ECOSYSTEM-BASED ADAPTATION TO CLIMATE CHANGE: A CASE OF MOUNT ELGON FOREST ECOSYSTEM, TRANS-NZOIA COUNTY, KENYA

JUSPER MARANGA OMWENGA

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DECLARATION

DECLARATION BY THE CANDIDATE

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Omwenga Jusper Maranga

SES/DPHIL/16/10

Signature …… **Date** ……....

DECLARATION BY THE SUPERVISORS

This thesis has been submitted for examination with our approval as university supervisors.

Signature…… **Date**…….…….

Prof. Paul Omondi,

Moi University, Kenya.

Signature …… **Date** ……..

Dr Fatuma Daudi

University Of Eldoret, Kenya

DEDICATION

This work is dedicated to my wife Caroline and to our dear children Judy, Emmanuel and Caleb.

ABSTRACT

Ecosystem-based Adaptation (EbA) is a nature- based and cost effective strategy that uses biodiversity and ecosystem services to adapt to climate change impacts. While there is some evidence of climate change and its impact in the study area, there is no comprehensive study that has been conducted to determine the extent to which the Mt. Elgon ecosystem and its role in the provisioning of goods and services can be integrated into local climate change adaptation policies, programmes and plans. This study therefore investigated how the Mt. Elgon forest can within the EbA context be best integrated and incorporated into national, local and sectoral plans to reduce vulnerability of the immediate, downstream and riparian communities to climate change-induced impacts in the Mt. Elgon Ecosystem. The specific objectives that guided this research included finding out existing climate change related vulnerabilities, identifying the existing climate change adaptation interventions, establishing existing natural resource governance regimes influencing EbA, and, to establish the existing capacity for Ecosystem-based adaptation in the Mt. Elgon Ecosystem. The study utilized the tragedy of the commons and the evolution theories as important guides for designing resource usage plans. It also used the Human Ecological Approach concept to help in better understanding the complex link between climate change, ecosystem services and livelihoods. Finally, the Regional Planning concept guided this research on how sub-national climate change adaptation decisions can be integrated into policies, programmes and plans of devolved governance systems. To accomplish this, 405 households were sampled from the study area and responses elicited from them. Data was collected by use of questionnaires, interviews, FGDs, and direct observation. Results indicated that the majority (90.6%) of households grow maize as compared to other food crops. Farming of this food crop doubled up as the main source of household income to many (47.4%) households making the study area a specialty economy. A larger percentage (63.4%) of respondents noticed a good representation of sectoral institutions responsible for the management of the individual natural resources, though a majority (77%) of these respondents singled an uncoordinated approach in natural resource management as being a major contributor to the deteriorating ecosystem health. Majority (73.2%) of government and civil society respondents associate this problem with conflicting sectoral mandates. These must be addressed in order to increase ecosystem health that eventually will lead to enhanced EbA services in the study area. The overall conclusion is that EbA approach can be a viable coping and adaptation strategy in the Mt. Elgon ecosystem if only the health of the Mt. Elgon's biodiversity can be assured. There is need to support the integration of EbA into the local climate change adaptation plans, programmes and policies.

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LIST OF ACRONYMS

ADC	Agricultural Development Corporation
CBD	Convention on Biological Diversity
CBO	Community Based Organizations
CDM	Clean Development Mechanism
CFAs	Community Forest Associations
CoP	Conference of Parties
CPR	Common Property Resources
CSO	Civil Society Organization
DRR	Disaster Risk Reduction
EbA	Ecosystem Based Adaptation
EMCA	Environmental Management and Coordination Act
EU	European Union
FGD	Focus Group Discussions
GHGs	Greenhouse Gases
GIS	Geographic Information System
GOK	Government of Kenya
ha	Hectares
IBA	Important Bird and Biodiversity Area
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
IIED	International Institute for Environment and Development
KNBS	Kenya National Bureau of Statistics
KMD	Kenya Meteorological Department
KIIs	Key Informant Interviews
KFS	Kenya Forest Service
KNHPC	Kenya National Population and Housing Census
KTB	Kenya Tourism Board
KWS	Kenya Wildlife Service
LDCs	Less Developed Countries

LPG	Liquefied Petroleum Gas
MAM	March April May
MoA	Ministry of Agriculture
NAMA	National Appropriate Mitigation Measures
NAP	National Adaptation Plan
NAPA	National Adaptation Programmes of Action
NCCRS	National Climate Change Response Strategy
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
NMK	National Museums of Kenya
NLC	National Land Commission
OND	October November December
OECD	Organization for Economic Cooperation and development
PELIS	Plantation Establishment and Livelihood Improvement Scheme
PES	Payment for Ecosystem Services
PFM	Participatory Forest Management
PRSP	Poverty Eradication Strategy Paper
REDD++	Reducing Emissions from Deforestation and Forest Degradation
SIDs	Small Island Developing States
SLDF	Sabaot Land Defense Forces
UON	University of Nairobi
UNESCO	United Nations Educational, Scientific and Cultural Organization
UN	United Nations
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
WHO	World Health Organization
WRA	Water Resources Authority
WRUAs	Water Resource Users Associations
WTA	Water Towers Agency

WB	World Bank
WWF	World Wide Fund for Nature

OPERATIONAL DEFINITION OF TERMS

Adaptation	Reducing vulnerability to avoid or cushion the impacts of climate change, and enable people to respond to climate risks by moving towards a climate resilient society.
Climate change	Is a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over a comparable time periods.
Climate variability	Refers to fluctuations of the climate about the 'mean average conditions' with some periods experiencing 'normal' climatic conditions, others experiencing below 'normal' conditions and still others experiencing above 'normal' conditions.
Ecosystem - Based Adaptation	Ecosystem-based adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change
Integration	Process of accepting EbA as a climate change adaptation strategy by National, Regional and devolved governance systems.
Mitigation	Taking actions, where possible, to encourage GHG emissions that are lower than business-as-usual practice; and to reduce the human causes of emissions by moving toward a resource efficient economy that is as low carbon as possible.
Mt. Elgon Ecosystem	This constitutes the Mt. Elgon's protected area comprising of 1,865.8 Km^2, its habitats, the associated settled landscape which is contained in the four sub-counties of the study area. , namely; Saboti,Kwanza, Kiminini and Endebess subcounties, of the larger Trans-Nzoia County, interacting as one ecological system.

Potential	Possibility of EbA adoption implementation and actualization in the Mt. Elgon ecosystem
Resilience	Refers to the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning and its capacity for self-re-organization and to adapt to stress and change
Vulnerability	This is the degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extreme weather.

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achieve my goal. Their patience, understanding and encouragement during the entire study period is recognized and highly appreciated.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Ecosystem-based Adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (UNDP, 2015). While EbA is a new concept, it also builds on existing practices such as integrated water resource management, community-based natural resource management and forest landscape restoration, bringing in the climate change adaptation angle (IIED, 2016). Ecosystem-based Adaptation (EbA) measures use sustainable management, conservation and restoration of natural and agro-ecosystems, taking into account anticipated climate change impact trends to reduce the vulnerability and improve the resilience of ecosystems and people to climate change impacts.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) anticipates rapid changes in climate even if greenhouse gas emissions are reduced quickly (IPCC, 2007). Climate change is being increasingly recognized as a developmental and environmental issue with the most recent IPCC report on climate change indicating that the frequency of occurrence and intensity of episodes of climate variability in East Africa will be expected to increase significantly over the decade (IPCC, 2014). Planned development outcomes in a number of countries are likely to be undermined by climate change impacts and thus pose significant challenges for the resilience of many livelihoods and ecosystems. Though vulnerability to climate change varies from region to region and country to country, it is highest in developing countries where anticipated impacts will be especially severe not only due to low institutional and financial capacity to cope, but also

because a much higher share of their economies are dependent on climate-sensitive sectors such as agriculture or forestry and natural resource extraction.

The evidence of climate change in Kenya is unmistakable with climate variability posing major threats to the environment, economic growth, and to sustainable development. Data from Kenya Meteorological Department clearly show that temperatures have generally shown increasing trends in many parts of the country starting from the early 1960s (GoK, 2016). This agency further reports that rainfall patterns have become irregular and unpredictable, and that when it rains; downpour is more intense than previously recorded. It observes that extreme and harsh weather is now the norm in Kenya and singles out the early period from the early 1960s where both the minimum (night) and maximum (day) temperatures have been on a warming trend. All sectors of the economy have felt the effects of this climate change. In the face of new climatic uncertainties, economic diversification from national to local level will be needed to reduce reliance on any one source of income.

In the wake of climate change, measures to enhance the ability of developing countries to respond to, manage and cope with increasing variability are thus of highest priority (World Bank, 2009). The urgency to adapt to the impacts of climate change is growing, especially in developing countries. Existing coping strategies to deal with climate variability, as well as new and enhanced adaptation approaches are required. Adaptation is frequently presented as a process or set of processes designed to reduce vulnerability and to minimize the potential negative impacts of variable climate stimuli. Available and cost effective adaptation solutions are often prioritized (Clarke & Jupiter, 2010).

Ecosystem-based Adaptation has the potential to increase adaptive capacity and social and ecological resilience to climate change in both developed and developing countries (IIED, 2016). The role of ecosystems in adaptation is recognized at the international level under the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity, and the United Nations Convention to Combat Desertification (IPCC, 2007). IUCN's Position Paper on Ecosystem based Adaptation to climate change observes that the conservation, sustainable management and the restoration of ecosystems can help people adapt to the impacts of climate change. The concept uses biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change in sensitive ecosystems. EbA utilizes the premise that healthy, well managed ecosystems have climate change mitigation potential. The approach is gaining increasing attention as it is accessible to the rural poor in developing countries due to its cost-effectiveness (IUCN, 2009).

Ecosystem-based Adaptation (EbA) offers a valuable yet under-utilized approach for climate change adaptation, complementing traditional actions such as infrastructure development; community based adaptation and integrated natural resource management. Baig (2016) observes that although there are cases where hard engineering solutions for adaptation are necessary, there are many instances where nature-based approaches provide cost effective and/or economically beneficial, as well as longer term solutions, with a range of co-benefits in terms of the goods and services provided by ecosystems. Andrade et al. (2010) observes that interventions in the areas of policy-making, planning, institutional capacity building, implementation of ecosystem transformation actions, and management

of residual effects, are the key principles of a successful Ecosystem-based adaptation strategy.

The Mount Elgon ecosystem supports various habitat types and rare animal and plant species on its slopes which reach over 4,000m above sea level. This ecosystem that straddles the border between Kenya and Uganda is one of the world's forest biome and has the ability to provide a wide range of benefits to society both at local and national levels. These crucial livelihood support impacts that span a range of economic sectors have the potential of offering EbA services (IUCN, 2008). The accruing benefits have direct impacts on local community and the nation's capacities to cope with the impacts of global climate change (Ongugo et al., 2014). This ecosystem sits adjacent to a heavily populated agricultural landscape supporting over two million people. This natural landscape has been degraded by excessive use, yet the livelihoods and economic activities of the locals depend on its goods and services (IUCN, 2008). This landscape is a unique case where, a forest reserve and a national park extend and border with the local communities who live adjacent to the forest and depend on its forest for their livelihood. The forest provides most of the goods and services, which form the basis of their subsistence.

1.2 Problem Statement

The impacts of climate change are already being felt by both people and the environment around the world and they are set to get a lot worse. Sea levels are rising, threatening island nations and coastal areas, storms are becoming more violent bringing floods and landslides, and droughts are intensifying. These impacts are expected to deepen poverty, food insecurity, poor livelihood and unsustainable development. The situation is anticipated to grow worse in the less developed countries of the sub-Saharan Africa such as Kenya where

climate change impacts are exacerbated by a number of non-climatic factors such as endemic poverty, hunger, high prevalence of disease, chronic conflicts, low levels of development and low adaptive capacity.

Vulnerability to these adverse effects of climate change is the most crucial concern of many middle level economies. The widely adopted approach to climate change adaptation relies on infrastructure and technological solutions to reduce the vulnerability of people to the associated impacts. While richer nations can try to "buy" protection in this form, poorer people in developing countries who are bearing the brunt of the impacts urgently need a proven, accessible and affordable option. The complexity and cost associated with infrastructural and technological solutions in addressing climate change vulnerability do not always match with the manpower and technological capacity of African LDCs.

Improving adaptive capacity is critical to reducing vulnerability to climate change. Research has shown that there is growing recognition of the role of healthy ecosystems in supporting adaptation through providing a diverse range of services, including sustainable water management, disaster risk reduction and food security. This approach, better known as Ecosystem based adaptation to climate change, encourages the sustainable managing, conserving and restoring ecosystems so that they can continue to provide the services that allow people to adapt to climate change. Managing agricultural land using local knowledge of crop varieties and maintaining diverse landscapes can help ensure food supplies in uncertain conditions. Healthy ecosystems provide a range of other natural services that people rely on among them the provision of food, clean water, shelter, firewood, fibre and medicine.

Despite its usefulness, little has been published on how it can be included in the relevant national plans and policies related to climate change adaptation. This is especially true for the sub Saharan Africa where there is a high dependence on natural resource but no specific policy or planning tool that prioritizes Ecosystem based adaptation approaches. A notable omission in climate change adaptation planning is the lack of an elaborate policy, legal and institutional provisions for the inclusion of nature-based ecosystem goods and services in climate change adaptation.

In developing African nations where population growth remains a main development challenge and where economies rely on rain-fed agriculture (UN, 2011), much more research needs to be conducted to establish the utility of natural ecosystems as a cost-effective climate change adaptation option. This should be further anchored in climate change adaptation policies, programs and development plans.

Mt. Elgon is a natural mountainous ecosystem with high natural resource and livelihood dependency by the adjacent community. This is especially so in the provision of environmental goods and services more importantly during periods of adverse climatic conditions. Research has shown that the adjacent community and their economic activities have for decades relied on the provisioning, regulating, cultural and spiritual services of this ecosystem (Ongugo et al., 2014; IUCN, 2008). For instance, there are many live supporting activities that are taking place along the main rivers that emanate from the Mt. Elgon. Notable activities include irrigation agriculture, grazing of livestock, fish farming and sand harvesting. Fetching of medicinal herbs and firewood are other important cultural services that are offered by this ecosystem.

Much research has highlighted the role of Mt. Elgon's ecosystem goods and services. Less has been written regarding the link that exists between its ecosystem goods and services and climate change adaptation. Literature is almost silent on how to integrate this natural afro-montane ecosystem in the local climate change adaptation policy and plans given the prevailing circumstances where the many sectoral policies and laws are not harmonized with each other and with the constitution. For instance, policies and laws relating to agriculture, land, water, forests, trade and industry which have significant implication on the environment are in conflict with each other and the constitution.

A review of the policy documents, strategic plans and the County Development plans for Trans Nzoia County reveals that the recognition of this important ecosystem and its climate proofing potential role is glaringly missing, in its climate change adaptation strategy documents. Little too has been studied about the potential of this threatened ecosystem as a cost effective and sustainable alternative to climate change adaptation in this regional governance unit despite the overwhelming evidence of climate change impacts in the area. The benefits that come with EbA have not being fully taken up and exploited by both the national and county governments. It is against this backdrop that this study sought to examine the potential of this approach to be adopted and mainstreamed in the climate change adaptation plans, policies, programs, activities, and funding decisions by the devolved unit of Trans Nzoia County and possibly for further adoption by other devolved governance systems with similar ecological settings. In doing this, this study addresses the existing gap in the science-policy interface on the utility of EbA in climate change adaptation planning at the regional planning levels.

1.3 Main objective

The general purpose of this study was to find out the possibility of using ecosystem based adaptation approach in climate change adaptation plans, programmes and policies in Mt. Elgon Ecosystem in order to reduce the societal vulnerability associated with climate change impacts.

1.4 Specific objectives

The specific objectives that guided this study are as follows;

1. To describe the nature of climate change related vulnerabilities in Mt. Elgon Ecosystem.
2. To identify the climate change adaptation interventions in Mt. Elgon Ecosystem.
3. To establish the role of natural resource governance regimes on EbA in Mt. Elgon Ecosystem
4. To establish the existing capacity for Ecosystem-based adaptation in Mt. Elgon Ecosystem.

1.5 Research questions

This research was guided by the following questions;

1. What is the nature of the existing societal vulnerabilities that are exacerbated by climate change impacts in the Mt. Elgon ecosystem?
2. What are the existing climate change adaptation interventions in the Mt. Elgon Ecosystem?
3. How do the current natural resource governance regimes influence EbA in the Mt. Elgon Ecosystem?
4. What are the existing capacities for Ecosystem-based adaptation in the Mt. Elgon Ecosystem?

1.6 Significance of the study

With climate change being a reality, there is an urgent need in Kenya to develop, implement, and fund ecosystem-based adaptation strategies in forested mountainous areas as a central part of the global response to climate change. This requires the aligning of natural resource management policies that guide the sustainable use and management of forests and suitable land-use practices that can lead to an increase in carbon stocks while enhancing resilience both of local stakeholder livelihoods and the ecosystem services that are precursors for climate change adaptation. Utilizing scientific research on the role of our natural heritage and championing for their being mainstreamed in our policies, plans, and development activities can prove to be alternative and cost effective mode of reducing the community's vulnerability to the effects of climate change.

Mt. Elgon forest being an important UNESCO recognized trans-boundary ecosystem between Kenya and Uganda that comprises of five protected areas (PAs) has the potential

to sustainably provide the much craved for ecosystem goods and services. This important water catchment, which also doubles up as an Important Birdlife Area (IBA), has other key values such as natural heritage, biodiversity, agricultural base, and tourism potential. The significance of this ecosystem for local communities is partly related to the extractive uses (traditional foods and medicines), as well as its immense cultural roles.

It is hoped that the findings of this research will be useful to policy makers and planners because it presents a cost effective adaptation strategy to the effects of climate change as opposed to the costly engineered adaptation solutions. The research findings from Mt. Elgon Forest ecosystem are of great relevance to Trans Nzoia County. This County together with the adjacent counties such as Bungoma and West Pokot, can utilize these research findings by incorporating them in climate change adaptation plans and policies.. Further, this study is to increase the knowledge of the potential ways to mainstream ecosystem adaptation into county planning, creating policies and infrastructure investments.

1.7 Study area

This study was carried out in Trans Nzoia County located between the Nzoia River and Mount Elgon 380 km Northwest of Nairobi. At its centre is the town of Kitale which is the capital and largest town. The county borders Bungoma to the west, Uasin Gishu and Kakamega to the south, Elgeyo Marakwet to the east, West Pokot to the north and the republic of Uganda to the Northwest. Trans Nzoia covers an area of 2495.5 square kilometers. Historically the area has been inhabited by the Kalenjin and Bukusu people. After independence many of the farms vacated by white settlers were bought by individuals

from other ethnic groups in Kenya. Kitale, its capital town, is now more cosmopolitan with inhabits from other tribes in Kenya occupying almost 15% of her population (GoK, 2013).

The county is largely agricultural with both large scale and small scale wheat, maize and dairy farming. The county is referred to as the "food basket" of Kenya for its role in food production in the country. The majority of its inhabitants are however generally poor (KNBS, 2018). Most outstanding places of interest include Mount Elgon National Park, Saiwa Swamp National Park and Kitale Nature Conservancy. Mt. Elgon National Park is located approximately 11 kilometers from Kitale town.

1.7.1 Location and size

The study area comprises of four administrative sub counties namely, Endebess, Saboti, Kiminini and, Kwanza. These are further sub-divided into eighteen administrative wards. Endebess Sub County, covering an area of 680 Km^2 is the largest of the four Sub Counties in the study area followed by Kiminini with 466.9 Km^2. Saboti Sub County has the least area covering 323.6 Km^2. On the other hand; Kiminini Sub County with six wards has the highest number of wards while Endebess Sub County has the least number of wards with three. Mt. Elgon which is an extinct volcano is situated on the border of Uganda and Kenya and it rises to an altitude of 4,321m above sea level (**Figure 1.1**).

This mountain supports a rich diversity of flora of at least 400 species, occupying altitudinal niches within the open moorlands within the crater and the extensive montane forests on its slopes (KWS, 2010). While annual rainfall on the Western slopes (Ugandan) is significantly higher than on Mt. Elgon's Eastern (Kenyan) slopes, Mt. Elgon still counts as one of Kenya's "five water towers" (UNEP, 2007). Arising on Mt. Elgon's Eastern

slopes, the Nzoia River traverses Kenya's Western Province, enabling a range of productive activities including irrigated agriculture and industry to an estimated watershed population of over 1.5 million (GoK 2013), but also threatening the lives and livelihoods of thousands of people due to flooding (Olago et al., 2015).

1.7.2 Agro-ecological zones, physiographic and natural conditions

The study area is divided into three major agro-ecological zones which include: the Upper Highland Zone, Upper Midland Zone and the Lower Highland Zone. The Upper Highland Zone covers the hills and slopes of Mt. Elgon, Cherangany hills and the boundary zone towards West Pokot County. This zone lies between altitude 2,400 and 4,313 meters above sea level and constitutes about 16 percent of the county land area. The area is covered with heavy vegetation cover, shallow stony soils with rocky outcrop. Mt. Elgon National Park situated in this zone is a major tourist attraction. A transition zone has been establishment around the Mount Elgon National Park. It plays a significant role as a buffer zone for the protected area and acts as mitigation against human-wildlife conflicts. The area also has limited potential for sheep and dairy especially at the transition area.

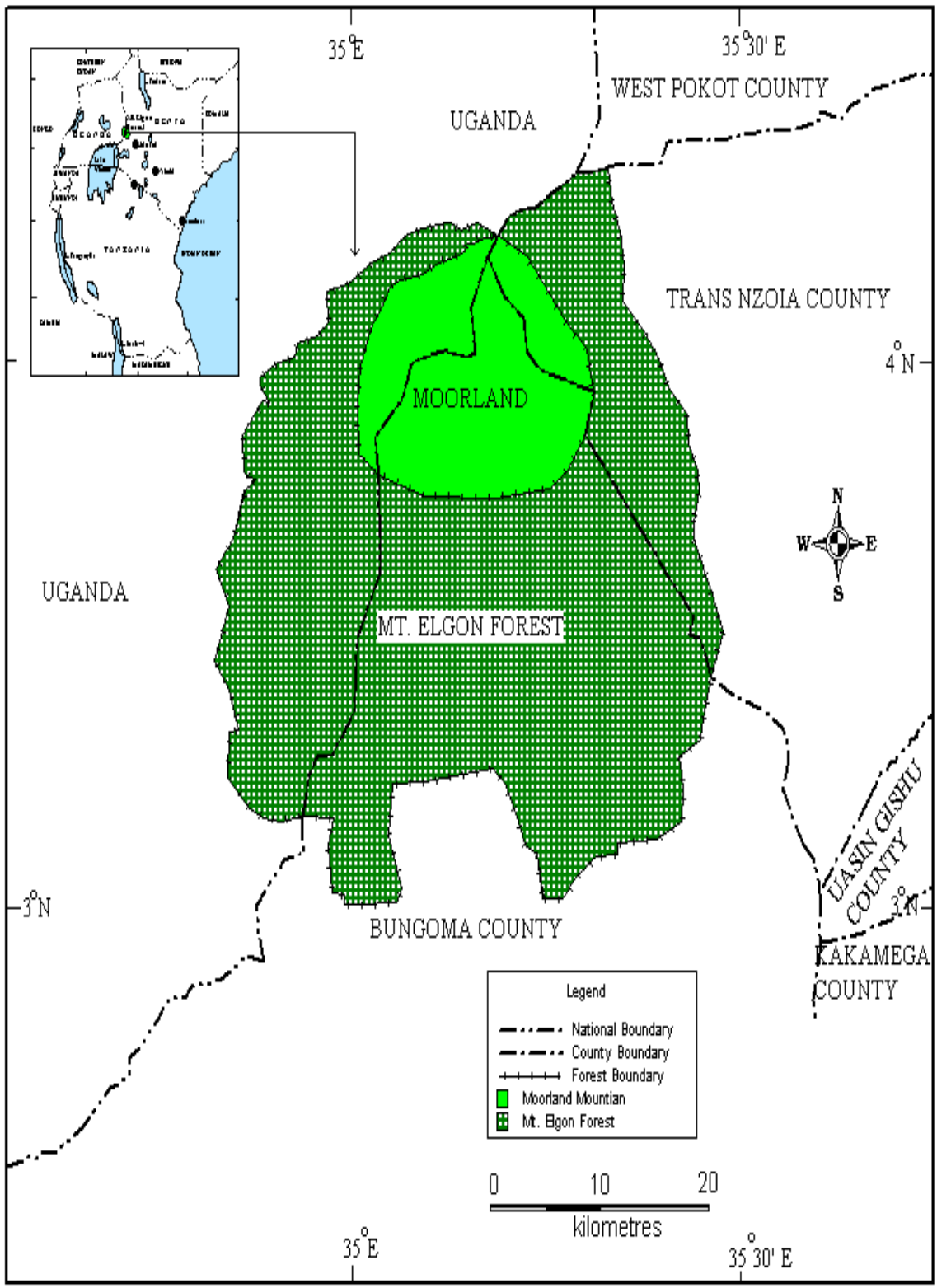

Figure 1.0.1: Mt. Elgon Forest.
(Prepared by GIS Lab, Geography Department, Moi University, 2015)

The Lower Highland Zone covers the slopes of Mt. Elgon and Cherangany Hills with the altitude ranging from 1,800 - 2,400 meters above sea level. This zone covers 848.64 km^2 and it constitutes 34 percent of the total area of the County. The soils found in this zone are red and brown clays derived from volcanic ash. These soils are fertile with a high content of clay mineral which gives a continuous supply of plant nutrients. This is mainly a transitional zone in the county with high potential for various agricultural and livestock activities. The agricultural activities in this region include growing pyrethrum, wheat, tea, maize, barley, sunflower, coffee and horticulture as well as rearing of cattle and sheep. Despite the high potential of these areas the major set-back to its exploitation is the poor communication network for efficient transportation of the farm produce to the markets.

Upper Midland Zone covers 1,248 km^2 comprises about 50 percent of the total area of the County. The zone lies between altitudes 1,700 and 2,000 meters above sea level. The mean annual rainfall in this zone is between 900 to 1,400 mm per annum. The region includes the Endebess Plains stretching east to the Kitale Plains and further towards the areas below the slopes of Cherangany Hills. To the south, the zone stretches to the border of Tongaren Scheme in Bungoma County and Northwards towards West Pokot County. The Zone is covered with well drained deep red and brown clays and sandy clays derived from the basement complex. There is a considerable size of land with black cotton soil along the Koitobos River in the Endebess Plains. Land use in this region includes cultivation of maize, sunflower, coffee, wheat and barley as well as cattle rearing, sheep and horticulture production.

