0	5.0	88.3
	agree	11	9.2	9.2	97.5
	strongly agree	3	2.5	2.5	100.0
	Total	120	100.0	100.0	

are you experiencing climate change?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	33	27.5	27.5	27.5
	disagree	46	38.3	38.3	65.8
	neutral/no opinion	27	22.5	22.5	88.3
	agree	12	10.0	10.0	98.3
	strongly agree	2	1.7	1.7	100.0
	Total	120	100.0	100.0	

climate change has impacts on wildlife ecosystems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	4	3.3	3.3	3.3
	disagree	6	5.0	5.0	8.3
	neutral/no opinion	58	48.3	48.3	56.7
	agree	39	32.5	32.5	89.2
	strongly agree	13	10.8	10.8	100.0
	Total	120	100.0	100.0	

climate change has led to change in temperatures

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree	5	4.2	4.2	4.2
	neutral/no opinion	55	45.8	45.8	50.0
	agree	53	44.2	44.2	94.2
	strongly agree	7	5.8	5.8	100.0
	Total	120	100.0	100.0	

climate change has led to changes in rainfall

		Frequency	Percent	Valid Percent	Cumulative Percent

Valid	neutral/no opinion	37	30.8	30.8	30.8
	agree	75	62.5	62.5	93.3
	strongly agree	8	6.7	6.7	100.0
	Total	120	100.0	100.0	

climate change has led to change in land production

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	neutral/no opinion	42	35.0	35.0	35.0
	agree	72	60.0	60.0	95.0
	strongly agree	6	5.0	5.0	100.0
	Total	120	100.0	100.0	

there are measure to mitigate climate change

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree	25	20.8	20.8	20.8
	neutral/no opinion	15	12.5	12.5	33.3
	agree	51	42.5	42.5	75.8
	strongly agree	29	24.2	24.2	100.0
	Total	120	100.0	100.0	

mitigation measures adopted by community

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strongly disagree	4	3.3	3.3	3.3
	disagree	13	10.8	10.8	14.2
	neutral/no opinion	34	28.3	28.3	42.5
	agree	37	30.8	30.8	73.3
	strongly agree	32	26.7	26.7	100.0
	Total	120	100.0	100.0	

APPENDIX VII

GRADUATE SCHOOL RESEARCH CLEARANCE LETTER

CHUKA  **UNIVERSITY**

Telephones: 020 268-7625
020 2310518
Email address: *postgradute@chuka.ac.ke*

P.O. Box 109-60400
Chuka

OFFICE OF THE DIRECTOR
BOARD OF POSTGRADUATE STUDIES

Our Ref: ND11/11682/14

19th October 2016

TO WHOM IT MAY CONCERN

RESEARCH AUTHORIZATION FOR EDWIN MUCHOMBA KIRIA STUDENT REGISTRATION NO. ND12/11682/13 AND ID NO. 22722611

The above named person is a *bona fide* student of Chuka University pursuing a three year **Doctor of Philosophy in Environmental Science.**

Mr. Kiria is conducting his research on; **Analysis of Land Use, Land Cover and Climate Changes on Wildlife Ecosystems Planning in Meru Conservation Area; A Spatial Multi-Criteria Evaluation**. The supervisors are Prof. Adiel Magana and Dr. Cyprian Njue.

The research will be carried out within the protected areas and adjacent lands in Meru, Isiolo, Tharaka Nithi and Isiolo counties

Kindly accord him necessary assistance.

Yours Sincerely,

17 OCT 2016

Komen Kibet (AR)
FOR DIRECTOR
BOARD OF POSTGRADUATE STUDIES

KK/lk

Chuka University is ISO 9001:2008 Certified

APPENDIX VIII

NACOSTI RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. EDWIN MUCHOMBA KIRIA
of CHUKA UNIVERSITY, 0-60204
mitunguu,has been permitted to
conduct research in *Isiolo , Kitui , Meru , Tharaka-Nithi Counties*

on the topic: ***ANALYSIS OF LAND TENURE, LAND USE AND CLIMATE CHANGE ON WILDLIFE ECOSYSTEMS PLANNING IN MERU CONSERVATION AREA; A SPATIAL MULTI-CRITERIA STUDY***

for the period ending:
31st December,2015

.....
Applicant's Signature

Permit No : NACOSTI/P/15/3740/6981
Date Of Issue : 5th August,2015
Fee Recieved :Ksh 1,000

.....
Director General
National Commission for Science, Technology & Innovation

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref; No.