There are several major rivers which sustain the livelihoods of the residents in the study area that originate from Mount Elgon. These are Kaibei, Kapteka, Kimoson, Mubere, Kiptigot, Chebirirbey, Kamuchong', Chepchoinor, Kipyoywan, Kisawoy, Kipkulkul, Cheptantan, Rongai, Kamakoiwa, Sosio, Laba, Kipkuresai Kimelil, Kibuk, Kimobo, Kibingey, Kitaban, Kibusi, Kapkateny, and Terem. Others include Kuywa, Kaptenai, Emia, Morkiis Emanang, Sitt and Rakook (Sobett, 2017). Generally, the rivers are fast flowing. The drainage pattern is radial to parallel on the upper and mid-slopes respectively. Most communities in the study area are served by gravity flow water systems originating from the mountain. Others get their water from springs located near their homes.

According to Sobett, (*op cit*) rivers have certain religious significance attached to them. They are regarded by Sabaot people as sacred or holy places, where certain vital societal rituals are carried out. During circumcision, initiates are required to carry out customary practical lessons in the river. Each of the Sabaot territorial clans have its own specific river, belonging to them historically and religiously. In Mount Elgon, rivers Rakook, Terem, Sosio Kisawoi and Suam have a lot of spiritual, emotional and cultural beliefs attached to them by the various Sabaot clans such as Rakook for the Kamukeek clan. A newly married woman from western Elgon could not cross Kisawoi River into Trans-Nzoia or Kitale without denouncing her witchcraft and throwing it into the river (Sobert, *op cit)*.

1.7.3 Climate

The County has a highland equatorial type of climate. Rainfall ranges between 900 mm and 1400 mm and exhibits a bi-modal pattern. The slopes of Mt. Elgon to the west receive the highest amount of rainfall while the region bordering West Pokot County receives the

least. Though it is well distributed throughout the year, the long rains occur from April to June, while the short rains fall from July to October. According to the Trans Nzoia County Integrated Development Plan, 2013-2017 (GoK,2013) the County Government of Trans Nzoia has noted with a lot of concern on the manner in which rainfall variability is impacting the agricultural sector in the county mainly because it relies on rain-fed agriculture. Granados et al. (2017) points out that rainfall variation can have a great impact on agricultural productivity, on food security and on the economy. Besides production losses, a parallel consequence is marginalization of the population because producers' income is increasingly reduced due to smaller crop volumes.

Temperatures range from a low of 10°C during the night to a high of 30°C during the night with a mean temperature in the county being 18.6°C. With climate change and variability, temperatures of above 30°C of have been recorded in the study area (GoK, 2015). According to Jerry and Prueger (2015), high temperatures affect crops in different ways and cause decreased photosynthesis, leaf senescence, decreased pollen production and pollen viability, seed abortion, and consequently lower grain number and grain weight. The county has favorable climate for both livestock and crop production. The average daily relative humidity is 65 percent and the wind speed is two knots.

1.7.4 Population breakdown per Sub County

The 2009 Population and Housing Census enumerated a total of 623,584 persons in the study area. Out of these 310,576 were male and 313,008 were female. The inter-census growth rate was 3.7 percent between 1999 and 2009 which is above the national average of 3.0 percent. Assuming the growth rate is maintained, the population in the study area in 2015 is projected to be 778,590 persons of which 387,777 are male and 390,813 are female

(**Table 1.1)**. Kiminini Sub County had the highest population of 199,386 people in 2009 and it is projected to have risen to 231,191 and 268,069 persons in 2013 and 2017 respectively. Kwanza, Saboti and Endebess sub counties had 193,087, 193,038 and 113,860 persons respectively in 2013.

Table 1.1: Population projection by sub-county

Sub county		**Projections**		
	2009	**2013**	**2015**	**2017**
Kwanza	199,386	231,191	248,948	268,069
Endebess	166,482	193,038	207,865	223,830
Saboti	166,524	193,087	207,917	223,887
Kiminini	91,192	105,738	113,860	122,605
TOTAL	**623,584**	**723,054**	**778,590**	**838,391**

*(**Source**: Trans Nzoia CIDP 2013 -2017)*

Saboti Sub County with a projected population density of 597 in 2013 is the most populated Sub County. This is followed by Kiminini Sub County with a population density of 578 while Endebess Sub County with a population density of 155 persons per square kilometer is the least populated (**Table 1.2**).

Table 1.2: Population density per sub-county

Sub county		Population density projections		
	2009	**2013**	**2015**	**2017**
Kwanza	357	414	445	480
Endebess	134	155	167	180
Saboti	514	597	642	692
Kiminini	504	585	630	678
TOTAL	**1,509**	**1,751**	**1,884**	**2,030**

(Source: Trans Nzoia CIDP 2013 -2017*)*

1.7.5 Human Settlement patterns

The general land use in the study area is characterized by large scale maize and sugarcane growing with scattered human settlements **(Figure 1.2)**. Other significant land use features include; Institutional presence of schools and churches, Markets and small scale trading activities, and, public amenities such as Provincial Administration offices.

The whole of Trans-Nzoia was part of the 'white highlands'. The Maasai tribe (El-gonyi) who practiced pastoralism was the local original inhabitants of Trans Nzoia. The El-Gonyi people were few and because of their pastoralist way of life, the land appeared practically empty to the colonialists during the colonial times (Medard, 2010; UoN, 2015). Following the outbreak of War in 1914, the matter was placed in abeyance, but in 1919 a settlement scheme for demobilized soldiers had been approved by the Imperial Government. Under this scheme, many surveyed farms in Trans Nzoia were occupied and, subsequently, a predominantly soldier settler community emerged.

The allocation of land to the settlers later resulted in displacement of the local people. Trans Nzoia was opened up as a settler-farming district by the settlers being allotted 2000-3000

acre farms. With the introduction of guaranteed prices on specific scheduled crops by the mid-1920s, most settlers concentrated on growing maize which was especially prevalent, thus resulting to mono-crop farming. Notably, there arose chronic inefficiency of settler production in terms of an inability to utilize most of the land allocated to them. As a result, local people became workers to offer cheap source of labor on the farms while squatting on large white-owned farms. This was followed by influx of predominantly young male migrant wage labor force which flowed into Trans Nzoia as the demand for their labor soared (UoN, *op cit*).

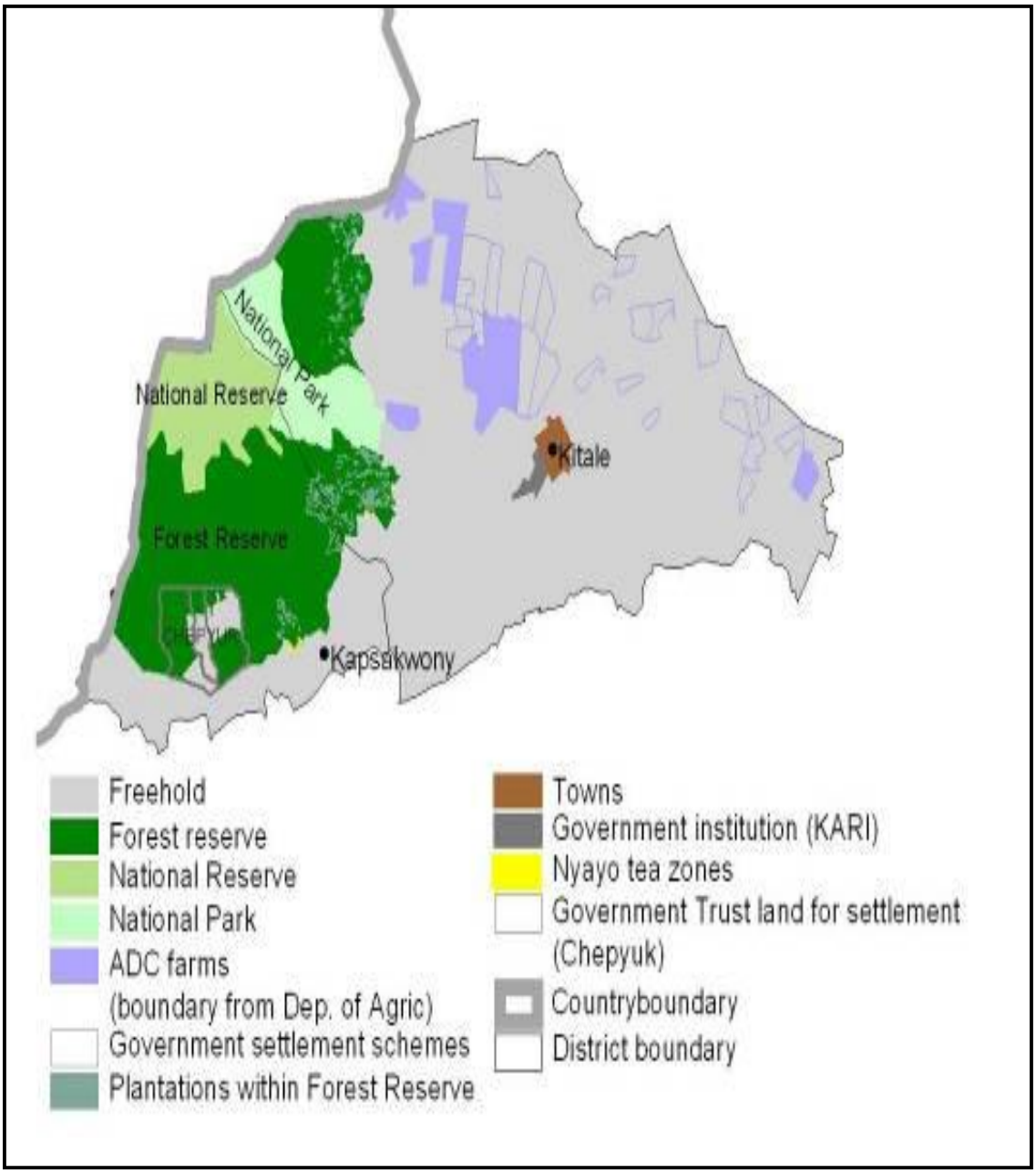

Figure 1.2: Land use in Mt. Elgon ecosystem
(Source: GoK, 2013)

After independence, the white farms in Trans-Nzoia were disposed of. There were basically four ways in which the land ended up in the hands of new owners: Kenyan individuals bought whole farms, Cooperatives bought the land collectively and divided it among their members, Government bought the farms, some of which was put under the Agricultural

Development Corporation (ADC) farms and others subdivided for smallholder settlement schemes and, Settlement Funds Trustee bought and sub-divided them for small-scale farming. Large chunks of land in Trans-Nzoia are currently under the management of the ADC with the workforce being provided mainly by people who are squatting on the farms. Some of the original ADC farms have been sub-divided for small-scale agriculture. Currently, there are eight ADC farms in Tran-Nzoia (GoK, 2013). The farms which cover about 40,000 acres in total are mainly in Endebess Sub County. These farms, together with Kenya Agricultural Research Institute and Kenya Seed Company, engage in seed production and bulking.

Large-scale farming is an important source of employment in the district. Although most of the farm employees are usually given small pieces of land to cultivate, they are squatters kept on the farms to provide casual labor and are a major threat to the integrity of Mt. Elgon ecosystem (GoK, 2013). In May-August, there are about 2000 of these landless workers on each of the ADC farms. This group of landless families meets their livelihoods by farming on the riparian land and by encroaching into the adjacent Mt. Elgon forest (GoK, 2013).

In 2005, the forest boundaries in the County were resurveyed and part of the initially landless population was found to reside in the forest reserve. This led to a major ‘reshuffling’ of land. The process led to widespread dissatisfaction, as former investments in land were not given consideration when the area was re-divided amongst ‘eligible’ land applicants. Village elders were and are still used in identifying ‘original’ or ‘indigenous’ people who can get land in the area. Thousands have been left landless and have been a source of land related conflicts in the area (Medard, 2006). This has spread to the neighboring Bungoma County where up to date; the Chepyuk area has remained

government land characterized by unending conflicts. The moorland area is now Trust land called Chepkitale National Reserve. In Trans-Nzoia, smaller areas of land disputes exist. These are forest areas that have been irregularly given out for settlement without being de-gazetted by the government.

The study area has two urban centres: Kitale municipality which has been relegated to a town status and Kiminini which is not categorized in line with the Urban Areas and Cities Act, 2011 (GoK, 2013). Total population for these centers is projected to be 136,644 in 2013 and is projected to increase to 158,440 in 2017. This rapid increase in the population for these two urban centers is as a result of the youth seeking more non-farm employment opportunities.

The poverty situation in the Trans Nzoia region is manifested in various forms such as inaccessibility to health services, food security, inadequate potable water, inadequate shelter, poor sanitation, inaccessibility to education and landlessness. Most of Endebess Sub-county in Trans-Nzoia, and parts of Cheptais and Kapsokwony have the highest percentage of poor households. (GoK, 2010)

1.7.6 Major agricultural activities

The main crops produced in the study area are maize, beans, wheat, tea and potatoes. Other crops include coffee and a variety of horticultural crops. The total acreage under food crops is 143,807.5 hectares while that under cash crops is 1,477.12 hectares. Most of the land that is under cash crop production is in Kwanza Constituency. The average farm size in the County is 0.607Ha. However, this varies across the constituencies within the County. For instance in Saboti Constituency, the average farm size is one and half hectares for small

scale farming and thirty hectares for large scale farming. For Kwanza subcounty the average farm size for small scale farming is four hectares and 30 hectares for large scale farming.

Trans Nzoia County is a major producer of agricultural products and has great potential for investments in agro industries, but very little of the produce is processed within the county. The County has two tea processing factories; namely Kapsara and Kapretwa, with only the later falling within the study area. Large scale maize farming and maize seed farming is also taking place in the county. In order to add value to maize seed enterprise in the county seed companies such as Agricultural Development Corporation, Western seed, Kenya seed, and SeedCo, have established seed processing plants within the study area. The main type of on-farm storage facilities in the County is ordinary stores/cribs and in the houses while go-downs and National Cereals and Produce Board silos are used for off farm storages. Some of the produce is also stored in traditional farm stores (granaries). In order to maximize on profits and reduce loses due to climate related vagaries, some farmers have ventured into greenhouse farming (**Plate 1.1)**

Plate: 1.1: Investment in floriculture and sugarcane farming under freehold tenure in Saboti sub county (Source : Author, 2019)

Poultry, cattle, sheep and goat are the predominant livestock reared by most residents in the study area. Related industrial enterprises include two milk cooling plants, New KCC and Brookside. There exists some smaller fresh dairy milk bulking centers across the study area.

1.8 Scope and limitations of the study

Mt. Elgon ecosystem was selected as the focus for this research because of its high conservation value and because of its significant ecological contribution to the larger watershed ecosystem's services and livelihoods. Despite its significant contribution, this

ecosystem is under pressure from illegal encroachment, logging and the effects of climate change. This study focused on the capacity for utilizing this ecosystem in climate change planning in order to cushion the residents of Mt. Elgon ecosystem against the impacts of climate change. Specifically, the study narrowed down to determining the nature of existing selected conditions that can exacerbate vulnerability of the locals in the face of the climate change and its associated impacts. In achieving this, the study confined itself to the vulnerability indicators that included food security, access to healthcare, land size and tenure, and preference of conflicts. These have been considered sufficiently sound for climate change vulnerability studies and are a representative of the methods currently available (Ludena, 2015; Fussel, 2010; World Bank, 2009).

As regards to the identification of climate change adaptation interventions in the Mt. Elgon Ecosystem, the study examined only those practices that have an implication on biodiversity and by extension the quality and quantity of the ecosystem goods and services. The management practices that recognize the ecosystem as working as one functional unit and enhancing ecosystem health were viewed as being best practices that can contribute positively to EbA. The study finally gives special emphasis on determining the capacities for inclusion of EbA as a better and cost effective approach to climate change adaptation in the Mt. Elgon ecosystem. Managerial, institutional and policy opportunities are explored and gaps identified for action in order to accommodate EbA.

Though Mt. Elgon straddles the Kenyan border to Uganda and into Bungoma County; this study was limited to the four sub-counties of Trans Nzoia County. The other sub-counties were excluded because they were falling in a different water catchment drainage system, their inaccessibility, time, and financial resource constraints. It was however, hoped that

the information obtained could be generalized not only to all forest-adjacent areas of the study area but also to other parts of the country.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature related to the potential for integrating ecosystem based adaptation to climate change in Mt. Elgon Ecosystem, Trans Nzoia County, Kenya. This section covers literature on global climate change, manifestation of its effects, future threats posed by climate change and, the concepts of vulnerability and adaptation. The chapter discusses in detail the concept of Ecosystem based adaptation to climate change and its utility in adaptation to the effects of climate change. This section also outlines the governance structure of the devolved system of governance in Kenya so as to point out the areas where EbA can be mainstreamed at the county planning level. Finally, the theoretical and conceptual frameworks are presented in this chapter.

2.2 Climate change debate

Global warming is the term used to describe a gradual increase in the average temperature of the Earth's atmosphere and its oceans, a change that is believed to be permanently changing the Earth's climate (Awudu et al., 2017). There is great debate among many people, and sometimes in the news, on whether global warming is real with some calling it a hoax (World Bank, 2016). But climate scientists looking at the data and facts agree the planet is warming (UNDP, 2008). While many view the effects of global warming to be more substantial and more rapidly occurring than others do, the scientific consensus on climatic changes related to global warming is that the average temperature of the earth has risen between 0.4 and 0.8 °C over the past 100 years (IPCC, 2014). IPCC (2007) reports that the increased volumes of carbon dioxide and other greenhouse gases released by the

burning of fossil fuels, land clearing, agriculture, and other human activities, are believed to be the primary causes of the global warming that has occurred over the past 50 years. The same report reveals that scientists from the Inter-governmental Panel on climate carrying out global warming research recently predicted that average global temperatures could increase between 1.4 and 5.8 °C by the year 2100 (IPCC, 2007). According to Ongugo et al. (2014), temperature increases in the study area resulting from global warming may increase the occurrence and enhance severity of storms. It may also lead to episodes of extreme weather events and therefore increasing the vulnerability of the resident communities to the effects of climate change.

2.3 International climate change policy

International climate policy is organized in the United Nations Framework Convention on Climate Change (UNFCCC) whose secretariat is located in Berlin (World Bank, 2016). This treaty which has a strong EU representation and has further been ratified by 197 member governments to reduce atmospheric concentrations of greenhouse gases with the goal of preventing dangerous anthropogenic interference with Earth's climate system (UNFCCC, 2006). The framework did not set binding limits on greenhouse gas emissions for individual countries and contained no enforcement mechanisms (UN, 1992). Instead, it outlines how specific international treaties, also called protocols or Agreements, may be negotiated to set binding limits on greenhouse gases.

According to a report by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety of 2016 (World Bank, 2016) parties to the convention have met annually from 1995 in Conferences of the Parties (COP) to assess progress in dealing with climate change. In 1997, the Kyoto Protocol was concluded and established legally

binding obligations for developed countries to reduce their greenhouse gas emissions in the period 2008-2012. According to the Netherlands Environmental Assessment Agency (2015), Cancun agreements state that future global warming should be limited to below 2.0 ℃ relative to the pre-industrial level. The Protocol was amended in 2012 to encompass the period 2013-2020 in the Doha Amendment (Kosolapova, 2018), which as of December 2015 had not entered into force. In 2015 the Paris Agreement was adopted, governing emission reductions from 2020 on through commitments of countries in ambitious Nationally Determined Contributions (GoK, 2015).

One of the first tasks set by the UNFCCC was for signatory nations to establish national greenhouse gas inventories of greenhouse gas (GHG) emissions and removals, which were used to create the 1990 benchmark levels for accession of Annex I countries to the Kyoto Protocol and for the commitment of those countries to GHG reductions. Updated inventories are supposed to be regularly submitted by Annex I countries (UN, 1992).

2.4 Vulnerability and adaptation

The ordinary use of the word ‘vulnerability’ refers to the capacity to be wounded, that is, the degree to which a system is likely to experience harm due to exposure to a hazard (Fussel, 2010). Vulnerability refers to the degree to which people or the things they value are susceptible to, or are unable to cope with, the adverse impacts of climate change. Thus, vulnerability determines how severe the impacts of climate change might be (Yamal, 2017). The same author explains further those things that man values not only refer to economic value and wealth, but also to places and to cultural, spiritual, and personal values. In addition, this expression refers to critical physical and social infrastructure, including

such physical infrastructure as police, emergency, and health services buildings, communication and transportation networks, public utilities, and schools and daycare centers, and such social infrastructure as extended families, neighborhood watch groups and fraternal organizations. The expression even refers to such factors as economic growth rates and economic vitality. People value some places and things for intrinsic reasons and some because they need them to function successfully in our society.

Fussel (2010) defines vulnerability to climate change as "the likelihood that an individual or group will be exposed to and adversely affected by a hazard. He points out that vulnerability to climate change can be decomposed into three distinct components; risk of exposure to hazards, capability for social response, and attribute of places such as geographical location. The so-called common-pool resources and public goods at multiple scales are required to cope with climate change. Indices of vulnerability to climate change may include observed data on socio-economic, environmental and other factors as well as model-based estimates of future conditions. According to Fussel *(op cit.)* each of these data sources is associated with specific advantages and disadvantages.

Ludena and Yoon (2015) identify two types of approaches to local climate vulnerability assessment. The first type is based on projected impact on a vulnerable region, sector and/or nation. Generally, this type of study utilizes climate change and precipitation scenarios that are based on scientific simulation models. The second type is based on the qualitative analysis of climate change impacts using a matrix of participatory process. The so called 'bottom-up' approach has been commonly used for this type of local vulnerability assessment. The two approaches identify the commonly examined sectors by local vulnerability assessment studies as agriculture, water, forestry and health. Specifically,

they identify precipitation variability, seasonal temperature change, extreme events such as drought and flood, dependency of income in agriculture, lack of diversification and/or specialization of occupation or crops, poverty, land size and land use characteristics, dependency on forestry, type and location of houses, and access to primary health care.

2.5 Adaptation to climate change

According to Fisher et al. (2016), there are two main policy responses to climate change: mitigation and adaptation. Whereas mitigation addresses the root causes by reducing greenhouse gas emissions, adaptation seeks to lower the risks posed by the consequences of climatic changes (OECD, 2006). Both approaches are necessary, because even if emissions are dramatically decreased in the next decade, adaptation will still be needed to deal with the global changes that have already been set in motion (Denton et al., 2014)

IPCC (2014) defines adaptation as being an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effect, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished; including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (OECD, 2006). Fisher et al. (2016) notes that UNFCCC puts adaptation to climate change as being the practical steps to protect communities and countries from the likely disruption and damage that will result from effects of climate change. The author further notes that humans have been adapting to their environments throughout history by developing practices, cultures and livelihoods suited to local conditions – from the Mediterranean siesta to the Vietnamese practice of building homes on stilts to protect against monsoonal rains. However, climate change raises the possibility that existing societies will experience climatic shifts (in temperature, storm

frequency, flooding and other factors) that previous experience has not prepared them for. IPCC (2001) reports that adaptation measures can help reduce vulnerability by for instance lowering sensitivity or building adaptive capacity as well as allowing populations to benefit from opportunities of climatic changes, such as growing new crops in areas that were previously unsuitable.

WWF (2016) cautions against maladaptation which may result at times due to adaptation action that leads to increased vulnerability to climate. Short-sighted planning, where short-term benefits are gained, either knowingly or unknowingly, is often the cause of this and it may lead to the situation becoming worse in the future or cause additional problems. WWF (*op cit.*) further reports that maladaptation can also result from non-inclusive planning, where one group benefits from the adaptation action at the expense of another. The report cites an example of a situation where people near the source of river abstract water in times of drought leading to shortage of water available to downstream communities.

2.5.1 The global response to climate change

Climate change adaptation is being discussed globally in several bodies of the United Nations, from which the most relevant is the UNFCCC (OECD, 2006). The issue of adaptation is included under the UNFCCC in Article 4.1(e), which calls on all countries to cooperate in preparing for adaptation to the impacts of climate change, develop an elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods (UN, 1992). Articles 4.8 and 4.9 also refer to the need to address vulnerability to the adverse effects of climate change and

take into account the needs of the LDCs. During the process of negotiating the decisions of the UNFCCC, adaptation appeared as a cross cutting issue (IPCC, 2007). However, in the UNFCCC's Bali Action Plan highlights, the significance of adaptation and its strong and tight linkages between climate change adaptation and Disaster Risk Reduction (DRR), as well as the need for integrating adaptation actions into sectoral and national planning is strongly recognized (Harmeling & Bals, 2008). Almost all LDCs have prepared National Adaptation Programmes of Action (NAPAs), which identify priority activities that respond to their urgent and immediate needs to adapt to climate change (Andrade et al. , 2010).

2.5.2 Ecosystem-based adaptation to climate change

The changing climate is no longer an abstract issue, and the realities of its impacts are being felt across the globe. Climate change is affecting millions of people, and thwarting their efforts to escape poverty. Against this harsh reality, it will be imperative to speed up the integration of climate risk considerations into policy, in order to ensure that development proceeds along pathways that are resilient to climate change (Reid, 2011). However, the questions as to the type of strategies, approaches and actions required still generate divergent views on the international policy arena. Closer attention to a broader spectrum of adaptation options is urgently needed (Munang et al., 2013). Ecosystem-based adaptation approaches have proved to provide flexible, cost effective and broadly applicable alternatives for reducing the impacts of climate change and as such are a critical tool at planners' disposal for tackling the threats that climate change poses to people's lives and livelihoods across the globe.

Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change

(Vignola et al., 2009; World Bank, 2009). Ecosystem based approaches to adaptation, harness the capacity of nature to buffer human communities against the adverse impacts of climate change through the sustainable delivery of ecosystems services (Munang et al., 2013). The UNDP (2015) reports that as one of the possible elements of an overall adaptation strategy, ecosystem-based adaptation uses the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change.

Ecosystem-based adaptation aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. There is increasing attention that has been paid to the complex interactions between human and environmental systems, especially regarding the conservation and management of ecosystem services (Vignola et al., *op cit)*. However, the role of ecosystem services in supporting adaptation to climate change is a relatively new issue in the scientific discourse, and even more so in the policy. Ecosystem-based approaches address the crucial links between climate change, biodiversity and sustainable resource management and, by preserving and enhancing ecosystems, enable society to better mitigate and adapt to climate change. Hence the key tenet is the need to protect the ecosystems that provide the essential 'life support systems' (ecosystem services) that we all depend on ((Munang et al., 2013).

Healthy, fully functioning ecosystems are more resilient to stressors and therefore better able to support adaptation to impacts. Further, healthy ecosystems imply a greater element of flexibility in adaptation response options. This implies that restoration of degraded ecosystems as part of an EbA provides a mechanism for carbon sequestration and hence climate change mitigation, sources of employment and enhancement of resources to

support livelihoods (Ebba &Wamsler, 2014, World Bank 2009). Ecosystem-based adaptation can generate significant social, economic and cultural co-benefits, contribute to the conservation of biodiversity, and build on the traditional knowledge and practices of indigenous people and local communities, including the important role of women as custodians of local knowledge (Baig et al., 2016).

Strengthening and protecting ecosystems can be likened to a long-term investment that ensures an array of environmental, social and financial benefits well into the future. Moreover, education and outreach policies should raise societal awareness about the relevance of ecosystem services and adaptation for sustainable development. Because of market failures, current regulations fail to conserve ecosystem services that are valuable for society. Thus, sectors benefiting from ecosystem services should be involved in funding ecosystem management or conservation.

2.5.3 Guiding Principles for Ecosystem-based Adaptation

Research and management experience from around the world has demonstrated the importance of EbA and has informed the development of core EbA principles. These principles have been expressed differently in different contexts, and their implementation must be tailored to each specific site or region (Clarke & Jupiter, 2010).

The first EBA principle call for the maintenance and restoration of connectivity between social and ecological systems that allows for the use of nature's infrastructure first in addressing adaptation to climate change impacts before resorting to expensive "hard" engineering options (Vignola et al., 2015). Natural ecosystems provide valuable protection and other services that should be tapped. Maintaining and restoring "nature's

infrastructure" should be a priority for reducing vulnerability to climate change impacts. As the effects of climate change become more severe, there will be, however, situations where engineering and hard structures may be necessary, such structures need to be built in sync with nature and its changing patterns. The EbA approach promotes collaboration and coordination of various sectors, communities and players that utilize ecosystem services (Muthee et al., 2017)

Another EbA principle requires the maintenance of healthy, productive and resilient ecosystems. Ecosystem-based management seeks to maintain ecosystem structure, function and key processes to maintain resilience and productivity over time. Ecosystem-based adaptation strategies should include a focus on minimizing other anthropogenic stresses that have degraded the condition of critical ecosystems. It is also important to take into account the full range of impacts, as one environmental change may have cascading effects (Clarke & Jupiter, 2015, Vignola, 2010). Ecosystem-based adaptation recognizes the vital role of ecosystems in meeting basic human needs and supporting sustainable livelihoods, and calls for a long-term management approach that makes protecting and restoring ecosystems and all their services the primary focus, above short-term economic or social goals. Only intact, healthy ecosystems can provide the full range of benefits that humans want and need over long periods of time (Baig et al., 2016). The functioning and resilience of ecosystems depends on dynamic relationships within species, among species and between species and their abiotic environment, as well as the physical and chemical interactions within the environment.

The third EbA principle calls for the involvement of stakeholders through participatory governance. Ecosystem-based management involves engaging stakeholders in

participatory management planning processes to find common solutions (Clarke & Jupiter, 2015). Effectively managing human impacts on ecosystems is a complex process, with many interactions, side-effects and implications. It is important to involve the full range of relevant expertise and stakeholders to promote the sharing of management responsibility between decision-makers and external parties with an interest in the success of natural resource management (Andrade et al., 2010). Depending on the situation, the decision-makers may be community members empowered with traditional authority, such as the village elders, or government officers in charge of regulation of natural resources under national legal frameworks. Involving a wide range of stakeholders in management planning processes will help to ensure that the concerns and priorities of those stakeholders are taken into account in management decisions. It also improves the quality of decision-making by increasing the range of information and perspectives considered. Finally, it increases awareness, understanding, acceptance and ownership of decisions (Andrade et al. et al., 2009). This activity comes with associated benefits for monitoring, compliance and implementation.

Adopting an integrated approach to ecosystem management is another invaluable principle in ecosystem based adaptation to climate change. Ecosystem-based adaptation being an integrated approach that considers interactions between humans and the environment, working with government and the private sector should be encouraged. This is in order to provide incentives for “climate smart” development and discourage development in vulnerable and sensitive ecological habitats. This integrated vision stands in stark contrast with the sectoral approach to resource management adopted by government agencies in both developed and developing countries (Mhalanga, 2014).

In the Pacific, the effectiveness of government interventions in natural resource management issues is often undermined by fragmentation of responsibilities and jurisdiction between government agencies (Clarke & Jupiter, 2010). Ecosystem-based adaptation overcomes the shortfalls of sectoral management by adopting a comprehensive approach to managing people's impacts on ecosystems within a specific geographic area. Ecosystem-based adaptation seeks to integrate management activities across sectoral boundaries and promote synergies between government agencies, partner organizations and communities (Baig, 2016). It emphasizes that diverse stakeholders be involved in strategy development. Ecosystem-based adaptation presents a tangible opportunity to solve climate change problems by aligning conservation, development, and poverty alleviation interests. Such synergies benefit from government collaboration with indigenous and local communities, conservationists, relevant private sector stakeholders, development specialists, and humanitarian aid specialists. A regional approach is sometimes needed especially when ecosystems stretch beyond political and geographical boundaries, which is particularly true for Mt. Elgon forest environment. Therefore, efforts need to be made to design adaptation measures that are not limited by these boundaries. Adaptation measures for a resource shared by multiple states can succeed only through integration of a regional or trans-boundary dimension (Ongugo, *op cit*).

The fifth EbA principle requires the incorporation of economic, social and cultural values in EbA practice (Baig, 2016). Ecosystem-based management incorporates human use and values of ecosystems in management planning and implementation. Natural resources are fundamental to the livelihoods, lifestyle and culture of most communities in the mountainous ecosystems (Andrade et al. 2009). High levels of natural resource dependence

demand an approach to EbA that recognizes the economic, social and cultural importance of continued resource use, while working to ensure that the use of those resources is sustainable over time. It is therefore necessary to identify efficient, equitable and effective management measures that strike a balance between short-term costs and the long-term benefits of maintaining and restoring ecosystem services. These long-term benefits can be measured against the costs of inaction. For poor rural communities, economic costs and benefits will play a key role in decisions about the use and management of natural resources.

The sixth EbA principle is to recognize uncertainty and embrace adaptive management. While the general trends in climate change are well-documented, the timing and magnitude of local changes remain difficult to predict accurately (Baig, 2016; Clarke & Jupiter *op cit*). Ecosystem processes and functions are complex and variable. This calls for the deployment of ecosystem-based adaptation strategies that include monitoring so that management actions can be quickly adjusted in response to changing conditions. The level of uncertainty is increased by interaction with human activities. Therefore, ecosystem management must involve a learning process, which helps to adapt methodologies and practices to the ways in which these systems are being managed and monitored. Adaptive management seeks to improve the effectiveness of management measures over time by monitoring management outcomes, and modifying management measures as new scientific and socio-economic information becomes available. Adaptive management requires carefully designed monitoring programs, flexible management rules and responsive management institutions.

Use relevant scientific, traditional and local knowledge as an EbA principle requires all forms of relevant information, including scientific, traditional and local knowledge be invoked. This is in recognition of the fact that ecosystems are complex (Vignola, 2015). Understanding human impacts on ecosystems and designing effective management responses is a challenging task, best undertaken with the benefit of the full range of relevant information. Information from all sources is critical for the development of effective management strategies.

2.5.4 Financing ecosystem-based adaptation approach

Funding for adaptation remains one of the main gaps in transferring societal set goals into actually implemented adaptation (UNEP, 2014). There is significant potential to make the case for financing for EbA through public finance, incentive schemes and Payment for Ecosystem Services (PES). Climate change policies need to be translated into budget allocations and expenditures, thereby making climate change part of the national budgeting process (Andrade et al. et al., 2015). One of the easiest ways to prioritize budgets for climate change is through increasing allocations for climate change actions within Ministries (Miller, 2013). It is also important to reduce interventions, which are contributing to non-climatic pressures on ecosystems. Public financing for EbA can be allocated through national budgets across sectors and at multiple scales, ranging from local to regional and national level budgets (UNDP, 2015). Mainstreaming EbA into government policies and budgeting processes at national level can have a far reaching impact on EbA finance in the long run, and enable the integration of EbA into national, regional and local planning and implementation processes.

Community economic incentive schemes are important in making the case for EbA at local level to communities and local government, especially before the benefits of EbA measures could be shown, either due to the early stage of implementation or the time needed to achieve catchment scale impact (UNDP, 2015). Such schemes enhanced community commitment to implementing and maintaining mid- to long-term EbA measures. Incentive schemes for EbA should form part of a broader approach to adaptation planning and implementation (Miller, 2013). Supported EbA measures need to form part of broader adaptation strategies, so as to contribute to longer term benefits and ensure sustainability of adopted measures, with or without incentive schemes.

Payments for Ecosystem Services provide yet another relevant model for EbA financing (UNDP, 2015). Ecosystems do provide a variety of goods and services that are economically valuable. Payments for ecosystem services (PES) occur when a beneficiary or user of an ecosystem service makes a direct or indirect payment to the provider of that service. The idea is that whoever preserves or maintains an ecosystem service should be paid for doing so (UNDP, 2017). The provision of such services might require communities living in the proximity of the ecosystem to undertake or not to undertake certain activities. To complete these tasks in the absence of regulatory provision, the communities need a financial incentive. The Payments for Ecosystem Services (PES) is the mechanism that governs these payments. In other words PES involves a series of payments to land or other natural resource owners in return for a guaranteed flow of ecosystem services or certain actions likely to enhance their provision over-and-above what would otherwise be provided in the absence of payment. Payments for Ecosystem Services can thus support the

conservation and expansion of ecosystems when the latter generate services that can be valued in economic and financial terms (UNDP, 2017).

Such payments can provide additional financing for adopted measures, increase understanding of the value of ecosystem services and act as an incentive for implementing EbA (Smith et al., 2013). Ecosystem-based adaptation can provide such ecosystem services as water provision, carbon storage and biodiversity conservation, which can be applicable for PES payments. Identifying EbA measures that produce new or enhanced ecosystem goods and services, such as *Mondia whytei*, an indigenous plant in Kakamega forest in Kenya, can provide an alternative source of financing and enhance the sustainability of implemented measures (Ongugo, *op cit).*

2.5.5 Ecosystem based adaptation policy and planning in developing countries

Ecosystem degradation and vulnerability to climate change are development issues rather than strictly environmental problems. As the loss of natural capital and the associated vulnerabilities are a threat for sustainable development, national development policies should integrate ecosystem management to climate change and adaptation (Baig et al., *op cit*; Ebba &Wamsler, 2014). Multi-sectoral and cross scale approaches are needed for mainstreaming both adaptation and ecosystem services into policies. Policy-makers should create and enforce linkages between ecosystem managers and vulnerable sectors benefiting from ecosystem services. Further, in order to promote the role of ecosystem services in societal adaptation to climate change, it is important that a variety of actors, such as policy-makers, scientists and civil society, are actively involved in accordance with their mandates.

The Rio conventions provide international policy guidance for countries to implement and enhance action around sustainable management, conservation and restoration of ecosystems for climate change adaptation of both biodiversity and people, and to integrate such approaches into their policy frameworks (UN, 1992). Research findings by Vignola et al. (2015) show that opportunities do exist for identifying and promoting synergies in the delivery of these conventions around adaptation in developing countries. A first set of decisions address the need for ecosystems to adapt in the face of climate change, whereas the second set of references focus specifically on how ecosystem management, and the goods and services provided by ecosystems, can enable people to adapt to the impacts of climate change.

According to a report by IUCN (2016) many national and international environmental agreements acknowledge that the impoverishment of ecosystems is limiting the world's capacity to adapt to climate change and that ecosystem-based adaptation approaches should be harnessed as a priority. IUCN (2016) further reports that Ecosystem-based adaptation has the potential to increase adaptive capacity and enhance both social and ecological resilience to climate change in both developed and developing countries.

The EbA Mountain Ecosystems Programme (2011-15) which was carried out in collaboration with the Governments of Nepal, Peru, and Uganda, and implemented by national and district authorities responsible for the environment, provide examples of adaptation actions through climate resilient and sustainable management of natural resources (WB, 2009). Ecosystem-based adaptation studies on assessing the potential for pastoral communities inhabiting Kenyan Maasailand to adapt to climate change using conservancies and payments for ecosystem services have been conducted (Osano et al.,

2013). One of the conclusions drawn in this research is that PES can promote EbA among pastoralist communities. These researchers observe that Income from PES, for example, is critical during droughts because it can buffer pastoral families from fluctuating livestock income thereby helping them overcome liquidity constraints arising from drought effects.

2.5.6 Climate change adaptation context in Kenya

Climate change and climate variability pose major threats to the environment, to economic growth and to sustainable development in Kenya (UNDP, 2012). Although Kenya has little historical or current responsibility for global climate change, and emissions are insignificant relative to the global emissions, the country is highly vulnerable to the impacts of climate change. Most of the populations' livelihoods and economic activities are reliant on climate-sensitive natural resources. Therefore, the uncertainty posed by climate change is affecting development and livelihood options. At the same time emissions are likely to increase in the future due to population and economic growth (GoK, 2013). In this regard, climate change is likely to affect all sectors of the economy.

In order to enhance investment that aims to reduce vulnerability and build resilience of the society, and in line with the provisions of the United Nations Framework Convention on Climate Change and its implementing instrument the Kyoto Protocol, the Government of Kenya launched the National Climate Change Response Strategy (NCCRS). The strategy is the Kenya's first climate change agenda guide that attempts to enhance understanding of global climate change regime and impacts of climate change in Kenya (GoK, 2010). The strategy provides a basis for strengthening and focusing nationwide action towards climate change adaptation and mitigation. This was followed by the preparation of the National Climate Action Plan (GoK, 2013), a document that indirectly seeks to domesticate,

UNFCCC agreements in the country. It discusses adaptation in the context of the national adaptation and mitigation as anchored on UNFCCC requirements of Nationally Appropriate Mitigation Actions (NAMAs) and Reducing Emissions from Deforestation and Forest Degradation ($REDD^{+}$).

The development of the National Environment Policy (GoK, 2013) explicitly spells out the need of mainstreaming of environmental issues into National and County Development and Sectoral plans. According to (Herero et al., 2010) climate change could impact on the functions and sectors devolved to the county governments. In response to this threat, the National government recently enacted climate change legislation that among other things seeks to integrate climate change in the County Development plans, programs and policies (GoK, 2016).

In all the above initiatives, there are no elaborate and focused considerations given to adopt ecosystem-based adaptation to climate change as a cost effective strategy as opposed to expensive engineered solutions in Kenya and many other less developed countries (IUCN, 2016).

2.5.7 "Hard Engineering" adaptation option

Adaptation serves as an important strategy to cope with a changing climate and its impacts; however, in response to global climate change effects, countries invest in traditional options such as infrastructure for coastal fortifications and flood resistors, and new irrigation facilities and reservoirs for water shortages (Baig et al., 2017). These options are likely to be costly and generally do not take the conservation of ecosystems and

biodiversity into account. It's worth to evaluate interventions in terms of economic costs and benefits, in order to engage in an informed planning process.

Although there are cases where "hard engineering" solutions for adaptation are necessary, five climate change "hard engineering" projects funded by the Royal Danish Embassy (RDE) from early 2011 to June 2012 failed to meet their targets (UNDP, 2018). The reasons for projects getting low scores and their subsequent rejection were attributed to various reasons such as: very high budgets and long implementation periods, too high costs and inability to modify budget, feasibility being unclear, unclear benefits, potential involvement of high risk technologies, lack of links to communities, unclear impacts on poverty alleviation, lack of implementation capacity, full reliance on donor funds and reliance on outsourced technology and expertise.

2.5.8 Ecosystem Resources Management in Kenya

Kenya uses a sector based resource management system yet there is no single institution or organization that has the capacity to address the environmental issues that transcend their jurisdictional boundaries. The resource sectors such as land, water, fish, and other aquatic resources, wildlife and forests in Kenya are managed by single units that are not interconnected with each other (NEMA, 2009). For all these resources, their fragmented management is negatively impacting on resource sustainability. Consequently, the livelihoods of people relying on these resources are affected.

The pieces of legislations governing these resources are equally fragmented at national level. Here, different ministries which have specific mandates of managing specific natural resources. Typical legislation in the study area includes Forest Act 2011, Wildlife

Conservation and Management Act 2013, Mining Act 2016, Water Act 2016, Climate change Act 2016, and EMCA, 1999. Different authorities thus administer different resources that are within the same geographical area and are interdependent. The major challenge continues to be the proliferation of natural resource management institutions and the ensuing problems of fragmented administration. Associated with this is the lack of an efficient coordination framework of these many institutions in order to achieve a sound planning and management of the natural resources in question.

The National Forest Policy guides the management of forest resources in Kenya as guided enshrined in the Forest Act, 2011 (Ongugo, 2014). The Kenya Forest Service (KFS) under the Ministry of Environment and Natural Resources is responsible for all the gazetted forests. The main activities of KFS include active management of plantations, law enforcement to control illegal extraction, licensing of extraction of forest products and fire protection. With enactment of the Forests Act of 2005, Kenya embraced Participatory Forest Management (PFM) as an approach towards achieving sustainable forest management. This was out of realization that involvement of the stakeholders would significantly contribute towards sustainable management of forests. In this approach, local communities and other stakeholders participate in management of forest resources as provided for in the Forests Act 2005. The main challenges facing PFM are corruption, micro-management of Community Forest Associations (CFAs) by KFS staff, and over-reliance on funding by KFS which makes the CFAs ineffective in discharging their mandate.

Mount Elgon forest was gazetted as a government forest reserve in 1932. It currently covers an area of about 49,382.9 ha. The forest is divided into three management units namely the

natural forest reserve, the commercial exotic plantations and the national park. These are named Kimothon forest, Mt. Elgon and Chorlem forest blocks respectively. Kenya Forest Service manages the forest reserve while the Kenya Wildlife Service manages the national park.

In many developing countries, the creation of national parks and protected areas to enhance wildlife conservation is common (Ghai, 1994; Kamugisha et al., 1997; Ludena et al., 2000). As regards wildlife resource, the Kenya Wildlife Service (KWS) which was created as a parastatal in 1990 manages all national parks countrywide. Kenya Wildlife Service is supposed to work closely with KFS to conserve the natural environment complete with its flora and fauna for future generations. The organization also aims at using wildlife resources sustainably for the economic development of the nation and for the benefit of the people living in wildlife areas. Finally, it aims at protecting people and property from injury or damage caused by wildlife. Kenya Wildlife Service operates as a commercial entity and tourism provides a major source of revenue. A large part of the KWS strategy is to share proceeds from tourism with the local communities inconvenienced by the presence of the wild animals or creation of the parks. The Mt. Elgon national park was gazetted in 1968 and covers an area of 16 900 ha.

Management of all water resources in Kenya including those in the Mt. Elgon ecosystem remain vested in the state (Moraa et al., 2012). The 1974 Kenya Water Act underwent major revisions in 1999 and 2002, which mainly focused on the decentralization of water services and separating water policy formulation from regulation and services provision (Ogendi, 2009). In 2002, the water sector reforms in Kenya culminated in the passing of the Water Act that was gazetted in October 2002. The Water Act introduced new water

management institutions to govern water and sanitation. As a result of the provisions in the Water Act of 2002, the Water Resources Management Authority was created. Its mission is to manage, regulate and conserve all water resources in an effective and efficient manner by involving the stakeholders, guaranteeing sustained access to water and equitable allocation of water while ensuring environmental sustainability.

Among other functions, WRA is tasked with the responsibility of mapping and publishing of key water catchment areas, groundwater resources and flood prone areas (Ongugo et al., 2014). Besides WRA, The Kenya Water Towers Agency which was established in 2012 supports Kenya's national strategic plans for the water and the environment. Forest cover is closely related to water conservation, this ecological phenomenon becomes clearer when forest cover is removed and its subsequent impacts on river flow (KFS, 2017).

2.5.9 Devolved governance and ecosystem based adaptation in Kenya

According to Mwikali and Wafula (2015), devolution is the transfer of political, administrative and fiscal management powers from central government to sub-national (e.g. state, regional, or local) authorities. SID (2011) adds that decentralization as a governance tool is based on the principle of subsidiarity, which assigns specific functions hitherto conducted by the centre of an entity, to the lowest feasible sub-centers on the periphery. In government, such distribution of responsibilities could involve any one or more responsibilities, including problem identification, policy making, planning, revenue generation, budget execution, accounting and auditing, and monitoring and evaluation.

The Policy on devolved system of Government in Kenya (GoK, 2016) cites devolution as one of the most transformative changes to Kenya's governance system brought about by

the Constitution of Kenya, 2010. Lubale (2012) points out that devolved Government provides for the setting up of the County Governments. Article 174 of the Constitution of Kenya (GoK, 2010) provides that one of the key objectives of devolution is to promote social and economic development and provide proximate, easily accessible services throughout Kenya. The Constitution provided for, among others, enhanced checks and balances within the government, an enhanced role of Parliament and citizens, an independent judiciary, and a most progressive Bill of Rights. Notably, the Constitution provided for a major devolution not only of resources and functions, but also creating a whole new layer of county government.

Further decentralization within Counties is mandated by County Government Act 2012 and Cities and Urban Areas Act 2012 that provide mechanisms for further decentralization within counties (Mwikali & Wafula, 2015). Among the more prominent arguments for devolution is the issue of efficiency: the expectation that decentralizing functions to the lowest feasible level of decision making and implementation will optimize information flows and reduce transaction costs. According to the constitution of Kenya (GoK, 2010), County Governments are supposed to address the environmental and natural resource based concerns such as controlling air pollution, regulate cultural activities, and spearhead county planning and development including land survey and mapping. These devolved units are also supposed to implement specific national government policies on natural resources and environmental conservation. This includes soil and water conservation; forestry, storm water management systems in built-up areas; and, offer water and sanitation services. Integrating ecosystem based adaptation to Climate change principles can greatly

complement the County Governments' efforts in management of these natural resource based services.

According to Ghai (2013), counties can make law about, and administer these matters. They have fiscal resources from the national government and those they raise in the county. The authority and institutions of the counties and their relationship with the national government are established in and protected by the constitution (Ghai, *op cit*).

The County Government of Trans Nzoia which is under the leadership of a Governor has a total of 13 departments as stipulated in the fourth schedule Part 2 of the Constitution of Kenya 2010 (GoK, 2013). These departments are; Executive, Treasury, Education, Health, Water, Environment and Natural Resources, Youth Gender and Sports, Transport and Infrastructure, Agriculture Livestock and Fisheries, Tourism Land Planning and Housing. The County Assembly which has a lifespan of 5years legislates as necessary to facilitate delivery of its mandated functions, review the county executive committee's development planning proposals and supervise the committee's implementation of priorities as spelled in Article 185 of the constitution of Kenya 2010).

2.5.10 Resource use conflicts in Mt. Elgon Ecosystem

The population in the study area is multi-ethnic but dominated by the Sabaot (Ongugo et al., *op.cit*). The Sabaot sub-ethnic of the Kalenjin group (tribe) occupies over half of Mount Elgon and its surrounding areas. This community regards itself as a marginalized community and has perceived the immigrant communities as competitors who are interested in taking their ancestral land and the associated natural resources (Sobett, 2017).

This has occasionally led to incidents of insecurity where the non-indigenous settlers are harassed in order to move out of this area.

Insecurity incidents rose in the region in the late 2005 when there was a culmination of the Sabaot Land Defense Force (SLDF). By the year 2007, the SLDF had acquired so much power in the region in terms of both military and political influence that was a major cause of insecurity. The SLDF kidnapped, tortured and killed the inhabitants in the region who they claimed supported the government. This has since reduced significantly but there continues to be periodic instances of criminal activities.

2.6 Theoretical Framework

This section discusses the relevant theories that inform this study. The theoretical framework provides the context for examining the research problem being investigated. It further discusses the theoretical rationale for developing the research questions. The framework also guided this study in systematically, logically and precisely identifying defined relationships among variables.

This study is informed by the Hardin's tragedy of the commons theory (Ostrom, 1998), Darwinian Theory of evolution (Merila & Hoffman, 2016), the Human Ecological Approach concept (Boon & Ahenkam, 2012) and, the regional planning concept (Murphy, 1984).

2.6.1 Tragedy of the Commons theory

The tragedy of the commons is the depletion of a shared resource by individuals, acting independently and rationally according to each one's self-interest, despite their

understanding that depleting the common resource is contrary to the group's long-term best interests (Ostrom, 1998).

According to Ongugo et al. (2014), Mt. Elgon forest ecosystem's role in the provisioning goods and services can play an important role in helping communities to adapt to climate change. This adaptation issue cannot only be solved by technical means. It is a problem that is distinct from those with solutions that require "a change only in the techniques of the natural sciences, demanding little or nothing in the way of change in human values or ideas of morality". Just as argued by Hardin (Ostrom, 1990), this class of problems includes many of those raised by human population growth and the use of the Earth's natural resources that includes the atmosphere (Latta, 2009)

The Tragedy of the Commons applies to Mt. Elgon Ecosystem's natural resources which are common resources that plays important role as sinks for atmospheric Green House Gases (GHGs). Sinks are stock resources which provide a flow of sink services. According to Ostrom (1990) watercourses, air basins and global atmospheric sinks have a comparable capacity to absorb pollutants by natural processes. The Author further observes that atmospheric GHG sinks fulfill the first condition of being a Common Property Resource (CPR) because the use of units of sink services is rival or subtractable. This implies that a unit used by one user is not available to others. He further observes that the challenge in governing atmospheric sinks is to constrain the use of CPRs so as to prevent their destruction. A derivative task is to distribute the sustainable capacity to provide sink services among the competing users. Determining and dividing up sustainable sink capacity is obviously wrought with uncertainty in practice.

Atmospheric GHG sinks also fulfill the second condition of being a CPR because it is difficult to exclude unauthorized users from using them (Paavola, 2008). The users of GHG sinks range from large coal powered electricity generation plants to families driving a car or keeping cattle. The size of the sink, the range of activities that make use of it, and the large number of users make it difficult to monitor the use of the sinks, and to exclude unauthorized users. The absence of clear borderlines and perfect mixing of emissions of GHGs in the atmosphere contribute to the difficulty of exclusion (Ostrom, 1990). Because of foregoing resource attributes, atmospheric sinks may experience the ultimate "tragedy of the commons" (Latta, 2009). This is because users have incentives to use sink service units before other users make them unavailable. Because of the difficulty of exclusion, they can also do so. When everybody acts on his own self-interest rather than exercise constraint to conserve global GHG sinks, the tragedy is high. Latta (*Op cit*) remarks that though Hardin has later been optimistic about the emergence of a constraint in the use of global atmospheric sinks, progress to date has been modest.

According to Ostrom (1998) Tragedy of the Commons is an important theory for designing resource usage plans. Its fundamental assumption about how rational humans can act in a way to bring about destruction of their resource gives a reason to set artificial limitations on usage through governmental policy. This demonstrates the need to increase cross-scale and cross-sectoral linkages in adaptation planning so that important GHG sinks such as the Mt. Elgon system can sustainably continue to provide climate change adaptation and mitigation services.

2.6.2 Adaptation theory

Developed by Charles Darwin between 1809 – 1882, the theory of evolution, also known as Darwinism, states that species of organisms arise and develop through the natural selection of small, inherited variations that increase the individual's ability to compete, survive, and reproduce (Merila & Hoffman, 2016). The theory postulates that organisms change over time as a result of changes in heritable physical or behavioral traits and that in the process these changes allow an organism to better adapt to its environment and thus survive and have more offspring.