Date:
5th August, 2015

NACOSTI/P/15/3740/6981

Edwin Muchomba Kiria
Chuka University
P.O. Box 109-60400
CHUKA.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Analysis of land tenure, land use and climate change on wildlife ecosystems planning in Meru Conservation Area; a spatial multi-criteria study,"*** I am pleased to inform you that you have been authorized to undertake research in **selected Counties** for a period ending **31st December, 2015.**

You are advised to report to **the Chief Executive Officers of the selected Government Agencies, the County Commissioners and the County Directors of Education of the selected Counties** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: DIRECTOR-GENERAL/CEO

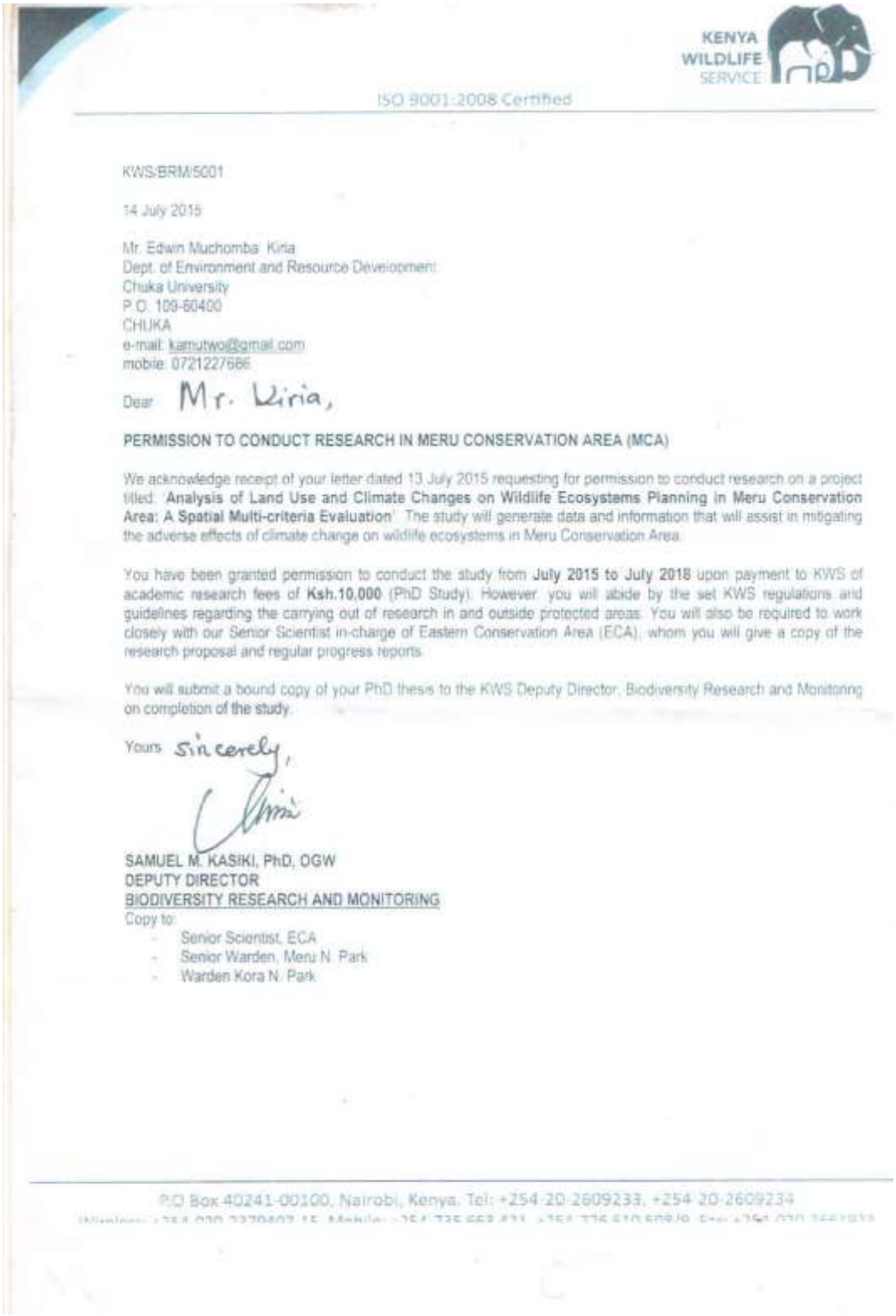
Copy to:

The Chief Executive Officers
Selected Government Agencies.

The County Commissioners
Selected Counties.