Paleoanthropologists have proposed a variety of ideas about how environmental conditions may have stimulated important developments in human origins (Gardener, 2017). Diverse species have emerged over the course of human evolution, and a suite of adaptations have accumulated over time. The same researcher further observes that organisms encounter some amount of environmental change which may occur over a short time, and may be cyclical, such as daily or seasonal variations in the amount of temperature, light, and precipitation (Merila & Hoffman, 2016). Many organisms have habitat preferences, such as particular types of vegetation (grassland versus forests), or preferred temperature and precipitation ranges. Gardener (2017) argues that when there's a change in an animal's preferred habitat, they can either move and track their favored habitat or adapt by genetic change to the new habitat. Otherwise, they become extinct. Another possibility, though, is for the adaptability of a population to increase – that is, the potential to adjust to new and changing environments (Hoffmann & Sgro, 2011). The ability to adjust to a variety of different habitats and environments is a characteristic of humans.

2.6.3 Human ecological approach

To ensure a balanced understanding of the complex link between climate change, ecosystem services and livelihoods, the study will adopt a Human Ecological Approach (HEA) which refers to the study of the dynamic interrelationships between human populations and the physical, biotic, cultural and social characteristics of their environment and the biosphere (Boon & Ahenkam, 2012). This is because the link between climate change, ecosystems and livelihood is complex, multifaceted and broader than the realm of any single discipline and can therefore be most effectively examined by using inter-disciplinary and multi-disciplinary frameworks. Knowledge from the disciplines of ecology, forestry, sociology, geography and economics are synthesized to enhance the understanding of this complex issue.

2.6.4 Regional planning concept

Murphy (1984) report that regions have been viewed differently by different researchers who belong to various disciplines. They however observe that researchers generally agree that a region reflects the fact that the planet Earth is a conspicuously heterogeneous object and that it shows distinct differences in its spatial characteristics. They explain that a region can be considered to be any portion of the earth's surface' where physical conditions are homogeneous. Pinson (2007) views a region as being a complex of land where water, air, plant, animal, and man, are regarded in the spatial relationship as together constituting a definite portion of the earth's surface.

Martek (2016) views a region as encompassing the decision-making and planning process systems. According to Martek *(op cit),*the foregoing implies that regional planning is made synonymous with the development of policies at the subnational level and possibly informs

the national level processes of decision making. This implies that tailor made regional interventions are designed to address pertinent and relevant investment decisions at the regional level and with economic development programmes having far reaching benefits beyond the sub-national areas.

2.7 Conceptual Framework

The conceptual framework used in this study, outlines possible courses of action and presents the most preferred approach to the research idea. It describes the relationship between specific variables which were identified during the study. The study is anchored on the link between ecosystem services, livelihoods, climate change, adaptation, and policy planning for continued benefits to natural ecosystem dependent communities through provisioning; regulating; supporting; cultural; and recreational services. The principal premise of this research is that ecosystem services provide foundation for livelihoods and human wellbeing. Any negative change in an ecosystem therefore, has consequences in the supply of ecosystem services and livelihood improvement hence the need to involve multiple stakeholders with distinct roles and responsibilities in the sustainable management of such ecosystems. This is critical to successful ecosystem-based adaptation because ecosystems typically support diverse sectors and different social groups in multiple ways.

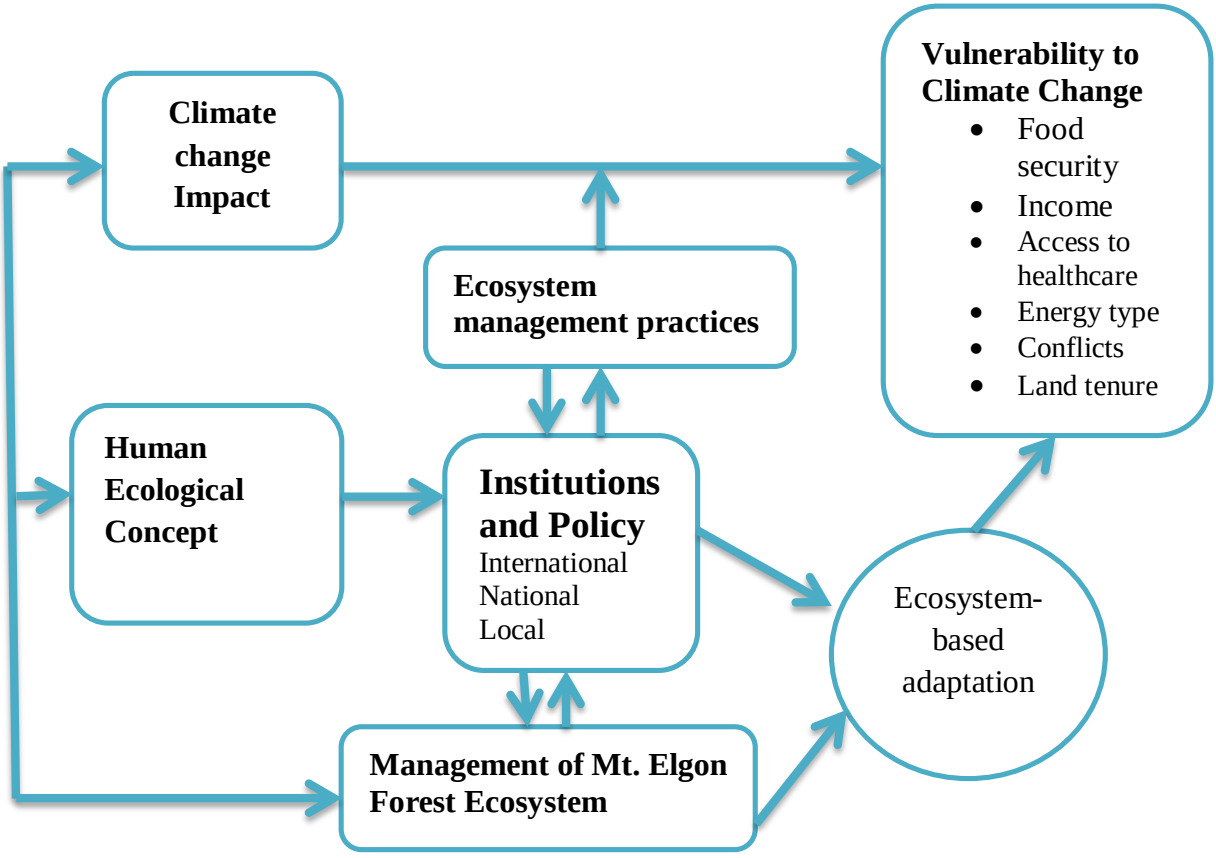

Figure 2.1: Diagrammatic representation of the conceptual model

2.7.1 Climate change and societal vulnerability

Economies with poor adaptive capacity are likely to be hit hardest by climate change, and the capacity to respond to climate change is lowest in developing countries and among the poorest people in those countries (Santiago, 2001). Vulnerability to climate change is closely related to food insecurity, limited income sources, poor access to healthcare, household energy type, conflict preference, land size and tenure because they partly determine the ability of a community to respond to climatic stimuli. Furthermore, certain regions of the world are more severely affected by the effects of climate change than others.

2.7.2 Ecosystem goods and services and societal vulnerability

According to the World Resources Institute (2003) the Millennium Ecosystem Assessment distinguishes four categories of ecosystem services: provisioning (e.g., of honey, timber), regulating (e.g., of climate, floods), supporting (of other services, e.g., pollination, and pest control for food production, photosynthesis), and cultural (e.g., serenity, inspiration, traditional shrines), (Chan, et al., 2006). Healthy, well-functioning ecosystems enhance natural resilience to the adverse impacts of climate change and reduce the vulnerability of people. Ecosystem-based management offers a valuable yet under-utilized approach for climate change adaptation, complementing traditional actions such as infrastructure development. This approach, known as "Ecosystem-based Adaptation" (Ecosystem-based adaptation), uses biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels.

2.7.3 Climate Change Adaptation

It is increasingly recognized that well-managed ecosystems can help societies to adapt to both current climate hazards and future climate change by providing a wide range of ecosystem services such as provision of water during droughts (Locatelli et al., 2009).

2.7.4 National and Regional adaptation plans

Ecosystems are hardly integrated into national planning processes aimed at addressing any of these national development challenges. This is evident in some of the national documents of some developing countries such as the Poverty Eradication Strategy Paper to the World Bank and the First national communication to UNFCC. According to the Economics of Ecosystems and Biodiversity group (TEEB, 2009), maintaining nature's

capacity to buffer the impacts of climate change is often less costly than having to replace lost ecosystem functions by heavy infrastructure or technology.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the sampling design. Data collection methods such as household questionnaires, Focus Group Discussions, field observation and key informant interviews are explained. Limitations of the study are also outlined in the chapter.

3.2 Sampling Design

The sampling design consisted of descriptive survey which allowed large amounts of data to be collected over a short period of time. It provided numeric descriptions of the population. It also enabled the researcher to describe and explain relationships between the dependent and independent variables. Descriptive design was chosen because it assisted the researcher to establish the nature of climate change related societal vulnerability in the study area, describe the existing ecosystem planning and management practices, profile the existing natural resource managerial, institutional and policy challenges to and opportunities for EbA inclusion to reduce societal vulnerability to climate change impacts, and finally to suggest a suitable ecosystem-based adaptation approach for Trans Nzoia County.

3.3 Data needs

The ecosystem-based adaptation study partially adopts an approach advanced by Ludena and Yoon (2015) which identifies vulnerability indicators that have been used in climate change studies. These indices include precipitation variability, seasonal temperature change, extreme weather events such as drought and flood, dependency on income from agriculture, lack of diversification and/or specialization of occupation or crops, poverty,

land size and land use characteristics, dependency on forestry, type and location of houses, and access to primary health care.

3.4 Selection and description of the study area

Mt. Elgon Forest **(Figure 3.1)** which is mainly a mountainous ecosystem was selected as the study area because of the presence of the Forest, its associated rich biodiversity, and the influence it has on the adjacent community's livelihoods. The rivers and many rivulets which emanate from this forest have for a long time influenced greatly the livelihoods of the immediate and downstream communities. The quality and quantity of these goods and services have deteriorated due to increased adverse human activity, coupled with the impacts of climate change. This has in turn threatened the local community's livelihoods and exposed them to the life threatening impacts of climate change.

The study area covered four sub-counties whose residents directly or indirectly interact and depend on the Mt. Elgon forest for their livelihoods. As a result of the ecological changes occasioned by human activities and climate change and variability, availability of the various ecological goods and services is likely to be affected. The situation is worsened by the clear lack of a coordinated joint conservation action by relevant stakeholders.

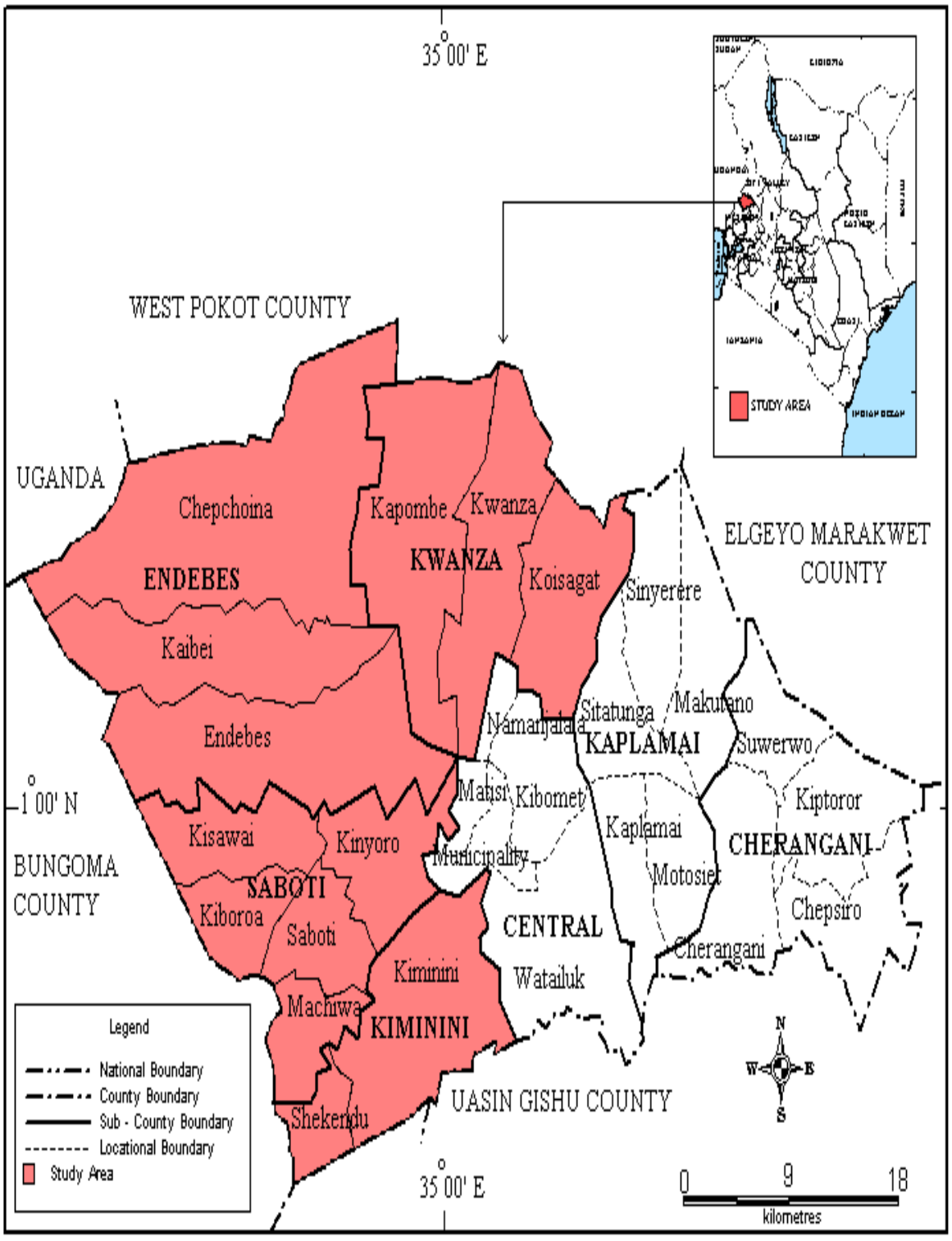

Figure 3.1: Map of Trans Nzoia County showing Kwanza, Kiminini, Saboti and Endebess Subcounties as the study area.

(Source: GIS Lab, Geography Department, Moi University, 2015.)

3.4 Target Population

The study targeted households drawn from four sub counties that make up the study area. A total of 393,531 (GoK,2010) households were used to arrive at the sample size in the entire study area which consists of residents in Saboti, Kiminini, Endebess, and Kwanza sub- counties as shown in **Table 3.1**

Table 3.1: Size of the study area by sub-county

Sub-county	Area in Km^2	Wards
Kwanza	466.9	Kwanza; Keiyo; Bidii; Kampomboi
Endebess	680	Endebess; Matumbei; Chepchoina
Saboti	323.6	Kinyoro; Matisi; Tuwani; Saboti;Machewa
Kiminini	395.3	Kiminini; Waitaluk; Sirende; Hospital; Sikhendu; Nabwiswa

(**Source**: **Trans Nzoia CIDP 2013 -2017*)***

3.5 Determination of sample size

According to Mugenda and Mugenda (2003), it is advisable to obtain a large sample as much as possible, a factor that is influenced by the availability of resources and time. Nevertheless, the authors gave the formula below that can be used to determine an acceptable sample size especially in situations where the target population is over 10,000.

$$n = Z^2pq/d^2$$

Where: n = the desired sample size

Z= standard normal deviate at the required confidence level

p = the proportion in the target population estimated to have characteristics being measured

q = 1-p

d = the level of statistical significance set

The target population in the study area was 393,531 households. Based on the above formula, the sample size was calculated as follows;

$$n = (1.96)^2(.50).50)/(.50)^2$$

=384 households

Consequently, the researcher had an option of taking a minimum of 384 households. But since it is advisable to take a larger sample size in order to minimize the standard error (Mugenda & Mugenda, *op cit.)*; the researcher took extra (21) 5% households distributed equally across the study area. This gave a total of 405 households which were sampled and interviewed.

3.6 Sampling procedure

The actual 405 respondents were then chosen using both stratified and simple random sampling. First the study area was stratified in terms of the four sub-counties. The number of households to be drawn from each sub-county was proportionate to the population of households in each sub-county relative to the entire study area (**Table 3.2**). Respondents from households were randomly selected from a household list that was readily available at the respective Chief's offices.

Table 3.1: Stratification of sampled households

Sub-county	No of households	Number in sample
Kwanza	139,708	$\frac{139,708}{393,531} \times 405 = 144$
Endebess	53,811	$\frac{53,811}{393,531} \times 405 = 55$
Saboti	141,575	$\frac{141,575}{393,531} \times 405 = 146$
Kiminini	58,437	$\frac{58,437}{393,531} \times 405 = 60$
Total	**393,531**	**405**

Table 3.3 below shows all Government and civil society group responds selected using purposive sampling technique and based on their relevance to Mt. Elgon forest and climate change adaptation matters. They were mainly from the County Government of Trans Nzoia's Departments of Agriculture; Environment and Natural Resources; Lands and Urban Planning. Others were, the Water Resources Authority; Kenya Forest Service, State Department of Tourism, and Kenya Wildlife Service.

The same technique was applied to responses obtained from the civil society organizations. This category of respondents included the local NGOs, CBOs, and development partners drawn from VI-Agroforestry, Community Forest Associations (CFAs), Water Resource Users Associations (WRUAs) and Community wildlife wardens.

Table 3.2: Government and civil society groups interviewed

Governance level	Department/Organization	Designation of respondent
County Government of Trans Nzoia	Ministry of Agriculture and Livestock Development, Ministry of Environment, Water and Natural resources	County Directors of Agriculture, Livestock, Fisheries, Environment, Water
National Government Ministries, Departments and Agencies (MDAs), Education institutions	Kenya Forest Service, WRA, , KWS, Education and Educational institutions, Environment,	Ecosystem conservator, WRA sub-Regional manager, KWS Regional Scientist, sub county Education Officers, Meteorological services, Station manager, Kimothon forest, Sampled Heads of Secondary and primary Schools.
Private sector	Manor House Agricultural College, Panocal International, Mt. Elgon Flowers	Liaison officers
NGOs	VI Agroforestry, KCWCG, KEETA, Dajopen Waste Management.	Liaison officers
CBOs	MANEWACTO, SABAOT, WRUAS, CFAs	Chairpersons of the CBOs

3.7 Data collection instruments

The study used three main instruments of primary data collection namely; household survey questionnaire, key informant interview schedules, focused group discussion guide. The choice of these three data collection instruments was informed by the need to triangulate data collection considering how touchy findings from the study could be. In addition, direct observation, photographs, remote sensing information and, Geographical information systems (GIS) were also used to collect more data and information. The selection of these tools was aimed at getting reliable data. It was also guided by the nature of the data that were being collected, the time available as well as the objectives of the study.

A reconnaissance was done in the area prior to conducting the actual data collection. Relevant archival and other library literature reviews were done in addition to acquisition of monthly and annual reports in the relevant departmental offices at the Trans Nzoia County headquarters.

3.7.1 Household questionnaire survey

The questionnaires were administered by 10 pre-trained research assistants who were knowledgeable with the area and its residents. The questionnaire as an instrument was used in this study because of a number of advantages. It is the most appropriate and cost effective method in surveying a large population as was in this research where 405 households were surveyed. Its cost effectiveness in surveying a large sample size is based on its standardized, highly structured design whereby the researcher asks in specific order, the questions of interest. This in most cases includes planned probes to make sure that each question to different respondents is asked in the same way.

3.7.2 Focused Group Discussion (FGD)

This involved discussions with the local people to get information regarding the trends of climatic parameters of interest to this study. A total of four FGDs were carried out, one in each sub-county. In order to observe inclusivity and avoid biased responses, each focus group consisted of four men, three women, and three youths. In the discussion, timelines and historical profile/recall methods were used in order to identify trends in ecosystem goods and services over time. Trends of the ecosystem goods and services in terms of their quantity and quality were specifically targeted. Focus Group Discussions were used to validate and triangulate the responses from the household survey.

3.7.3 Key informant interview

By means of purposive sampling a number of departments and institutions were identified based on their special involvement in the issues related to natural resource management and climate change. They included Kenya Forest Service (KFS), Department of Public Health, Water Resources Authority (WRA), Ministry of Agriculture, Heads of selected Primary and Secondary Schools, relevant NGOS and CBOs operating in the study area, County Government of Trans Nzoia's Environment Department, Kenya wildlife Service (KWS) and Kenya Seed Company Limited. The key informants provided vital information regarding policy, sectoral natural resource management challenges and opportunities. Some provided scientific facts and views about some observed climatic patterns and their associated effect on the vulnerability of the respondents to the effects of climate change.

A total of nine key informant interviews (KIIs) were conducted across the study area with the following individuals: two KIIs with two community elders (one male and one female); two KIIs with youth (one male and one female), three KIIs with officials drawn from the

Ministry of Agriculture, WRA, KFS, Public Health, two KIIs with social workers and two NGO officials working in the study area. The information gathered was used to cross-check the views of the respondents.

3.8 Validity and reliability of the study instruments

Validity and reliability are considered to be important parameters with regards to the extent to which results from the research instruments permit researchers to draw warranted conclusions about the characteristics of the individuals studied (Mugenda & Mugenda, 2003). For this reason the instruments were checked for both internal and external consistency of the items. For quality control purpose, the respondents were selected randomly from the households list available at the respective Chief's offices using a random number generator.

3.8.1 Validity

According to Mugenda and Mugenda (2003) validity of a research refers to how far its findings truly represent the phenomenon that a researcher claims to be measuring. It is also considered as the degree to which results obtained from the analysis of the data actually represents the phenomenon under study. If such data are a true reflection of the variables, then inferences based on such data will be accurate and meaningful. Two forms of validity were conducted for this study: face and content.

Under face validity, experts were asked their opinion about whether the research instruments used measured the intended concept. It was relevant for the appearance of the household questionnaire, focused group guides, and informant's interview schedule. The researcher with the assistance of the supervisors ensured that items were legible and

arranged systematically. Content validity was necessitated by the need to establish the extent to which the measures adequately represented all facets of ecosystem-based adaptation to climate change concept. Under this, the nature of climate change vulnerability in the study area was evaluated, appropriateness of natural resource management approaches and their implication on EbA approach and, finally to possibly adopt cost effective ecosystem based approaches to adaptation to climate change in the study area. Expert reviews of instruments using objectives and specifications were sought from peer reviewers, supervisors and other environment sector experts. The experts included the County Director of Meteorology, Ecosystem Conservator, the County Director of Agriculture, Area Warden and the County Chief Economist. This exercise was carried out in order to achieve high levels of content coverage. Key areas requiring grammatical correction among other requirements were pointed out and addressed.

3.8.2 Reliability

The questionnaire incorporated both open and closed ended questions to facilitate proper capturing and analysis of the variables of the study. The reliability of the questionnaires was verified through examination of internal consistency of the measures. This was achieved by computing the Cronbach's alpha coefficients on data collected through piloting of the developed questionnaire among a section of residents of Endebess Sub-county, Trans Nzoia County. The Sub County was chosen for piloting owing to the fact that it is within the study area, it's easy of accessibility, and it is equally faced with similar ecological and socio-economic conditions as other parts of the study area. Reliability coefficients of the six measurement scales used in the study are presented in **Appendix D.**

3.9 Data Analyses

Girot et al (2012) describes data analysis as a process of obtaining raw data and converting it into information useful for decision-making and users. Shamoo and Resnik (2003) observed that various analytic procedures "provide a way of drawing inductive inferences from data and distinguishing the signal (the phenomenon of interest) from the noise (statistical fluctuations) present in the data. The techniques of data analysis vary depending on the nature of data. In this research, relevant data were collected and analyzed to answer the research questions that guided this enquiry.

This research on the potential of integrating ecosystem based adaptation to climate change in Mt. Elgon forest is of mixed character and hence it called for the adoption of both qualitative and quantitative data analyses techniques. This, according to Bailey (2007) is a hybrid approach to data analysis whose main argument is that the analytical techniques are not mutually exclusive. According to him, almost all analytical techniques include the element of description. The differences among them are slight which makes choosing the most appropriate technique more difficult. In many instances choosing more than one technique is more appropriate or even required. This research which is multi-sectoral in scope, found it more appropriate to employ a triangulation of various data collection methods thus generating large amount of data and as such, both quantitative and qualitative data analysis techniques were required.

Descriptive statistics such as means, median and mode were utilized in data. Measures of dispersion such as range, quartile deviation, standard deviation and variance have also been used to describe a group of respondents. Coded data was entered into the Statistical Package for Social Scientists (SPSS) Version 20 which was then used to screen data for

missing values and computing response rate. Data from open-ended questionnaire items, interviews and group discussions were grouped under broad themes and converted into frequency counts. All data were analyzed at a significance level of 95% and the degrees of freedom depended on each particular case.

3.10 Ethical considerations

The study was undertaken in consideration of ethical issues in social science inquiry. The process of collecting, analyzing, and interpreting data was done in a way that respected the rights of participants and individual respondent groups. Specifically, prior to data collection, an introductory letter was prepared for the purpose of seeking informed consent from respondents to participate in the study. Details revealing the purpose of the study and guarantee of anonymity and confidentiality were included in the letter. All research assistants were required to show the letter to all potential respondents when soliciting participation in the research.

As indicated in the introductory letter, the right of anonymity and confidentiality was guaranteed. This included the assurance that the study was only for academic purposes and not for circulation to other parties. Anonymity of respondents was assured by concealing respondents' identities. Consequently, the respondents name was not required. Confidentiality was assured by the researcher taking responsibility to protect all data gathered within the scope study.

Finally the study ensured that the respondents' right to privacy was guaranteed. This is the freedom of an individual to determine the time, extent and circumstances under which

private information should be shared with or withheld from others. The house hold and others relevant stakeholders were interviewed at their own convenient time.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter describes results derived from the study designed to investigate the potential for integrating ecosystem based adaptation to climate change approaches in the Mt. Elgon Forest. The study was carried out in the four sub-counties of Trans Nzoia County namely, Kiminini, Saboti, Endebbes and Kwanza. Consequently, the chapter presents results of an analysis of the nature of climate change related vulnerability in Mt. Elgon forest, the current climate change adaptation and ecosystem management interventions, the natural resource institutional and policy challenges and opportunities for EbA inclusion the ecosystem. Finally, the chapter frames EbA in the ecosystem by pointing out the missing links to make EbA a better alternative to adaptation to climate change adaptation as compared to other adaptation options in Mt. Elgon ecosystem as relates to climate change adaptation planning and policy development.

4.1 Response rate

Data were collected from household heads using household questionnaires, focused group discussions, key informant interviews and field observations. The response rate was computed for all the returned questionnaires. All the targeted 405 household respondents completed and returned the duly filled questionnaires translating to an impressive 100% response rate. The returned questionnaires were edited and processed before statistical analyses were conducted.

This study also elicited response from some selected government departments as well as from civil society organizations that have knowledge on the subject matter. A questionnaire targeting this group of respondents was prepared and administered to them. This target group equally registered a 100% response rate.

4.1.1 Demographic and socio-economic analysis of the study area

The socio-demographic characteristics of household heads were captured in terms of respondent's gender, level of education, marital status, source of income, and distance to health facilities, all of which were categorical variables. The continous variables used were age, number of various livestock owned, number of spouses and the number of children. The results on socio-demographic analysis are presented in **Table 4.1**.

The age of most respondents (44.2%) was above 39 years and was dominated by male respondents (66.2%) who the study revealed were the household heads. Where the female respondent participated, it was either she is the household head or the spouse was out probably to fend for the family.Whereas the majority were married (75.3%), a significant proportion of the respondents were single (19.3%). It was noted that cumulatively a significant portion of the respondents (17.3%) either had no basic education or got education only up to primary level with the majority having an education of up to secondary level (37.0%). It also emerged that 22.7% of the respondents had an education up to college level with an equal portion of the respondents having acquired university education.

Table 4.1: Socio-demographic characteristics of respondents

n=405					
Variable	**Description**	**Frequency**	**Percent**	**Valid percent**	**Cumulative percent**
	Below 18	6	1.5	1.5	1.5
	18- 25	41	10.1	10.1	11.6
Age of respondent	26- 32	61	15.1	15.1	26.7
	33- 38	118	29.1	29.1	55.8
	39 and above	179	44.2	44.2	100.0
Gender of respondent	Male	268	66.2	66.2	66.2
	Female	137	33.8	33.8	100.0
	Primary	61	15.1	15.1	15.1
	Secondary	150	37.0	37.0	52.1
Education level	College	92	22.7	22.7	74.8
	University	92	22.7	22.7	97.5
	A - Level	1	2	2	97.8
	None	9	2.2	2.2	100.0
	Single	78	19.3	19.3	19.3
	Married	305	75.3	75.3	94.6
Marital status	Separated	9	2.2	2.2	96.8
	Widowed	13	3.2	3.2	100.0
Total		**405**	**100.0**	**100.0**	

4.2 Vulnerability to Climate Change in Mt. Elgon Ecosystem

Research question one sought to establish the nature of climate change vulnerabilities that residents of the study area are exposed to. To achieve this, this research examined the state of food security in the study area by identifying the food crop and livestock characteristics in various homesteads. This research further examined the land size and common household land tenure characteristics and how they influence vulnerability to climate change in the study area. The dwelling structures, domestic energy options, diversity of household income sources, access to health facilities, and family security were other factors that were examined in relation to how they influence vulnerability to climate change.

4.2.1 Food security in the study area

As regards food security, this research examined the adequacy of food that is primarily produced in the study area and which the community largely depends for their survival.

Specifically this research established the types of food crops grown by respondents and how it influenced vulnerability to climate change. Results indicate that the common crops grown included beans, vegetables, maize, millet and sugarcane. These results further show (T**able 4.2)** that the majority (90.6%) household grew maize distantly followed by beans (3.7%). Other crops grown are vegetables (2.7%), millet (1.5%), and lastly sugarcane (1.5%). This is despite the fact that the soils and the climatic conditions in the study area are suitable for growing other crops such as millet, sunflower, and sorghum (GoK, 2013).

Table 4.2: Main crops grown by respondents

Crop type	Frequency
Beans	15
Vegetable	11
Maize	367
Millet	6
Sugarcane	6
Total	**405**

Key informant and FGDs revealed that maize is a staple food in the study area owing to food preferences. A cross tabulation **(Table 4.3)** clearly shows that the size of land owned does not hinder respondents from growing maize ($\alpha = 0.05$, $p = 0.207$).

Table 4.3: Relationship between size of land owned by respondent and the main crop grown

Size of Land Owned by Respondent	Main crop				
	Beans	Vegetable	Maize	Millet	Sugarcane
< 0.5 Acre	3	4	126	2	3
0.5 - 1 Acre	6	4	47	0	0
2 - 4Acres	5	2	106	4	3
5 - 10 Acres	1	1	55	0	0
> 10 Acres	0	0	15	0	0
None	0	0	18	0	0
Total	**15**	**11**	**367**	**6**	**6**

Findings further point out that the production of this locally produced staple food (maize) will expose the residents to the effects of climate change. There was a significant association of the level of education and the type of crop grown ($p = 0.012$, $\alpha = 0.05$) with crop diversification being associated with those with a higher education. However, the maize crop seemed to be the preferred crop irrespective of the education level attained (**Table 4.4)**.

Table 4.4: Influence of the respondent's level of education on the main crop grown

Respondent's Education Level	Crop					Total
	Beans	Vegetable	Maize	Millet	Sugarcane	
Primary	4	5	52	0	0	61
Secondary	4	2	144	0	0	150
College	1	2	82	2	5	92
University	6	2	79	4	1	92
A – Level	0	0	1	0	0	1
None	0	0	9	0	0	9
Total	**15**	**11**	**367**	**6**	**6**	**405**

Data collected established that there is no diversification of livestock rearing in the study area with only 2% rearing livestock types other than the conventional livestock common in the study area such as cattle, goats, and poultry (**Table 4.5)**. Findings also showed that

poultry is reared in most homesteads (34.9%) followed by cattle (34.7%) with. donkeys being the least preferred in most homesteads (8.2%).

Table 4.5: Livestock owned by respondents

Types of livestock reared		Responses		Percent of Cases
		N	Percent	
	Cattle	264	34.7%	75.4%
	Shoats	153	20.1%	43.7%
	Donkeys	62	8.2%	17.7%
	Poultry	265	34.9%	75.7%
	Other livestock	16	2.1%	4.6%
	Total	**760**	**100.0%**	**217.1%**

Table 4.6 shows that there was a statistically significant difference in the type of livestock kept by different age groups as determined by one-way ANOVA [(F_4 (400) =7.374, p=0.000].

Table 4.6: Cattle reared by different age groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.312	4	1.578	7.374	.000
Within Groups	85.599	400	.214		
Total	**91.911**	**404**			

A Turkey post-Hoc test **(table 4.7)** revealed that cattle rearing in the age group of 39 years and above was statistically significant higher (179 ±0.435) than other cattle rearing age groups interviewed.

Table 4.7: Respondents rearing cattle

Age of the Respondent	N	Subset for alpha = 0.05	
		1	2
Below 18	6	1.00	
39 and Above	179	1.25	1.25
18 – 25	41	1.32	1.32
33 – 38	118		1.40
26 – 32	**61**		**1.59**

The focus group discussion and the researcher's observations revealed that households which engaged in dairy cattle farming preferred rearing the Friesian dairy breed due to its perceived high milk production. This preference of the breed exposes the residents of this region to the effects of climate change.

4.2.2 Income diversity

To further understand the nature of climate change vulnerability of the community, this research examined the diversity of the existing livelihood options in the Mt. Elgon ecosystem. Household and FGDs revealed that the community in the study area rely on crop farming (47.4%) as the main source of family income. This is followed by formal employment (21.5%), family business (12.9%) and casual employment in the agricultural sector (10.9%). Livestock farming (6.9%) is the least depended source of household income (**Table 4.8)**. Other notable sources of household income in the study area accounted for 0.5%. They include informal activities such as gambling, touting and motorcycle riding. FGDs revealed that the majority of respondents who are in formal employment actually work in agriculture allied sectors.

Table 4.8: Common household income sources

Household income source	*Frequency*	*Percent*
Family business	52	12.8
Crop farming	192	47.4
Livestock farming	28	6.9
Formal employment	87	21.5
Casual employment	44	10.9
Others	2	.5
Total	**405**	**100.0**

Cross-tabulation of the respondent's age and the respondent's common source of income reveal that there is an overreliance on crop farming as common source of household income (**Table 4.9)**.

Table 4.9: Cross-tabulation of the age of the respondent and the common source of household income

		Common income Household income source						**Total**
		Family business	Crop farming	Livestock farming	Formal employment	Casual employment	Other	
Age of the Respondent	Below 18	0	6	0	0	0	0	6
	18 - 25	7	17	3	7	7	0	41
	26 - 32	7	28	2	14	10	0	61
	33 - 38	24	49	4	26	14	1	118
	39 and Above	14	92	19	40	13	1	179
Total		**52**	**192**	**28**	**87**	**44**	**2**	**405**

Pearson Chi-square test **(Table 4.10)** revealed that there are some income streams that are associated with the age of the respondent. However, crop farming has been taken up as a source of income by all age groups. The ages of below 18years are conspicuously missing in embracing family business and livestock farming as their source of income ($p = 0.050$, $\alpha = 0.05$).

Table 4.10: Relationship between the respondents' age and the main household income

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided)			Monte Carlo Sig. (1-sided)		
				Sig.	95% Confidence Interval		Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound		Lower Bound	Upper Bound
Pearson Chi-Square	31.381[a]	20	.050	.066[b]	.061	.071			
Likelihood Ratio	34.037	20	.026	.019[b]	.016	.022			
Fisher's Exact Test	30.213			.036[b]	.033	.040			
Linear-by-Linear Association	.000[c]	1	.997	1.000[b]	1.000	1.000	.506[b]	.496	.515
N of Valid Cases	**405**								

4.2.3 Land size and Land tenure systems

This study also sought to establish the average size of land that is owned by a household. Results show that the majority (34%) of the respondents own less than 0.5 of an acre of land **(Figure 4.1)** and that cumulatively, 78% of the respondents are small scale farmers owning less than 5 acres of land, with only 4% owning more than 10 acres.

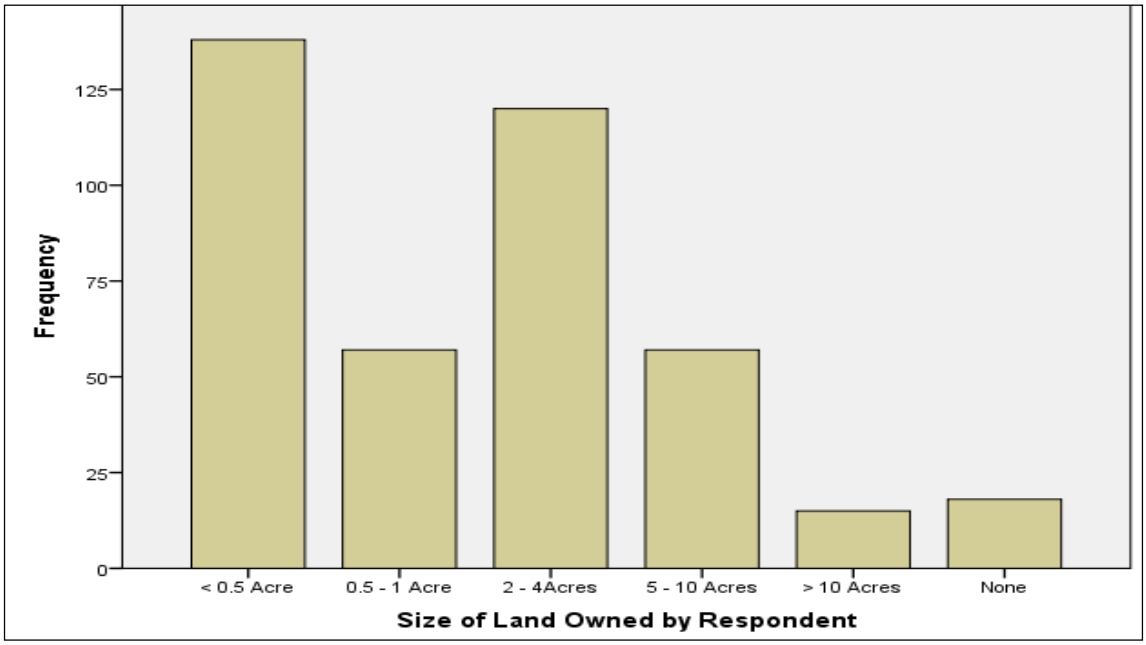

Figure 4.1: Size of land owned

Findings show that there is a significant relationship between an individual's level of education and the size of land owned ($\alpha = 0.05$, $p = 0.000$ most respondents who have received an education up to university level own land of more than 10acres (**Table 4.11**).

Table 4.11: Cross-tabulation of respondent's education level and size of land owned

		Size of Land Owned by Respondent						Total
		< 0.5 Acre	0.5 - 1 Acre	2 - 4Acres	5 - 10 Acres	> 10 Acres	None	
Respondent's Education Level	Primary	20	12	21	5	3	0	61
	Secondary	51	27	39	29	2	2	150
	College	31	7	34	12	2	6	92
	University	35	9	24	10	8	6	92
	A - Level	0	0	0	1	0	0	1
	None	1	2	2	0	0	4	9
Total		**138**	**57**	**120**	**57**	**15**	**18**	**405**

Results as indicate (**Figure 4.2)** that freehold land ownership is the predominant (49.6%) land tenure system in the study area. The rest of the respondents belong the less secure land

ownership regime of either leasehold (17.8%), communal (16.3%), squatter (7.7%) and untitled (8.7%).

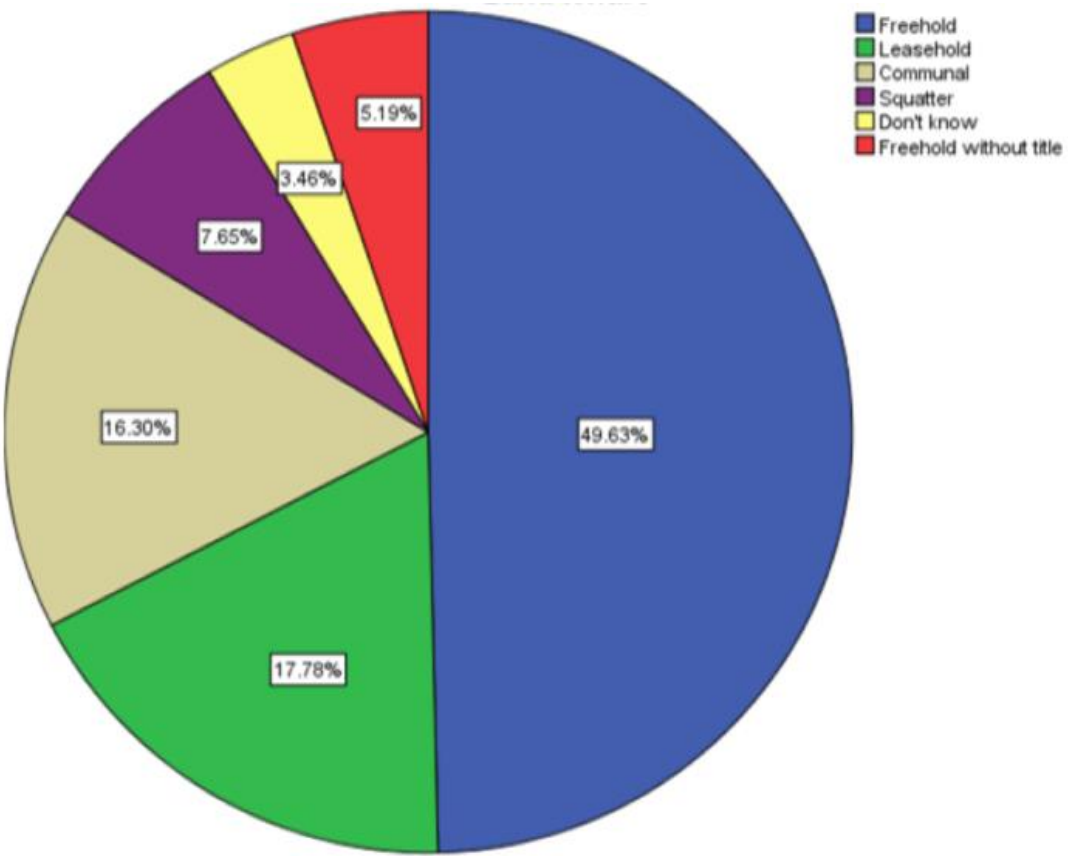

Figure 4.2: Land tenure systems in Mt. Elgon Ecosystem

In all tenure systems, the respondents practiced crop farming ($p=0.057$, $\alpha=0.05$), with maize farming being their crop of choice. **(Table 4.12)**

Table 4.12: Influence of land tenure on the main crop grown by respondents

		Main Crop					Total
		Beans	Vegetable	Maize	Millet	Sugarcane	
Land tenure	Freehold	6	5	184	4	2	201
	Leasehold	4	1	63	0	4	72
	Communal	0	1	63	2	0	66
	Squatter	1	3	27	0	0	31
	Don't know	2	0	12	0	0	14
	Freehold without title	2	1	18	0	0	21
Total		**15**	**11**	**367**	**6**	**6**	**405**

Another observation was that most farmers who are engaged in crop farming have leased a substantial amount of land from other residents who are either not active in crop farming or are unable to fully utilize their farms.

A small percentage (36.3%) of respondents live in permanent housing structures with the rest (67.3%) living in semi-permanent dwellings (**Table 4.13)** which can be susceptible to the effects of extreme climatic conditions **(Plate 4.1)**.

Plate: 4.1: Predominant housing types in insecure land tenure system in Endebess sub county, Trans Nzoia County (Source : Author, 2019)

Table 4.13: Type of dwelling owned by respondents

Type of house	Frequency	Percent	Cumulative Percent
Stone walled with iron sheets	147	36.3	36.3
Mud walled with Iron sheets	202	49.9	86.2
Mud walled with Grass roof	43	10.6	96.8
Other	13	3.2	100.0
Total	**405**	**100.0**	

Results show an association between land tenure and the type of dwelling unit owned by respondent ($p=0.001$, $\alpha=0.05$). Freehold land ownership regime has attracted a better housing as compared to the less secure land ownership regime **(Table 4.14)**.

Table 4.14: Relationship between land tenure and dwelling type

		Dwelling type				Total
		Stone walled with iron sheets	Mud walled with Iron sheets	Mud walled with Grass roof	Other	
Land tenure	Freehold	88	92	16	5	201
	Leasehold	26	38	6	2	72
	Communal	8	40	16	2	66
	Squatter	12	14	2	3	31
	Don't know	6	5	2	1	14
	Freehold without title	7	13	1	0	21
Total		**147**	**202**	**43**	**13**	**405**

4.2.4 Household Energy sources and vulnerability

In order to further describe the nature of climate change vulnerability in the study area, this study examined the household energy options that are available in the study area. Study findings (**figure 4.3)** show that there is an overreliance on wood fuel (84.9%) as the main source of domestic energy by residents of the Mt. Elgon ecosystem.

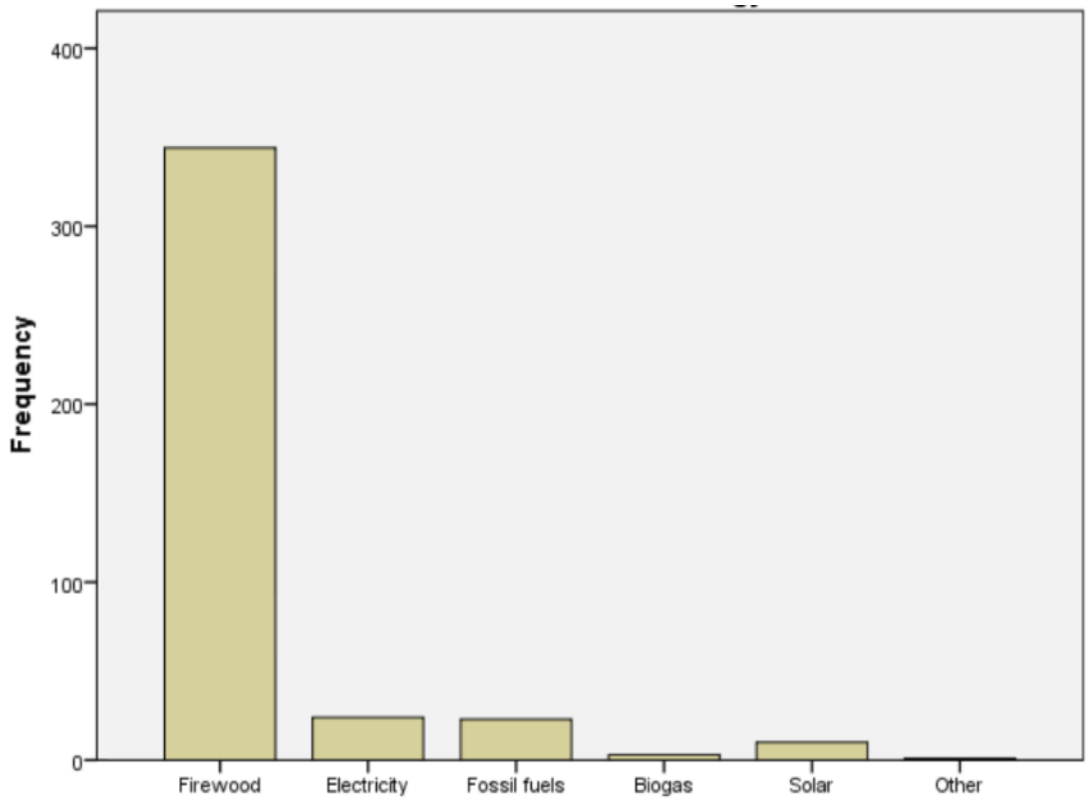

Figure 4.3: Main source of household energy

This is distantly followed by electricity (5.9%) and fossil fuels (5.7%). It was observed that the green energy options have not been fully adopted by most respondents with only 0.7% and 2.5% of respondents using the biogas and solar technologies respectively.

Table 4.15: Cross-tabulation of age of the respondent and the main source of household energy

		Main Source of Household Energy						Total
		Firewood	Electricity	Fossil fuels	Biogas	Solar	Other	
Age of the Respondent	Below 18	6	0	0	0	0	0	6
	18 - 25	30	7	3	0	1	0	41
	26 - 32	46	6	4	3	1	1	61
	33 - 38	102	4	6	0	6	0	118
	39 and Above	160	7	10	0	2	0	179
Total		**344**	**24**	**23**	**3**	**10**	**1**	**405**

Results show that respondents with the age of over 33 years old rely heavily on fuel wood ($p= 0.002$, $\alpha=0.05$) for their energy needs (**Table 4.16**)

Table 4.16: Age of the respond and the main source of energy

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	43.127[a]	20	.002
Likelihood Ratio	33.393	20	.031
Linear-by-Linear Association	4.061	1	.044
N of Valid Cases	**405**		

The respondents were further asked to give their general view on the trend in availability of wood fuel for household use. Their response which is summarized on **Table 4.17** shows that a larger percentage of respondents (75%) are of the view that wood fuel resources are declining. A focus group discussion confirmed this and added that wood fuel users had to venture deeper into the forest to get enough and "quality" firewood.

Table 4.17: Fuel wood status in the Mt. Elgon Forest ecosystem

Trend of biomass energy sources	Frequency	Percent
Increasing	100	24.7
Decreasing	304	75.1
Don't know	1	.2
Total	405	100.0

4.2.5 Access to healthcare

In order to understand better the nature of climate change vulnerability in the study area, this study further examined the ease with which respondents accessed healthcare services. This was measured by capturing information regarding the average distance travelled by respondents in order to access healthcare services. Results indicated that most residents (76.5%) are able to access medical care at local dispensaries that are within a radius of 1-5km (T**able 4.18)**.

Table 4.18: Distance to medical health facilities

Distance (Km) to medical facilities		Frequency	Percent
Nearest Dispensary	1 – 5	310	76.5
	6 – 10	69	17.0
	11 – 20	14	3.5
	21 – 30	12	3.0
Sub District Hospital	1 – 5	101	24.9
	6 – 10	118	29.1
	11 – 20	118	29.1
	21 – 30	48	11.9
	Over 30	20	4.9
County Hospital	1 – 5	64	15.8
	6 – 10	51	12.6
	11 – 20	102	25.2
	21 – 30	104	25.7
	Over 30	84	20.7
Referral Hospital	1 – 5	2	.5
	6 – 10	1	.2
	11 -20	11	2.7

	21 – 30 Km	17	4.2
	Over 30	374	92.3
Total	**405**	**100.0**	**100.0**

The findings further revealed that a substantial number (29%) receive medical care from sub-county hospitals that are over 10km away. Referral hospitals which offer medical services of a higher quality are at a distance of over 30km. **Table 4.19** shows that there was a statistically significant difference in the distance covered to the government referral hospital as determined by one-way ANOVA [(F_3 (401) =4.206, p = 0.006].

Table 4.19: One-way ANOVA for the distance from the nearest government referral hospital

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	2.924	3	.975	4.206	.006
Within Groups	92.904	401	.232		
Total	**95.827**	**404**			

A focus group discussion revealed that it's often difficult to access this category of referral health facilities due to frequent episodes of extreme and erratic precipitation that often render the roads impassable.

4.2.6 Conflict prevalence and vulnerability to climate change

It was in the interest of this research to establish whether the study area has experienced natural resource use conflicts and whether the same has an implication on the community's vulnerability to climate change impacts. 52.6% of the respondents confirmed that conflicts are prevalent in the study area (**Table 4.20**).

Table 4.20: Prevalence of conflicts

Presence/Absence of conflicts	Frequency	Percent
Presence of conflicts	213	52.6
No conflicts	192	47.4
Total	405	100.0

In **table 4.21** respondents indicated that conflicts are either unpredictable (45.7%), often occur (5.9%) or do take place yearly (3.2%) an overwhelming 45.2% mainly drawn from indigenous community indicated that conflicts have never occurred in the study area.

Table 4.21: Frequency of conflicts

Frequency of insecurity incidents	Frequency	Percent
Yearly	13	3.2
Very often	24	5.9
Unpredictable	185	45.7
Never occurred	183	45.2
Total	**405**	**100.0**

Table 4.22 indicates that there is a statistically significant difference in the prevalence of conflicts determined by one-way ANOVA [(F_3 (401) = 7,564, p=000]. The frequency of the conflicts is equally statistically significant in the study area [(F_3 (401) = 5.863, p=001].

Table 4.22: One way ANOVA for conflict frequency and prevalence

		Sum of Squares	df	Mean Square	F	Sig.
Prevalence of conflicts	Between Groups	5.408	3	1.803	7.564	.000
	Within Groups	95.570	40 1	.238		
	Total	100.978	404			
Frequency of conflict	Between Groups	9.048	3	3.016	5.863	.001
	Within Groups	206.275	401	.514		
	Total	**215.323**	**404**			

Key informant interviews revealed that the non-migrant Sabaot do regard the study area as their ancestral land and view any immigrant tribe as an intruder.