APPENDIX IX

KWS RESEARCH AUTHORIZATION



KENYA WILDLIFE SERVICE

ISO 9001:2008 Certified

KWS/BRM/5001

14 July 2015

Mr. Edwin Muchomba Kiria
Dept. of Environment and Resource Development
Chuka University
P.O. 109-60400
CHUKA
e-mail: kamutwo@gmail.com
mobile: 0721227666

Dear Mr. Kiria,

PERMISSION TO CONDUCT RESEARCH IN MERU CONSERVATION AREA (MCA)

We acknowledge receipt of your letter dated 13 July 2015 requesting for permission to conduct research on a project titled: '**Analysis of Land Use and Climate Changes on Wildlife Ecosystems Planning in Meru Conservation Area: A Spatial Multi-criteria Evaluation**'. The study will generate data and information that will assist in mitigating the adverse effects of climate change on wildlife ecosystems in Meru Conservation Area.

You have been granted permission to conduct the study from **July 2015 to July 2018** upon payment to KWS of academic research fees of **Ksh.10,000** (PhD Study). However you will abide by the set KWS regulations and guidelines regarding the carrying out of research in and outside protected areas. You will also be required to work closely with our Senior Scientist in-charge of Eastern Conservation Area (ECA), whom you will give a copy of the research proposal and regular progress reports.

You will submit a bound copy of your PhD thesis to the KWS Deputy Director, Biodiversity Research and Monitoring on completion of the study.

Yours sincerely,

SAMUEL M. KASIKI, PhD, OGW
DEPUTY DIRECTOR
BIODIVERSITY RESEARCH AND MONITORING

Copy to:
- Senior Scientist, ECA
- Senior Warden, Meru N. Park
- Warden Kora N. Park

P.O Box 40241-00100, Nairobi, Kenya. Tel: +254-20-2609233, +254-20-2609234

APPENDIX X

RESEARCH AUTHORIZATION, THARAKA NITHI COUNTY

REPUBLIC OF KENYA

MINISTRY OF EDUCATION
STATE DEPARTMENT OF EDUCATION

Telegrams: "Elimu", Chuka
Telephone: Chuka 630353
FAX: 064 630166
Email: *tharakanithicountyedu@gmail.com*
When replying please quote:

COUNTY DIRECTOR OF EDUCATION
THARAKA NITHI
P.O. BOX 113-60400
CHUKA.

25th October, 2016

TNC/ED/GC/GEN/5 VOL.11/63

Edwin Muchomba Kiria
Chuka University
P.O. Box 109-60400
CHUKA

RE: RESEARCH AUTHORIZATION

Your Ref. No. NASCOSTI/P/15/3740/6981 dated 5th August,2015 and Ref. NDII/11682/14 dated 19th October,2016 refers.

Your request to carryout research on "**Analysis of Land Use,Land Cover and Climate Changes on Wildlife Ecosystems Planning in Meru Conservation Area: A Spatial Multi-Criteria Evaluation**:" within Tharaka –Nithi County is hereby granted.

On completion of the research, you are expected to submit two hard copies and one soft copy in pdf of the research report/thesis to our office.

Best wishes.

Paul M. Kairiba
For:County Director of Education
THARAKA NITHI

APPENDIX XI

RESEARCH AUTHORIZATION, KITUI COUNTY

THE PRESIDENCY
MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

OFFICE OF THE
COUNTY COMMISSIONER
KITUI COUNTY
P.O. BOX 1 - 90200
KITUI

E-mail; *cckitui@gmail.com*
When calling or telephoning please ask for

.....

When replying please quote

Ref.K.C.603/I/126 **20th September 2016**

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION: EDWIN MUCHOMBA KIRIA

The above named is a student of Chuka University, He is authorized to carry out research on **"Analysis of land tenure, land use and climate change on wildlife Ecosystems planning in Meru Conservation Area; a spatial multi-criteria study,"** for a period ending July 2018.

Kindly accord him the necessary assistance he may require.

M.G. MAUKI
FOR: COUNTY COMMISSIONER
KITUI COUNTY

APPENDIX XII

RESEARCH AUTHORIZATION, MERU COUNTY

THE PRESIDENCY
MINISTRY OF INTERIOR AND CO-ORDINATION OF NATIONAL GOVERNMENT

Telegrams:
Telephone:
Email: ccmeru@yahoo.com
Fax:

COUNTY COMMISSIONER
MERU
P.O. BOX 703-60200
MERU.

When replying please quote

REF: ED.12/3/ (196)

21ST SEPTEMBER, 2016

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION – EDWIN MUCHOMBA KIRIA

This is to inform you that Edwin Muchomba Kiria has reported to this office as directed by the Commission for Science, Technology and Innovation and will be carrying out research on **"Analysis of land tenure, land use and climate change on wildlife ecosystems planning in Meru Conservation Areas: A spatial Multi-criteria study ".**

Since authority has been granted by the said Commission, and the above named student has reported to this office, he can embark on his research project for a period ending 31st December 2016.

Kindly accord him any necessary assistance she may require.

C.KEAH
FOR: COUNTY COMMISSIONER
MERU