Cumulatively, 25% of the respondents felt that their families are insecure at their present residence (table 4.10) while 64.7% indicate that security is fairly good. Only 10.9% of the respondents felt that their family is very safe at their current place of residence **(Table 4.23)**. Again this response was mainly from the indigenous Sabaot community.

Table 4.23: Family security at place of residence

Respondent's perception of human security in the study area	Frequency	Percent
Excellent	21	5.2
Very good	23	5.7
Good	262	64.7
Poor	88	21.7
Very poor	11	2.7
Total	**405**	**100.0**

4.3 Climate Change Adaptation Interventions in the Mt. Elgon Ecosystem

4.3.1 Climate change in Mt. Elgon ecosystem

Data obtained from the Kenya Meteorological Station in Kitale for the years between 2009 and 2017 indicate that there is an increase in the mean annual temperatures (F**igure 4.4**).

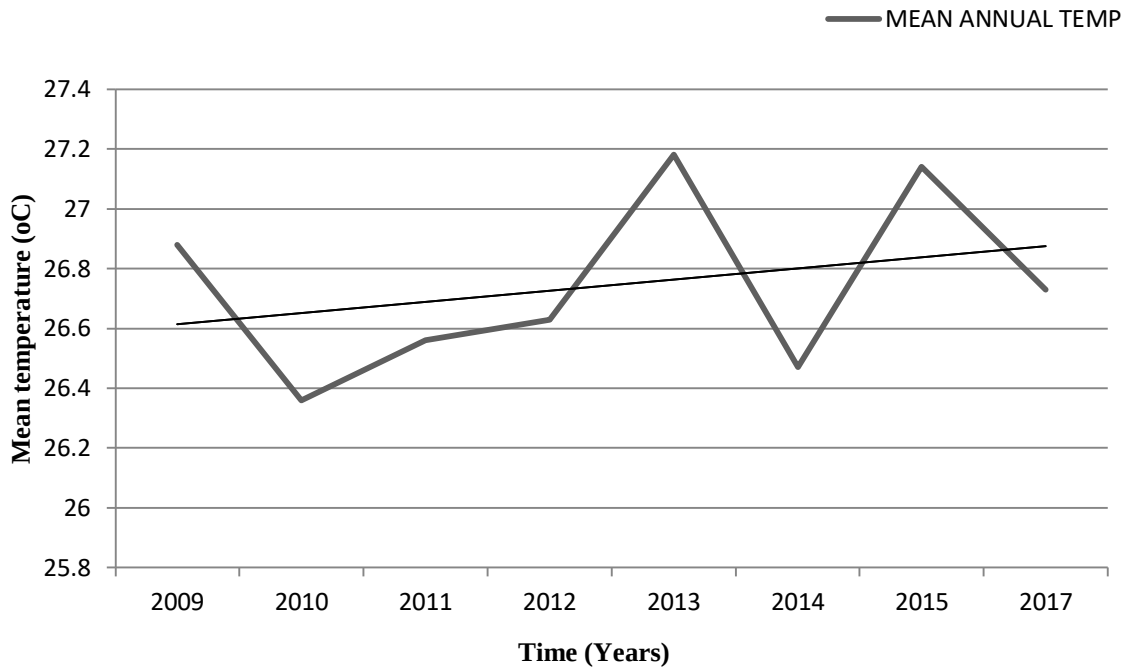

Figure 4.4: Mean annual temperature changes in the Mt. Elgon ecosystem

(Source: KMS Kitale, 2018)

Figure 4.5 shows that there was remarkable variation in the rainfall patterns during the long rain season of March, April and May (MAM). The same variation was noted in the short rains season of that covers October, November and December (OND) (**Figure 4.5)**.

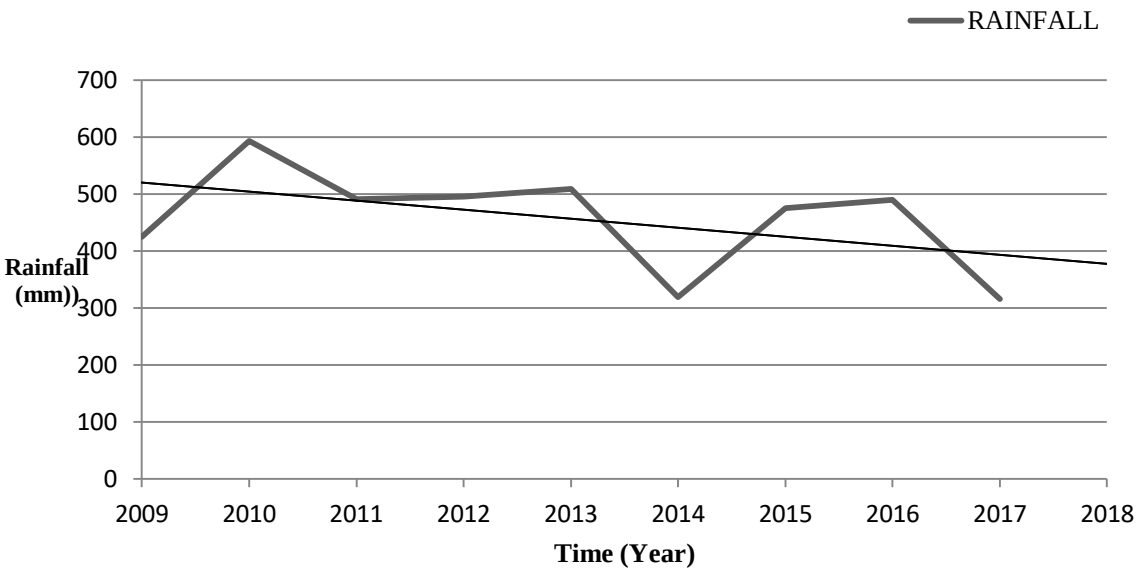

Figure 4.5: Rainfall variability in MAM over the years (2009 -2018)

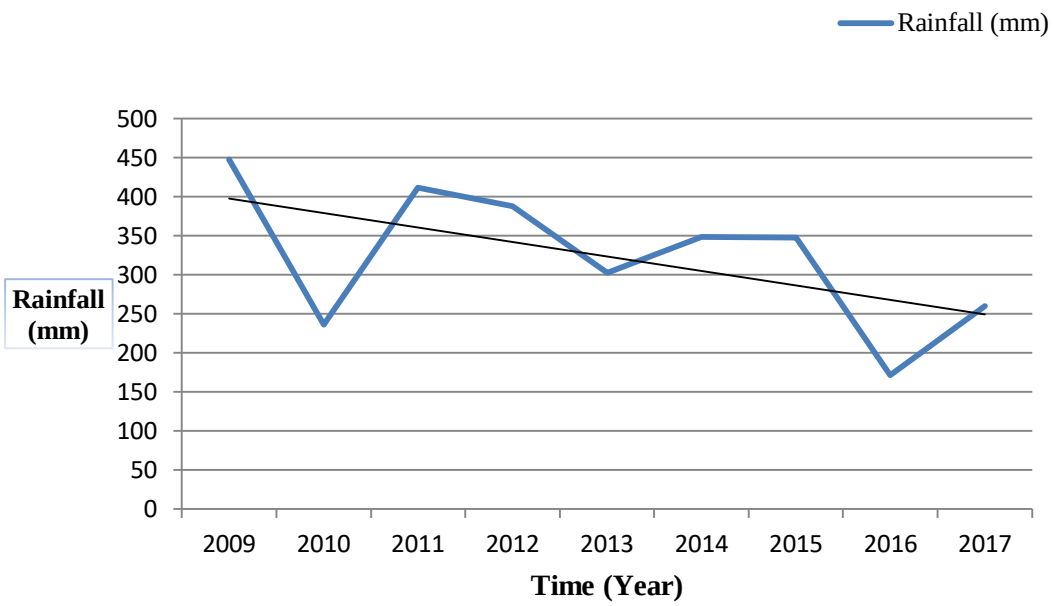

Figure 4.6: Rainfall variability in OND over the years (2009 – 2018)

Secondary data sources also show that the study area is becoming warmer **(Figures 4.7 and 4.9)**.

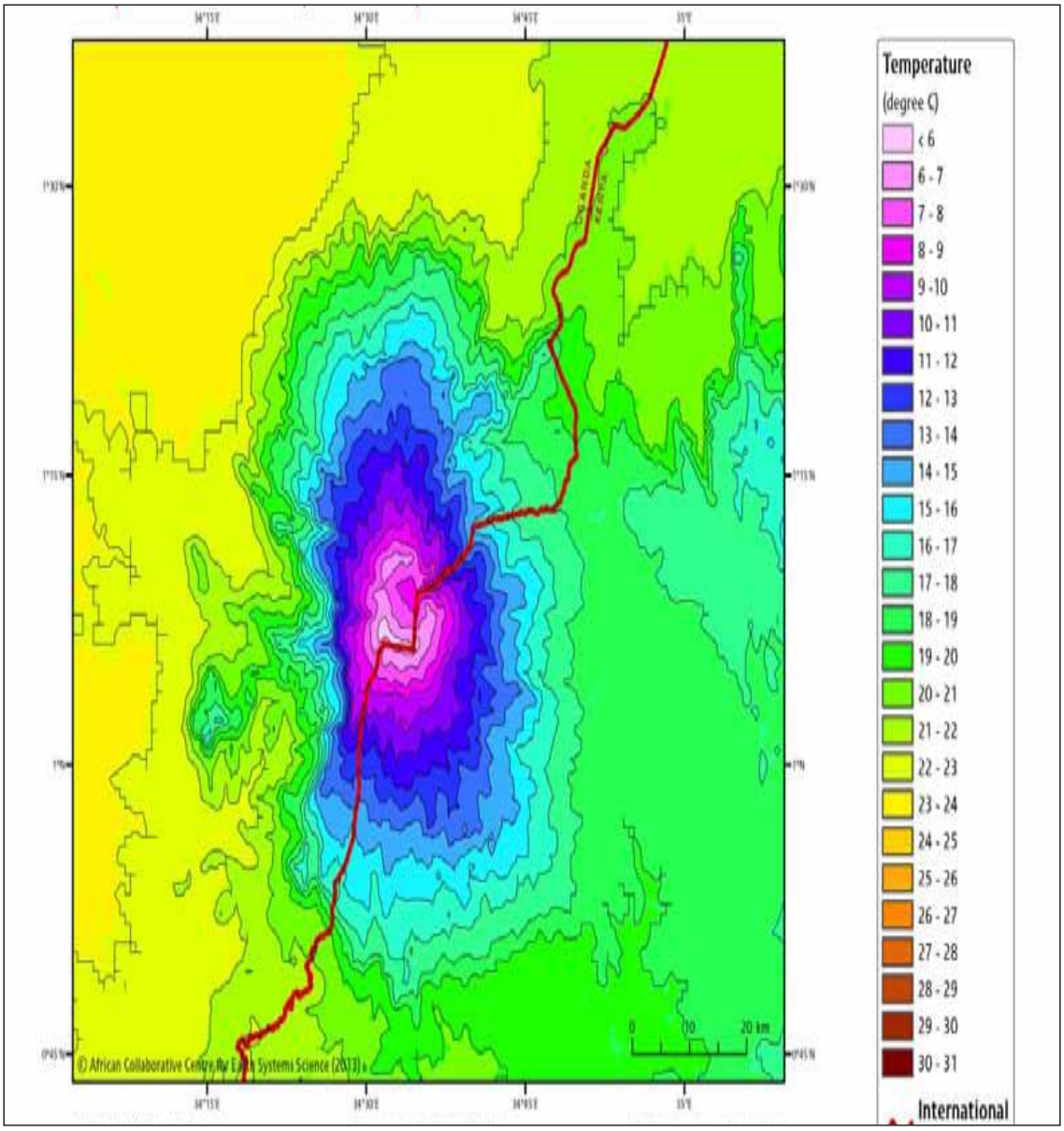

Figure 4.7 : Mt. Elgon region temperature baseline (1950 – 2000)

(Source: Olago et al., 2015)

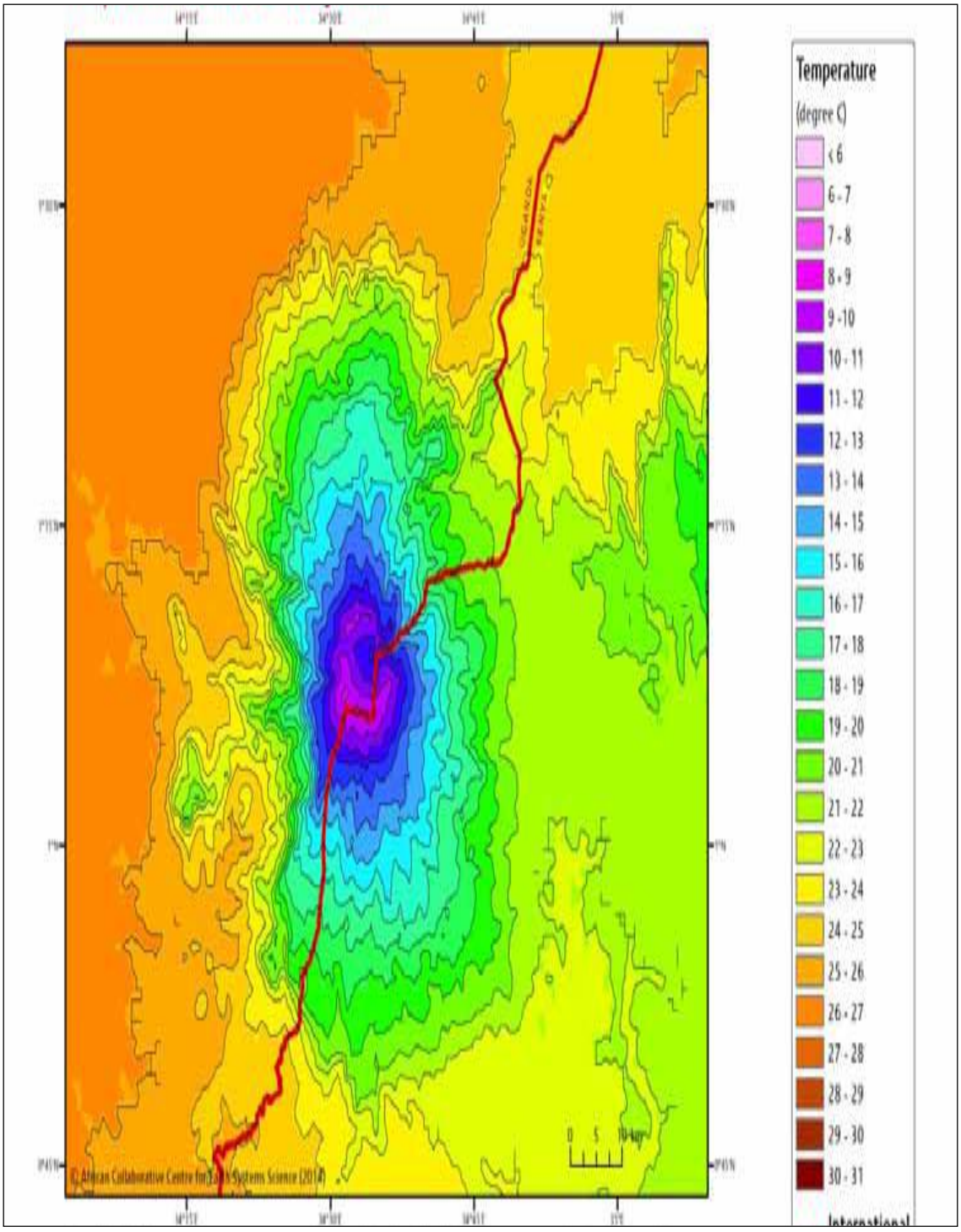

Figure 4.8: Mt. Elgon temperature projection 2060-2080

(Source: Olago et al., 2015)

Majority (88.4%) of the household respondents reported that the region's climate has become erratic as has been manifested through unusual rainfall experiences and occasional high temperatures attained (**Table 4.24)**.

Table 4.24: Community views on climate change in Mt. Elgon Ecosystem

Has climate changed in Mt. Elgon Ecosystem	Frequency	Percent
Yes	358	88.4
No	47	11.6
Total	**405**	**100.0**

This variation of climate change attributes has been noted by all respondents irrespective of their academic qualification. A total of 85 out of 92 respondents with a university education have also observed a variation in climate attributes (T**able 4.25**).

Table 4.25: Cross-tabulation of respondent's level of education and their view on climate change

Respondent's Education level	Has climate changed climate changed		Total
	Changed	Not changed	
Primary	59	2	61
Secondary	124	26	150
College	80	12	92
University	85	7	92
A - Level	1	0	1
None	9	0	9
Total	**358**	**47**	**405**

4.3.2 Climate change adaptation interventions

The respondents identified some specific projects that have been initiated by the Government of Kenya and other development partners to cushion them against the effects of climate change **(Table 4.26).**

Table 4.26: Climate change adaptation projects initiated in the study area

Climate change adaptation projects	Responses	
	N	***Percent***
Hand dug well	236	8.7%
Borehole	263	9.7%
Water pans	253	9.4%
Irrigation projects	230	8.5%
Flood control projects	304	11.2%
Water supply projects	326	12.1%
Fast maturing crops	337	12.5%
Drought resistant crops	327	12.1%
Alternative crops	304	11.2%
Other Climate Change projects	125	4.6%
Total	**2705**	**100.0%**

Results show that 12.5% of the respondents are aware that fast maturing crop varieties have been introduced in the Mt. Elgon ecosystem. The adoption of the same is being promoted as one of the coping strategy against climate change. Other notable coping interventions include the introduction of drought resistant crops (12.1%); supply of piped water (12.1%), planting of alternative crops other than the traditional staple food crops (11.2%), construction of water pans (9.4%), sinking of boreholes (9.7%), construction of hand dug wells (8.7%), and establishment of micro irrigation schemes (8.5%).

Government and civil society members who participated in this study revealed that most climate change adaptation projects are decided and implemented using a top-down approach **(Figure 4.9)**.

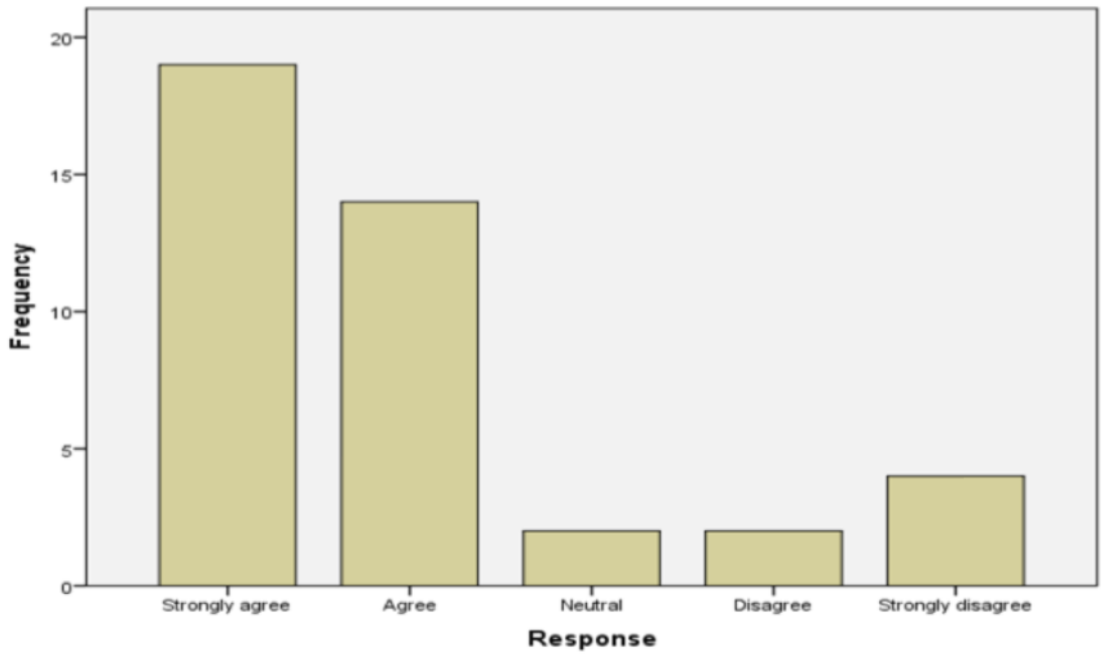

Figure 4.9: Respondents view on top-down approach in initiating adaptation projects

Cumulatively, 33 government and civil society respondents (80.4%) view a top-down approach as being the most preferred mode of identifying and initiating climate change adaptation projects.

However, 32.6% of the household respondents indicated that the community is not actively involved in the identification of climate change adaptation projects (**Table 4.27**).

Table 4.27: Public involvement in climate change project decisions

Community involvement in project identification	Frequency	Percent
Yes	273	67.4
No	132	32.6
Total	**405**	**100.0**

4.3.3 Effectiveness of adaptation interventions

Using data collected from household heads, government institutions, local NGOs and CBOs, the study found out that majority of the residents (65.2%) are optimistic that the

initiated projects will succeed in the long-term after the donor has stopped financing them (**Table 4.28**). However, a significant proportion of the respondents (34.8%) think otherwise.

Table 4.28: Views on the long-term success of climate change adaptation projects

Sustainability of adaptation projects	Frequency	Percent
Sustainable	264	65.2
Unsustainable	141	34.8
Total	**405**	**100.0**

4.4 Natural Resource Governance and Eba in Mt. Elgon

4.4.1 Management of Ecosystem Resources

For Ecosystem based Adaptation to be effective in adaptation to climate change, the ecosystem management approaches must be geared towards restoring and maintenance of the natural structure of an ecosystem. The major environmental resources found in the study area and were of interest to this research include the natural and plantation forests, rivers, wetlands, arable land, wildlife-Fauna, wildlife – flora, and cultural heritage. Findings from this research (F**igure 4.10)** show that line Ministries are largely responsible (63.4%) for the management of the individual relevant resources that occur in the Mt. Elgon ecosystem while a few other natural resources are co-managed (9.7%).

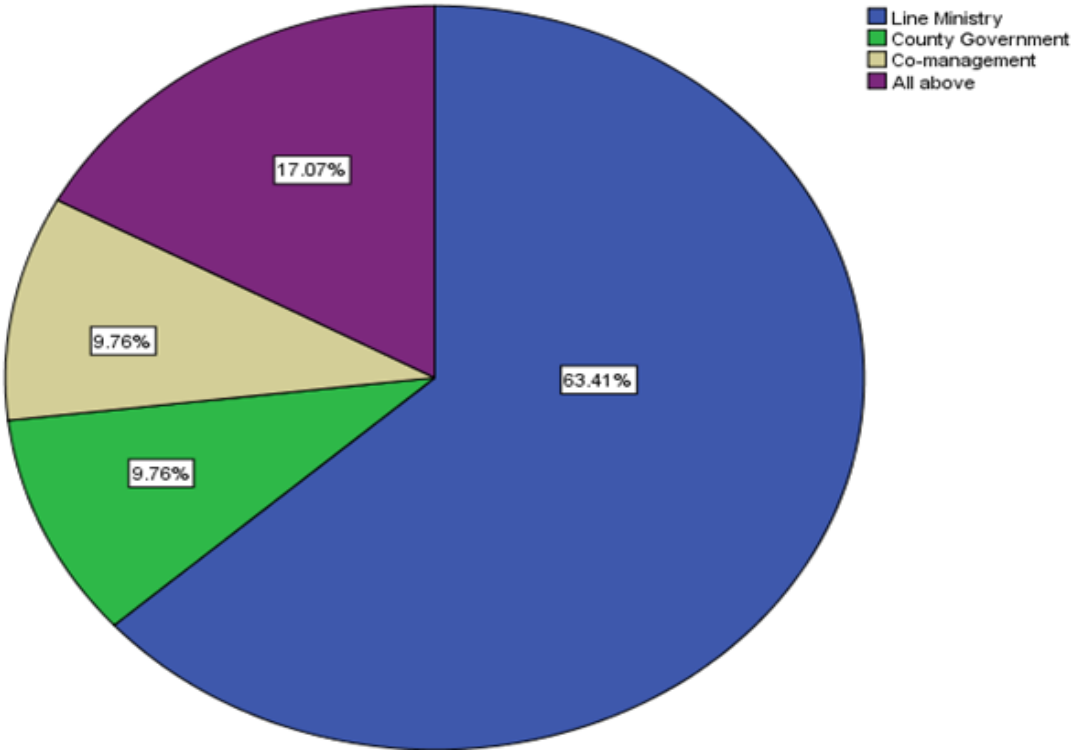

Figure 4.10: Governance of Natural Resources in the study area

Key informant and FGDs confirmed that individual resources within the ecosystem are managed by a line/sector resource management institution. Even with this heavy line ministry representation, there is wanton destruction of the Mt. Elgon ecosystem. (**Plate 4.1)**

Plate: 4.2: Illegal encroachment and land allotments in Mt. Elgon forest

(Source: Author, 2019)

4.4.2 Conservation versus community livelihoods

This research also investigated community views on whether the current management of individual resources contributes to the improvement of their livelihoods. Cumulatively 63.4% of the respondents confirm that the resource management regimes do take into consideration the fact that the adjacent community depend heavily on the ecosystem goods and services offered by the Mt. Elgon ecosystem for their livelihoods. Only 24.4 % of the respondents reported otherwise **(Table 4.29)**.

Table 4.29: Sensitivity of natural resource management regimes to community livelihoods

Management regime is sensitive to community' livelihoods	Frequency	Percent
Strongly Agree	105	25.9
Agree	152	37.5
Neutral	49	12.1
Disagree	47	11.6
Strongly disagree	52	12.8
Total	**405**	**100.0**

Analysis of data revealed that (30.6%) of the respondents did not observe any grass root leadership support in conserving the Mt. Elgon ecosystem. However, 54.5% of the respondents are of the contrary opinion (**Table 4.30**).

Table 4.30: Views on leadership support for natural resource conservation

There is strong leadership support	Frequency	Percent
Strongly Agree	88	21.7
Agree	133	32.8
Neutral	60	14.8
Disagree	67	16.5
Strongly disagree	57	14.1
Total	**405**	**100.0**

4.5 Capacity for EbA in the Mt. Elgon Ecosystem

4.5.1 Opportunities for Ecosystem-Based Adaptation in Mt. Elgon Ecosystem

Research question four sought to find out whether the prevailing managerial, institutional and policy environment augments the conservation narrative of the Mt. Elgon ecosystem for purposes of enhancing adaptation to climate change. To achieve this, the study identified opportunities presented by the ecosystem that can be tapped and enhanced in order to foster adaptation to climate change efforts. This research also further identified the challenges facing the adoption of EbA as a climate change adaptation strategy in the study area.

4.5.2 Mt. Elgon's ecosystem goods and services

Questionnaire responses and FGDs revealed that there is a wide range of goods and services that are obtained from the adjacent Mt. Elgon forest ecosystem **(Table 4.31)**. It was also established that most of the ecosystem goods and services are declining.

Table 4.31: Trends in quantities and qualities of goods and services

HOUSEHOLD RESPONSES (N=405)				GOVERNMENT/CIVIL SOCIETY RESPONSE (N=41)			
Goods/service	**Trend**	**Freq**	**Percent**	**Goods/service**	**Trend**	**Freq**	**Percent**
Food	Increase	111	27.4	**Food**	Increase	5	12.2
	Decrease	289	71.4		Decrease	36	87.8
Fuel wood	Increasing	100	24.7	**Fuel wood**	Increasing	7	17.1
	Decreasing	304	75.1		Decreasing	34	82.9
Fresh water	Increasing	78	19.3	**Fresh water**	Increasing	7	17.1
	Decreasing	321	79.3		Decreasing	34	82.9
Medicinal plants	Increasing	65	16.0	**Medicinal plants**	Increasing	7	17.1
	Decreasing	339	83.7		Decreasing	34	82.9
Air quality	Increasing	81	20.0	**Air quality**	Increasing	8	19.5
	Decreasing	321	79.3		Decreasing	33	80.5
Natural hazard regulation	Increasing	142	35.1	**Natural hazard regulation**	Increasing	16	39.0
	Decreasing	259	64.0		Decreasing	25	61.0
Water flow regulation	Increasing	127	31.4	**Water flow regulation**	Increasing	8	19.5
	Decreasing	275	67.9		Decreasing	33	80.5
Cultural and spiritual	Increasing	99	24.4	**Cultural and spiritual**	Increasing	6	14.6
	Decreasing	304	75.1		Decreasing	35	85.4
Biodiversity regulation	Increasing	118	29.1	**Biodiversity regulation**	Increasing	7	17.1
	Decreasing	284	70.1		Decreasing	34	82.9

Cumulatively, 83.7% of the respondents link the decline of goods and services to the ongoing destruction of the Mt. Elgon forest (**Table 4.32**).

Table 4.32: Link between decline in goods and services

Link between destruction of Mt. Elgon ecosystem resources and decline in goods and services	Frequency	Percent
Strongly Agree	151	37.3
Agree	188	46.4
Neutral	33	8.1
Disagree	29	7.2
Strongly disagree	4	1.0
Total	**405**	**100.0**

4.5.3 Natural Resource management institutions

It was established that already there are various institutions and stakeholders in the study area who are involved in managing various natural resources in the Mt. Elgon ecosystem. The primary agencies identified by household heads, government officials and civil society respondents included the Kenya Forest Service (KFS), Water Resources Authority (WRA), Kenya Tourism Board (KTB), National Lands Commission (NLC) National Environment Management Authority (NEMA), Water Towers Agency (WTA), County Government of Trans Nzoia and the Ministry of Interior Coordination of National Government (**Table 4.33**).

Table 4.33: Institutions managing Natural Resources in Mt. Elgon Ecosystem

Institution	Role in Mt. Elgon Ecosystem
KFS	Management of Forest resources
KWS	Management of wildlife resources
WTA	Management of Kenya's Water towers
WRA	Management of Kenya's water catchment areas
NEMA	Coordination and supervision over all matters related to environmental conservation
KTB	Promoting tourism to Kenya's tourism attraction sites
NLC	Administration of land in Kenya

Household questionnaire responses revealed that the community advocates for collaborative management of natural resources (47.7%) as opposed to sectoral management

regimes **(Table 4.34)**. Key informant interviews and FGDs revealed that there is a diversity of natural resources in the ecosystem that fall in different habitats of the same ecosystem but these resources are interconnected. Key informant and Focus Group Discussions added that this why they advocate for collaborative management.

Table 4.34: Household view on the best placed institution to manage natural resources in the Mt. Elgon ecosystem

Institution	Frequency	Percent
Provincial Administration	15	3.7
KFS	53	13.1
WRMA	8	2.0
NEMA	58	14.3
KWS	66	16.3
Co-management	193	47.7
None of the above	12	3.0
Total	**405**	**100.0**

Findings pointed out that cumulatively, 77% of the respondents are concerned by the uncoordinated approach in managing the ecosystem's natural resources. This they note has immensely contributed to the degradation of the culprit resources and thus affecting their livelihood sources **(Table 4. 35)**.

Table 4.35: Household opinion on management of ecosystem resources

There is poor coordination in the management of natural resources	Frequency	Percent
Strongly Agree	160	39.5
Agree	152	37.5
Don't know	35	8.6
Disagree	46	11.4
Strongly disagree	12	3.0
Total	**405**	**100.0**

All interviewees conclude that the various sectoral agencies mandated to manage and develop the various natural resources within the Mt. Elgon Ecosystem lacks an effective coordination mechanism. This they add has led to over-exploitation and degradation of these livelihood supporting resources. FGDs observed that Mt. Elgon forest has deteriorated in terms of cover, composition, and health and yet the requisite technical expertise is represented in the study area.

The study elicited responses from government and civil society actors on how they rate the natural resource inter-agency conservation efforts in the study area (**Table 4.36)**.

Table 4.36: Government and civil society view on Inter-agency Consultation during goal setting

		Interagency consultation during goal setting		Total
		Yes	No	
Position in institution	Senior management	4	1	5
	Middle management	9	8	17
	Lower management	6	8	14
	Other	4	1	5
Total		**23**	**18**	**41**

Data analysis revealed that 32% of the respondents have not seen nor heard about joint consultative meetings while 26.7% of the respondents reported that meetings took place yearly (**Table 4.37**).

Table 4.37: Household view on inter-sectoral ecosystem management meetings

Frequency of inter-sectoral meetings	Frequency	Percent
Weekly	6	1.5
Monthly	43	10.6
Bi-monthly	11	2.7
Quarterly	107	26.4
Yearly	108	26.7
Never	130	32.1
Total	**405**	**100.0**

4.5.4 Natural resource management policies

The government and civil society respondents pointed out the policies that are relevant to the management of natural resources in the Mt. Elgon. These are; the Environment policy (2013), Water policy, Wildlife policy (2014), Land policy, Agriculture policy and the Tourism policy.

Responses from 73.2% of government and civil society respondents have observed disharmony amongst the existing sectoral natural resource policies (**Table 4.38)** in the Mt. Elgon ecosystem whereas 26.8% are of the contrary opinion.

Table 4.38: Presence of Inter-agency Policy inconsistencies

Presence of inter-sectoral conflicts	Frequency	Percent
Yes	30	73.2
No	11	26.8
Total	**41**	**100.0**

4.5.5 Stakeholder and Institutional Participation

This study established that there are a number of stakeholders involved in the development and management of natural resources in the study area. They include Water Resources Authority (WRA), Kenya Forest Service (KFS), Kenya Wildlife Service (KWS), National

Land Commission (NLC), Ministry of Interior and Coordination of National Government, Kenya Tourism Board (KTB), National Museums of Kenya (NMK), Local investors, Local and International NGOs, and the local community. The types of roles they play were identified as regulatory (4%), service provision (16%), advisory (14%), oversight (6%) and partnering (1%) (**Figure 4.11)**.

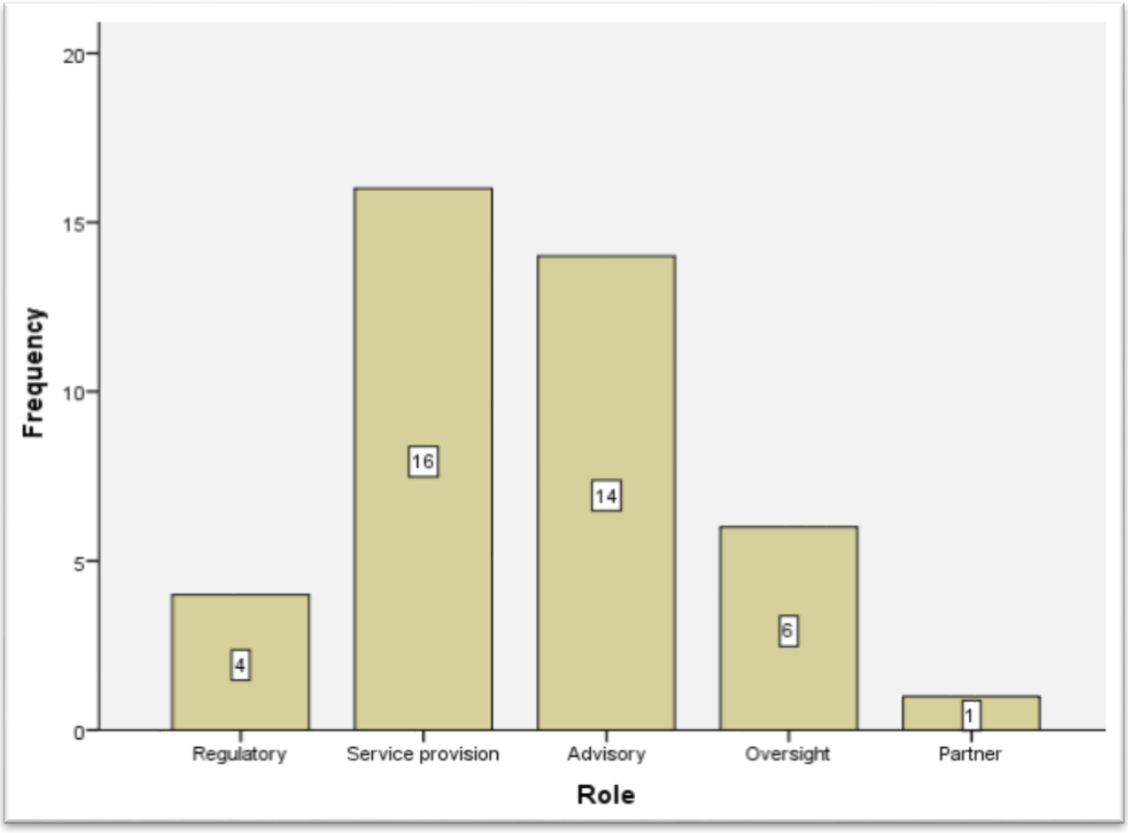

Figure 4.11: Role played by various stakeholders in Mt. Elgon Ecosystem

4.5.6 Recognition of Ecosystem Values

In total, of 86.7% of the household respondents interviewed indicated that Mt. Elgon Ecosystem is very important in the provision of various goods that support their livelihoods (**Table 4.39**). The goods mentioned included food (including game meat, roots, seeds, nuts

and other fruit, spices, fodder), fibre (including wood, textiles) and medicinal and cosmetic products (including aromatic plants, pigments).

Table 4.39: Household perception on provisioning role of Mt. Elgon Ecosystem

Mt Elgon ecosystem offers provisioning services	Frequency	Percent
Strongly Agree	251	62.0
Agree	108	26.7
Don't know	18	4.4
Disagree	12	3.0
Strongly disagree	16	4.0
Total	**405**	**100.0**

Majority of the respondents (90.37%) view the Mt. Elgon Ecosystem as being important in offering regulating services (**Figure 4.12**). Among such services mentioned in the FGDs and Key informant interviews are carbon sequestration, micro-climate and water regulation, and protection from natural hazards such as floods, water and air purification, and disease and pest regulation.

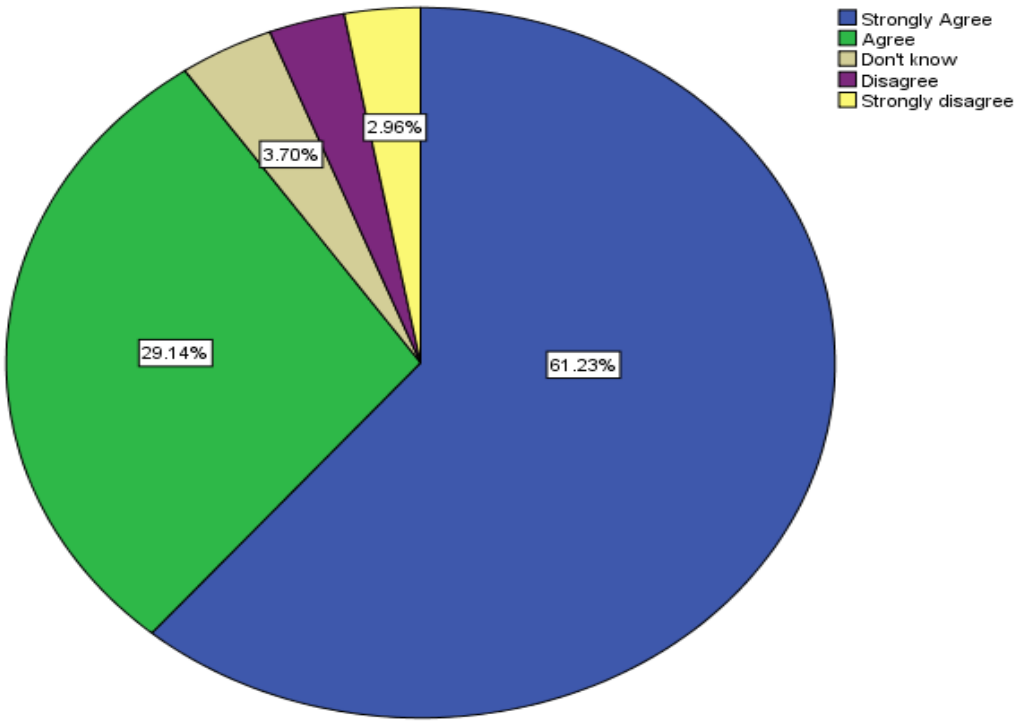

Figure 4.12: Perception of residents on the regulating roles of Mt. Elgon Ecosystem

Household respondents (80.49%) reported that the Mt. Elgon ecosystem is important in offering support services such as soil formation, primary (through photosynthesis) and secondary production, and nutrient cycling (F**igure 4.13)**.

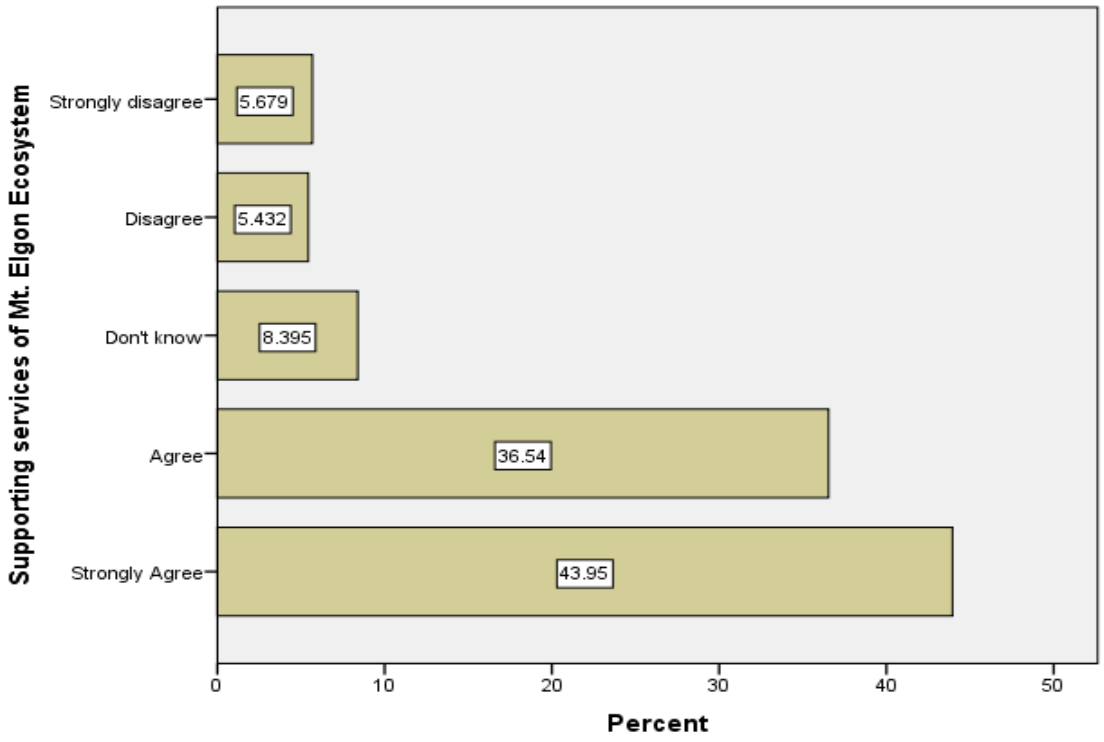

Figure 4.13: Supporting services offered by the Mt. Elgon ecosystem

Majority (81.7%) of respondents reported that they have some strong cultural and spiritual attachment to Mt. Elgon ecosystem (**Table 4.40**). Among the cultural importance attached to the ecosystem include provision of shrines, caves, and places for traditional ceremonies, myths associated with the mountain and the forest, and ancestral home to Sabaot sub-tribe.

Table 4.40: Perception on the cultural and spiritual importance of Mt. Elgon

Mt Elgon ecosystem offers provisioning services	Frequency	Percent
Strongly Agree	201	49.6
Agree	130	32.1
Don't know	29	7.2
Disagree	21	5.2
Strongly disagree	24	5.9
Total	**405**	**100.0**

4.6 Challenges to EbA in Mt. Elgon

4.6.1 Indistinct Ecosystem Management Context

Government and Civil Society respondents observed the sectoral approach (63.4%) as the main natural resource management strategy of in the Mt. Elgon ecosystem. This is followed by a collaborative approach at 26.9%, and lastly by the County Government of Trans Nzoia **(Table 4.41**).

Table 4.41: Management Approach of Natural Resources in Mt. Elgon Ecosystem

Who manages natural resources in Mt. Elgon ecosystem	Frequency	Percent
Line Ministry	26	63.4
County Government	4	9.8
Co-management	4	9.8
All above	7	17.1
Total	**41**	**100.0**

4.6.2 Atonality in Goals and Targets

This study elicited response on their perception on the existence of collaborative planning and target setting. Cumulatively, 72.1% of the respondents report that they have not noticed efforts geared towards joint collaborative goal setting with only 9.1% reporting that they have noticed it **(Table 4.42)**.

Table 4.42: Perception on collaborative setting of goals and targets for ecosystem conservation

There is joint setting of conservation goals	Frequency	Percent
Strongly Agree	13	3.2
Agree	24	5.9
Don't know	76	18.8
Disagree	129	31.9
Strongly disagree	163	40.2
Total	**405**	**100.0**

Resource users drawn from the community and who participated in the FGDs reported that lead sectoral agencies set their sectoral panning and setting of targets. Experts from other government departments together with private sector respondents indicated that there is no meaningful collaborative planning and target setting **(Table 4. 43).**

Table 4.43: Interagency consultation during goal setting

Notable consultation	Frequency	Percent
Inadequate	23	56.1
Adequate	18	43.9
Total	**41**	**100.0**

4.6.3 Discordant Management Strategies

A total of 73.09% of the respondents indicated that collaborative setting of ecosystem management rules does not exist among the various lead agencies working in the Mt. Elgon ecosystem **(Figure 4.14).** This is against 8.64% of the respondents who believe that there is joint collaborative setting of management rules and regulations.

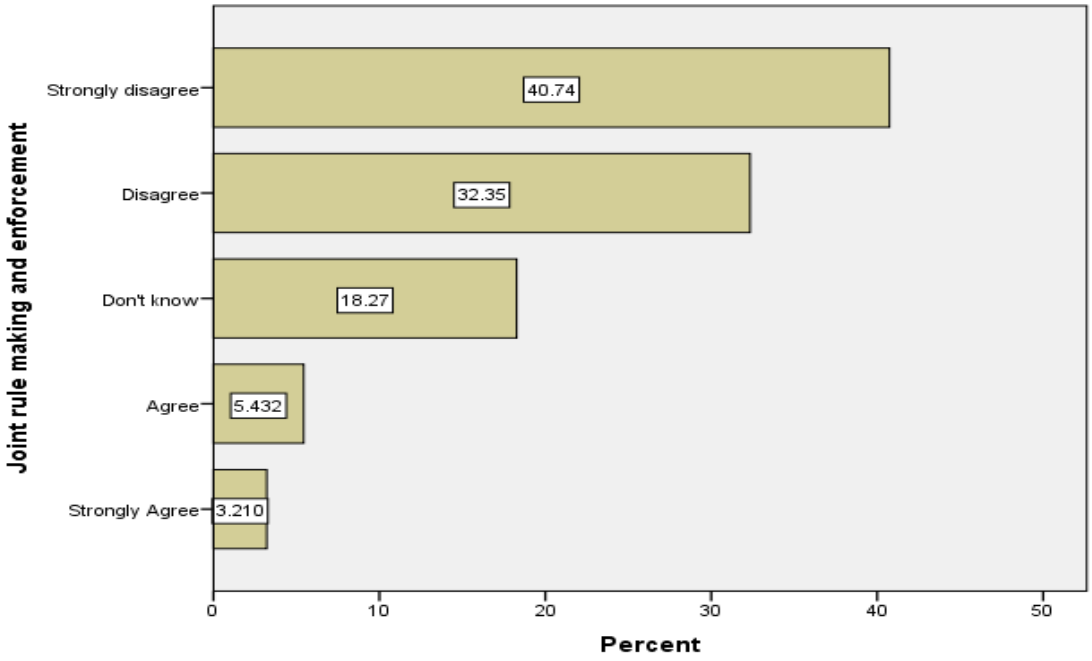

Figure 4.14: Households' Perception on collaborative setting of Ecosystem management rules

4.6.4 Uncoordinated Compliance Mechanisms

Key informant interviews indicated that compliance guidelines are in most cases developed sectorally with little or no input at all from other players in ecosystem management and conservation. This they attributed to financial resource constraints. Household respondents (72.60%) reported that they are no fully involved in the development of ecosystem rules and that there are no clear enforcement procedures of conservation rules in the study area (**Figure 4.15**). **Plate 4.3** illustrates the conflicting interests in the management of riparian area within Saboti Sub County in the study area.

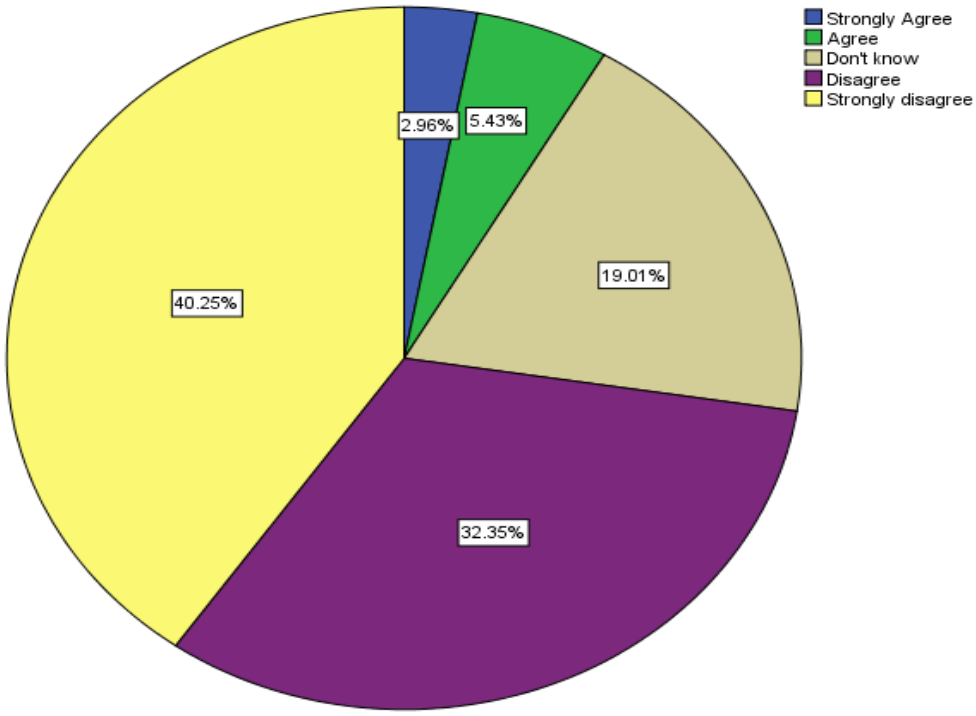

Figure 4.15: Perception on existence of collaborative development of compliance mechanisms.

Plate: 4.3: Conflicting sectoral objectives leading to riverine destruction in Kiminini subcounty (Source : Author, 2019)

4.6.5 Inadequate Education and Outreach Programs

A range of communication media and techniques are supposed to be identified to pass conservation message to the target groups. 72.4% of the household responses indicated that awareness programmes are inadequate (**Table 4.44**).

Table 4.44: Perception on Ecosystem management and conservation in Mt. Elgon Ecosystem

There is regular awareness on conservation	Frequency	Percent
Strongly Agree	13	3.2
Agree	24	5.9
Don't know	75	18.5
Disagree	129	31.9
Strongly disagree	164	40.5
Total	**405**	**100.0**

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Climate Change Related Vulnerability in Mt. Elgon Ecosystem

5.1.1 Food Security in Mt. Elgon Ecosystem

a) Crop diversification and food security

Maize is a staple food owing to the food preferences in the Mt. Elgon ecosystem. It is widely grown across the region as the most preferred food and cash crop. Due to widespread cultivation of this crop, Trans Nzoia County has been baptized as the "food basket" of Kenya (GoK, 2013). The adequacy of this crop determines how food secure the Mt. Elgon region is at any one given moment. In the event of a short supply occasioned by the effects of climate change, most households will have limited choices of other food stuffs and will be considered to be food insecure.

Maize production among other crops grown in the study area relies on rain-fed agricultural systems that are heavily influenced by the prevailing climatic fluctuations. This implies that the production of this staple food is exposed to climate related hazards and uncertainties. These changing climatic attributes expose the resident to the effects of climate change. The common climatic uncertainties that may affect the production of this crop include; variability in precipitation, temperature fluctuations, extremities in events such as drought and flood, and emergence of new crop pests and diseases.

Vulnerability of food security to the effects of climate change has been associated with local consumers whose food security depends primarily on regionally produced food

(Wang et al., 2010; Füssel, 2010). The overreliance and directing of more production efforts to this locally produced staple food (maize) is likely to as well expose the residents of the study area to the effects of climate change. The community has not seized the physiographic opportunities that promote crop diversification. Sugarcane farming and cultivation of other emerging crops can also do well in this eco-climatic zone. If adopted, it can help to cushion residents against the deleterious effects of climate change. It is expected that attaining a higher education can trigger crop farming diversify. However, it was observed that individuals with education to the level of tertiary level still prefer and have a strong bias towards maize farming just as those with basic education. This study finding contradicts O'Brien et al. (2011) who observed that the level of education may largely determine the way farmers acknowledge scientific information in making agri-business decisions that often lead to diversification. He observes that in studies which have included education level as a measure of coping capacity, adaptation practices are often found to be positively associated with education.

Maize farming is being practiced by all ages of respondents yet the prevalence of food poverty is 62 percent in the study area. This has been associated with the majority of the residents owning small parcels of land while a considerable number is landless. Bucciol et al. (2014) notes that socio-economic characteristic of respondents such as age; gender, marital status, occupation, social status inherited from parents and, education level define the social identity of an individual. The same researchers further reported that this social identity is a crucial factor that influences both magnitude of adverse impact from climate change and response capacity. They observe that an individual's perception of risk of information and self-efficacy often reflect how they see themselves in terms of group

membership. Herrero (2009) observes that in addition to impacts on food availability, climate variability can strongly affect the stability of food supplies and the ability of vulnerable people to access food at affordable prices. This may further lead to critical effects on food security.

b) Livestock Diversification and food security

It was observed that alongside crop farming, most households practiced livestock farming too. It was observed however that households preferred rearing of the exotic Friesian dairy breed to other local breeds. The reason advanced for this practice is the perceived higher milk yields that are achieved by this dairy breed as compared to other dairy animals. According to the Government and civil society respondents, this idea of integrated farming aims at enhancing food security in the study area. They add that Mt Elgon ecosystem has a huge potential of supporting other livestock such as donkeys, pigs and, fish. The community is therefore being encouraged to move away from this narrow range of farming and venture into other viable livestock enterprises that are suitable for the region.

Ayambila et al.(2016) observes that rearing of livestock as security against crop failure is common with farmers who are vulnerable to the effects of climate change. However, the narrow range of livestock animals reared by the community in the study area is likely to be detrimental. It is worth noting that even as farmers strive to improve the food security situation through mixed agriculture, knowledge that various livestock respond differently to extreme climatic perturbation will prove to be of benefit. Consequently, the bias towards the Friesian breed will expose the residents more to the effects of climate change. Campbell et al. (2016), observes that improved exotic livestock breeds are more vulnerable than the indigenous breeds. Herrero et al. (2009), notes too that most livestock keepers in

the developing world will be affected by variability of the weather patterns and that the experience is projected to increase. He attributes this to new pathogens and diseases that are already emerging and spreading due to climate change and variability. As a measure to counter this, most reviewed studies now advocate for diversification of livestock animals (within breeds) in situations similar with the study area.

A nutritional deficiency situation is likely to arise in the study area. Dairy products are known to be suppliers of global calories, proteins, and essential micronutrients (FAO, 2011). As the population of people in the study area increases under the narrow range of livestock rearing regimes that are further threatened by vulnerability to climate change, the supply of these nutritional requirements are under threat. The inter-censal population growth rate for Trans Nzoia was 3.7 percent between 1999 and 2009 which is above the national average of 3.0 percent (GoK, 2013). Assuming the growth rate is maintained, the population for the county is expected to increase from 949,359 persons in 2013 of which 472,121 are male and 477,238 are female to 1,100,794 by 2017 by 2050 (GoK, 2010). This implies that there will be an increased demand for livestock products, and by extension the nutritional security in the study area. To avert this likely nutritional crisis situation that can result from effects of climate change, adoption of livestock diversification is recommended as advised by FAO (2011).

There are some useful lessons related to livestock rearing that can help in reducing vulnerability to climate change in the study area. The more diversified the livestock are in a region, the wider the range of livestock products leading to reduced vulnerability to food insecurity. This is because there will be access to a broad livelihood choice by a community leading to a reduction of their vulnerability to climate change impacts.

Herrero et al. *(op cit*) further reports that, shifts in Livestock production systems towards mixed crop livestock systems can also reduce agricultural adaptation costs from 3% to 0.3% of total production costs. This may involve using different crop varieties, and shifting to mixed crop-livestock systems. This has the potential of reducing tropical deforestation by about 76 million ha globally.

Moreover, an integration of livestock and crop production is likely to be more resilient to climate extremes due to greater system and income diversity. As an additional adaptation strategy to enhance food security, farmers can opt to rearing livestock on land that is difficult in supporting crops. Other notable livestock farming practice that is worth embracing is the feeding of livestock with food that is not appropriate for human consumption and in return the animals providing manure to boost crop production.

5.1.2 Income diversity

The agricultural sector emerged as the single largest source of income that supports several homesteads in the Mt. Elgon region. This research established that most of those in formal employment and are earning regular wages were actually working in the agricultural sector establishments. Notable institutions in the sector that contribute significantly to the livelihoods of the community include Kenya Seed Company (KSC), Agricultural Development Corporation (ADC), Educational facilities and flower farms. These institutions have drawn a majority of their workforce from the study area and in returns reward them with a regular income that supports its livelihood. All these employees are in the agricultural sector value chains and facilities. These findings point out that the agricultural share of total labor force in the study area and associated income is big

Study findings point out to lack of diversification in income sources in the study area with crop farming being relied upon by respondents of all ages and regardless of an individual's academic qualification. There is an over-reliance on limited economic livelihood options in the Mt. Elgon ecosystem. Herrero et al. (2010) observes that diversification of income sources can help in cushioning households against the negative effects of climate change and lack of the same is an important socio-economic exposure to the effects of climate change.

The agricultural sector in the area relies on rain-fed technologies which are equally vulnerable to climate change. Respondents drawn from government departments pointed out some instances where crops have failed due to climate related factors such as hailstone occurrences. Ludena et al. (2015) reports that variability of farm and non-farm income occasioned by climate change impacts as one of the important determinant of local vulnerability. This then calls for the need to avoid overreliance on climate dependent agriculture and its income sources arguably because they can have direct negative effect on the income streams associated with it should the area be faced with climatic extremities. This has been cited as by the government and civil society organizations as being the leading cause of poverty in the study area.

Records (GoK, 2015) that Kwanza and Endebess which are predominantly maize growing areas have poverty levels of 46.4% and 46.5% respectively. Key informant interviews and focus group discussion revealed that women, the unemployed youth, widows, orphans, neglected retired old people, the street families and those living in the more marginal areas of the study area are the vulnerable groups that are hardest hit by poverty; a situation which has been associated with a narrow range of income sources. Livelihood in the study area is

influenced by agriculture. Adger et al. (2014) has observed that dependency on income from agriculture is an important aspect of vulnerability and is caused by reliance on. Such dependency may often lead to social and economic stresses. He further argues that there are links between poverty and lack of diversification of livelihood activities by the farmers and thus increasing poverty. Income-poverty tends to constrain people's ability to adapt to negative impacts, to seek treatment and to withstand disease. Haque et al. (2007) reports that families which have lower income and less access to productive natural assets face higher exposure to risk of climate change effects.

To address this problem in the Mt. Elgon ecosystem, diversification of income opportunities need to be explored. Herrero *(op cit)* strongly advocates for the broadening of income-generating opportunities by vulnerable groups especially with the imminent threats of climate change and its impacts. Gender inequality which was also singled out as a common phenomenon in the county draws its strength from the deeply rooted cultural and traditional values. Women are disadvantaged in terms of access and ownership to resources, as well as in decision-making over land use matters. They lack exposure as they do not attend development meetings. Extension services too regarding diversification of income options hardly reach them despite the fact that they perform most of the duties at the farm level.

5.1.3 Land size and Land tenure systems

It was established that most households in the study area own an average of 2.5 acres of land with a few of those with a higher education owning land of over 10 acres. Field observations show that farm sizes are larger in Endebess and Saboti sub counties; though there are pockets of small scale freehold land holdings that range from 1 to 5 acres. Maize

farming dominated in farms irrespective of size of land owned. Another observation was that those with large farms had invested in large livestock feed stores, hay production and storage, irrigation, mechanized farming and even weather monitoring sub-stations. It was observed that houses that were on freehold land tenure system were of better quality than those under other less secure land tenure systems.

According to Stolton and Redford (2014), a combination of the tenure systems can present forth both opportunities and constraints to adaptation to climate change impacts. Land size and tenure in the study area seemed to influence the climate change adaptation investments that individuals put in place on a farm. Those in large farms with secure land ownership regimes had put up climate proofing investments such as water pans, irrigation kits, and large-scale mechanized agriculture. Land size and tenure was associated too with the type and magnitude of agricultural activities that farmers ventured into with those owning large farms going for mechanized commercial large scale farming, while those with smaller parcels of land settled for subsistence farming.

The percentage of persons with title deeds in the county is 45 percent and can therefore get credit against their land as collateral to improve their lands (GoK, 2013). The remaining 55 percent of residents have no title deeds. Those who get collateral are able to make investments which can contain measures to cushion their livelihoods against the effects of climate change. It was however observed that capital investments undertaken by entrepreneurs in large scale farm holdings that are under freehold ownership regimes were higher as compared to those with less secure ownership regimes. One notable issue with freehold land ownership regime was that it is often difficult to enforce land use regulations. Land degradation was noted in some farms that had freehold ownership in the study area.

This was attributed to uncontrolled user rights that are associated with this tenure. This can eventually lead to increased vulnerability to climate change impacts.

Trans Nzoia County has a land tenure system such that there is trust land and leasehold of 99 years in urban centers (GoK, 2013). There is also leasehold tenure in the rural parts of the county where Africans bought the large farms owned by the White Settlers. In some other situations investors have leased land from individuals with large tracts of unused land. In such leased farms there are no capital investments on them. They lack farm infrastructure such as access roads, farm houses and store, soil and water conservation infrastructure, durable fencing, and water storage and irrigation structures. FGDs revealed that households were found to be less willing to invest in farmlands with less secure ownership arrangements. In the absence of assured long-term ownership, households are not willing to invest in climate proofing investments and thus increasing vulnerability to climate change impacts.

Land tenure is a sensitive issue to discuss and most people in the study area feel uncomfortable to talk about it (Egis, 2015). One reason for this is that several people have not finished paying the Government of Kenya for their land parcels and fear they might lose them. The other reason is that the effect of the ethnic clashes has made them develop fear on how permanent their settlement in this place is. There were reported past instances of landlessness in the County due to rampant cattle rustling and internal displacement of persons arising from the 2007 post-election violence. This led to displacement of people in parts of Chepchoina in Kwanza sub County. The incident triggered the settlement of squatters in and around areas perceived to be secured such as in ADC farms. The squatters get their livelihoods by farming in the riparian areas and by farming in the peripheries of

the Mt. Elgon forest often affecting the ability of the ecosystem to buffer the community against climate change effects.

It was observed that those who suffer from insecurity and insecure land tenure often have restricted rights to use of land. They therefore achieve limited success in improving their livelihoods. In the study area it was observed that there seemed to be a relationship between land tenure security and access to housing, and improved living and environmental conditions. This could be because farmers are reluctant to put up permanent structures in form of houses or even plant trees. This eventually exposes them to the effects of climate change. This to a larger extent influences the scale of agricultural production which in turn has a positive effect in reducing vulnerability to climate change.

In the less secure tenure system of communal land ownership and untitled parcels of land, people had put up temporary housing consisting of grass thatched with mud walled housing. This type of insecure ownership was observed in the neighborhood of the gazetted Mt. Elgon forest, Mt. Elgon National Park and at the controversial Chepchoina Settlement scheme. The community in this area has not invested in weather friendly houses nor have they embraced mechanized farming. With such simple housing structures, households have done limited improvements such as connecting them to the electricity energy grid. The housing structures are also prone to vagaries of nature such as flooding and strong winds. These enhance the residents' vulnerability to climate change impacts.

As observed by Nyametso (2012), land tenure can be a key factor in residents' ability to access better housing, improved standards of living and environmental conditions. FAO (2012) also reports that access to secure land and housing is a precondition to reducing

poverty and vulnerability to vagaries of nature. The implication is that, inaccessibility to decent, secure, affordable land in the study area exposes most households to health related complications occasioned by extremes in climatic factors. A similar study by Kataria et al. (2012 reports that land tenure can have a significant influence on investment decisions in fixed assets at farm level. The study findings further show that fixed assets of farmers including physical capital are significant economic components that can influence a locality's vulnerability to climate change impacts. The fixed investments cited include soil quality, land, agricultural machinery and agricultural infrastructure such as roads. Land tenure and size influences the scale of adaptation investment decisions besides affecting the value of the physical capital of which may cause its fluctuations over time (Ayamga et al., 2016).

Another significant observation was that households in the study area are less willing to invest in adaptation projects on farmlands which they received as gifts (gifted land). This was especially so for a land transfer transaction that they had not formally documented.

Addressing land tenure issues in the study area is important in seizing the opportunities and minimizing the risks involved in agricultural investments and ensuring that a farmer will be able to reap the full reward of any investment. A farmer considering investment balances its cost against the expected future benefits generated by the investment; otherwise worthwhile adaptation investments will therefore not be made if those expected benefits fall. HLPE (2011) reports that secure land ownership rights attracts significant economies of scale in the subsequent processing and marketing while playing important roles in generating food, employment and livelihoods that can significantly boost the adaptation agenda. It adds that, farming in sub-Saharan Africa which typically takes place

on small plots cultivated by individuals requires serious agricultural investment to raise yields as a means to improve food security. This calls for urgent action to streamline land tenure and property rights which affect the application of technologies for agricultural and natural resource management. A secured property rights regime and sufficient incentives to the farmers therefore must be assured in order to increase their efficiencies in productivity while ensuring environmental sustainability.

Tenaw (2009) observes that it is natural that without secured property rights farmers do not feel emotionally attached to the land they cultivate and do not invest in land development. Consequently, they will not use inputs efficiently nor will they put up the relatively costly climate proofing investments. The result is increased exposure to the effects of climate change. Awudu et al. *(*2010) too reports that tenure largely influences the investment decisions on land and that most investors prefer to invest in freehold and long-term land lease arrangements.

5.1.4 Household Energy Sources and Vulnerability

Study findings point to an overreliance on wood fuel as a source of household energy mainly for cooking but also for lighting in some homesteads. Other notable energy sources include LPG, gasoline, solar energy, biogas and electricity. Solar energy, biogas and natural gas belong to clean energy because of little emissions whereas gasoline and biomass energy belong to dirty energy due to producing large amounts of emissions. Petroleum products are also used but mainly used in the transport sector; although products like kerosene are is consumed in great quantities by the households. These products are readily available in the markets. Focused group discussions pointed out that energy sources like wind and solar are not fully utilized despite the key informant interview revealing that there

is a huge potential for their exploitation in the study area. The main hindrance to their exploitation is the lack of appropriate technology, lack of sensitization and poor marketing of the technologies especially in the rural interior.

The Mt. Elgon forest is the main source of biomass energy not only to the forest adjacent communities but also to the residents of the commercial and urban areas of Trans Nzoia County such as Kitale, Endebess, Kwanza, and Kiminini. It was revealed that as much as forest exploitation by the forest adjacent communities is beneficial, it equally has negative implications on the environment if it is not exploited sustainably. Uncontrolled extraction continues to endanger the livelihoods of the forest dependent communities by exposing them to the effects of climate change. The ecological services such as recharge of rivers and streams emanating from the forest were cited by households as some of the notable negative impacts arising from the unsustainable exploitation of the forest.

The rationale for conducting an analysis of household energy use was informed by the fact that energy is an essential material basis for a society's economic and social development and that depending on the type of energy used by households, vulnerability to the effects of climate change may vary. High biomass consumption is a contributor to climate change, environmental pollution and deterioration of human health. Kenya Integrated Household and Budget Survey 2005/2006 report (KNBS, 2007) indicate that 70.4 percent of the households in Trans Nzoia County use firewood for cooking, 18.4% use charcoal, 4.9% use paraffin, 3.7% use biogas residue, 0.8% use gas and 0.9% of the households use electricity. Another 1% uses other sources of energy for cooking. The figures clearly indicate that majority of the residents use non-renewable sources of energy for lighting and cooking fuel. It cites wood fuel as being the biggest type of energy used for lighting and

heating. The same County intends to increase her forest cover in the foreseeable future. This is a development challenge that needs to be addressed before it worsens ecosystem degradation leading to increased vulnerability to climate change effects.

Going by the WHO (2017) report, the reliance on wood in the study area as a main source of household energy can put considerable pressure on Mt. Elgon forest and other smaller forests in the study area. The situation is likely to be worse in areas that that have a relatively dense population yet fuel wood demand outweighs natural re-growth. This can lead to forest degradation which may result in loss of habitat and biodiversity. This will eventually lead to increased vulnerability to the effects of climate change. Haines et al. (2007) reports that impending climate change; partially driven by energy use, now threatens human health. He observes that there is need for policies that prevent dangerous anthropogenic interference with the climate while addressing the energy needs of disadvantaged people.

5.1.5 Access to Healthcare

The study adopted an approach whereby both the *ex-ante* analysis of the household's level of preparedness for health events and the *ex-post* analysis of the availability of community-level support and disaster relief are conducted in order to identify the adaptation mechanisms to deal with human health cases. To achieve this, just like in other similar studies (RHIH, 2017), this research adopted simple traditional measurements of the average of a household distance from to the nearest health facility and the availability of transportation besides the affordability of health-care costs. It emerged that household members travel slightly longer distances in order to receive proper medical attention. This

situation is further complicated by the bad state of the roads that characterize the Mt. Elgon region's road infrastructure.

Availability of medical facilities within a reasonable distance largely influences the mortality rates in a given human population. Distance and effective mode of transport to healthcare facility can greatly reduce mortality cases. People who face the highest risk of accessing healthcare are those that are least well prepared rural communities, both in terms of household-level *ex-ante* preparedness and community-level *ex-post* medical relief. Respondents linked the increased mortality to extreme weather events which provide limited transport options to hospitals. This led to delayed access to healthcare resulting to unnecessary loss of life. FGDs revealed that there is poor overall health in rural communities when compared to urban populations. Other rural risk factors for health that were mentioned include geographic isolation of some areas, lower socio-economic status, higher rates of health risk behaviors, poor state of public roads and limited job opportunities.

It was also established that services available in rural areas are less likely to include specialized and highly sophisticated or high-intensity care. This coupled with long distance to medical facilities prohibits timely access of healthcare services by people requiring higher level of care. For some services, such as emergency medical services, the lower level of care available in rural areas, when added to the delayed time to access the services caused by distance, can be the difference between life and death. These challenges on the access to healthcare services expose the residents of the study area to vulnerability to climate change effects. It was also observed that there are older and poorer who are

uninsured population in the rural areas of the study area. This coupled with rural populations who do not adopt positive health behavior, has implications on mortality.

Shortages of healthcare workforce are another area of concern that was highlighted by the focus group discussion. Very few physicians and surgeons would prefer to practice in rural settings. Individuals who are older, poorer and are vulnerable in these rural areas where medical attention is inadequate will therefore miss their services. Further revealed was the fact that health services available in rural areas are less likely to include specialized and highly sophisticated or high-intensity care. For some services, such as emergency medical services, the lower level of care available, when added to the increased time to access the services caused by distance, can be the difference between life or death. These challenges on the access to healthcare services expose the residents of the study area to vulnerability to the effects of climate change.

According to the Kenya National Housing and Economic Survey (KNBS, 2015), rural informal sector populations who have a higher rate of low to moderate income, are less likely to have employer-sponsored insurance coverage, and are more not likely to have any form of public health insurance. Rural residents who are more likely to be unemployed, have lower rates of post-secondary education, and have lower median household incomes than urban residents. Research has shown that these and other social determinants of health have a significant effect on healthcare status. Climate change impacts exacerbate this problem by making roads inaccessible and by also causing delayed access to the healthcare centers.

Moraa et al. (2012), points out that poor access to health care often results in delayed access to a health facility and that it is a key determinant of mortality in children under 5 years of age in developing countries. The findings about the higher vulnerability of rural populations are consistent with studies conducted by Rutherford et al., (2009) who points that transportation to healthcare facilities are a barrier to accessing timely healthcare due to long distances, poor road conditions, and the limited availability of public transportation options in rural areas. The author further observes that a longer distance of more than 3km to travel to reach the health facility at a cost of more than one (1) US dollar were significantly associated with child death. This research concludes that rural dwellers have a significantly greater likelihood of death than urban dwellers.

5.1.6 Conflict Prevalence and Vulnerability to Climate Change

The study found out that most families felt insecure and are unable to undertake long-term investments for fear of incurring huge loses should cases of insecurity arise. Key informant and FGDs revealed that security issues have influenced the local economic development and poverty levels within the Mt Elgon ecosystem. The reported forms of conflicts involved burning down of property, cattle rustling, loss of life, destruction of crops and rape. There have been incidents of the indigenous Sabaot tribe having conflicts with the immigrant tribes.

The link between conflict prevalence and vulnerability to climate change impacts is due to the fact that the scarcity of natural resources has the potential of triggering competition for the available meager resources among individuals, communities, and even institutions. The resulting rivalry for these declining resources has impaired human security and disrupted the existing adaptation strategies in the study area. It was observed that most inhabitants

were reluctant to engage themselves in long-term investments that could have cushioned them against the impacts of climate change for fear of incurring loses should similar insecurity issues arise. Conflict preference has also influenced the pace of economic growth, labor market dynamics, and demographic fluctuations in the Mt. Elgon ecosystem. This has worsened an already vulnerable state of the local community and thus making them more susceptible to the effects of climate change.

Historical analysis of the major tribes, culture, their livelihoods, and the political landscape, attempts to bring out the possible triggers of insecurity in the study area. Adger et al. (2014) report that the presence of conflict in any given area restricts the ability of individuals to adapt to climate change. Wanjiru (2015) and Adger et al. (*op cit*) also observe that human populations who are already socially marginalized through frequent conflicts, resource dependent, and have limited capital assets, will often feel humanly insecure and their efforts to adapt will progressively be undermined as the climate changes. Security studies by Adger et al. (2014) points out that the interaction of climate change with other types of stressors may significantly interrupt coping strategies.

O'Brien and Leichenko (2009) observe that human security is closely linked to the development of human capabilities in the face of change and uncertainty. Individuals and communities who are faced with both rapid change and increasing uncertainty are challenged to respond to climate change effects. They may be prevented from coming with new ways that protect their social, environmental, and human rights. They are often unable to empower themselves to respond to this challenge through both mitigation and adaptation. Hunger, malnutrition, disease, and homelessness are the outcomes of insecurity. Adger et al. (*op cit)* opines that human insecurity undermines livelihoods,

compromises culture and individual identity, increases migration that people would rather have avoided, and that it can further undermine the ability of states to provide the conditions necessary for adaptation to climate change.

5.2 Current Climate Change Adaptation Interventions

5.2.1 Climate change in Mt. Elgon ecosystem

Majority of respondents are of the strong opinion that the climate of the Mt. Elgon area has changed. This is based on the changes that they have observed in the change in rainfall characteristics, frequency of dry spells, experiencing of unusual climatic attributes such as hailstorms, lightening, and unpredictability of weather patterns. This they say has had some implication on the quality and quantity of the Mt. Elgon ecosystem goods and services and thus impacted negatively on their livelihoods. According to the respondents, this change has negatively exposed them to the effects of climate change.

5.2.2 Climate Change Adaptation Interventions

The Government of Kenya and other development partners have initiated climate change adaptation programmes and projects in the study area. These projects were identified as hand dug wells, boreholes, water pans, micro-irrigation schemes, flood control structures, introduction of fast maturing crop varieties, drought tolerant crops and, the introduction of alternative crops. These are meant to cushion the residents against the effects of climate change. The adaptation projects have been initiated in the Mt. Elgon ecosystem to assist the residents to cope with the effects of climate change. It is a response to dwindling quantities and quality of ecosystem goods and services hitherto provided by the Mt. Elgon forest ecosystem. Nearly all of these initiated projects draw their adaptation strength from

the costly engineering works such as dam construction. These interventions were found to be at different stages; with some being at the formative stage and others have been completed within the Mt. Elgon Ecosystem.

It's worth noting that Ecosystem-based Adaptation advocates for the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change and not the introduction of completely new projects into an ecosystem. It encourages the sustainable management, conservation and restoration of ecosystems that takes into account anticipated vulnerability and climate change impact trends to reduce the vulnerability. It also improves the resilience of ecosystems and people to such climate change impacts. It is advisable to integrate "soft" and "hard" engineering approaches to adaptation. This will allow for the development of structural measures aimed at protecting the natural ecosystems themselves, in cases where climate impacts extend beyond their natural resilience.

FGDs and key informant interviews revealed that the "hard" engineering approaches such as water supply schemes and flood mitigation projects may be not sustainable in the long-term due to financial and technological challenges. This may eventually complicate the adaptation to climate agenda of the targeted beneficiary groups. The justification for EbA use as opposed to "hard" engineering approaches passé, supports views by Lynne et al., (2009) who advocates for the "use nature's infrastructure" first before venturing into the costly alternatives**.** In this approach, natural ecosystems will provide valuable protection and other services for free, and the beneficiary community seizes the opportunity to enhance their livelihood. In doing so, EbA promotes the maintaining and restoring nature and the associated infrastructure. The established natural setup which is less costly buffers

the community against the effects of climate change. In case the effects of climate change become more severe, it will call for situations where combination of Eba and engineering efforts will be necessary, but such activities should be done in harmony with nature and its changing patterns.

As concerns the initiation of adaptation projects, the challenge lies with the type of undertakings to support the ability of socio-ecological systems to adapt in the long run, and which ones have little or no impact. Even worse, some initiatives can eventually proof to be harmful. This has been reported by Magnan et al., (2016). Consequently, although these efforts can potentially support the adaptation agenda in the short term, there is a risk that they affect territories', sectors', and people's long-term capacity and opportunities to cope with and manage the impacts of climate change. This possibility generally describes 'maladaptation (Magnan, *op cit*). McDowell et al., (2010) also note that

> "Despite the growing efforts worldwide to adapt to climate change, there appears to be little concern about the risk of maladaptation. There is a real possibility, however, that initiatives taken in the name of adaptation might not only waste financial resources, but could also aggravate the consequences of one-off and gradual climate-related changes. In essence, maladaptation describes an action that results in an undesirable and unintended outcome(s). This leads to increased vulnerability, the action which was meant to reduce. Interestingly, there is sometimes a very fine line between success and failure vis-à-vis adaptation, and this raises a crucial question: what does the risk of maladaptation mean in reality?"

5.2.3 Public Participation in identification of Adaptation Projects

Climate change mitigation and adaptation projects have been initiated by relevant individual resource sector managers who are represented in the study area. A top-down approach has been the most preferred mode of identifying and initiating climate change adaptation projects. A focus group discussion revealed that most at times these projects do not fit into each other. Further, the project proponents do not take into account the ecosystem's interconnectedness in its functioning. This is observed especially in the manner adaptation projects are identified, designed and implemented. This implies that collection of opinion from the beneficiaries regarding the projects of choice is often limited. Further, the objectives and tasks, as well as the preferred pathways for addressing the adaptation needs, sharing of indigenous knowledge and experiences with the goal of selecting suitable alternative adaptation strategies is not explored.

Bomberg, (*op cit*) observes that public participation is an essential normative goal in formulating response to climate change risks. Its main aim is to encourage the public to have meaningful input into the decision-making process and also share their indigenous traditional knowledge and experiences (Clarke & Jupiter, *op cit).* Embracing public participation in the study area will provide a platform for communication between all the agencies that have interest in the Mt. Elgon hence arrive at informed decisions. Public involvement and promoting project ownership and support greatly determines the long term success of a project in any given setup. This is in line with observations by Bomberg, (*op cit*) who recommends that community participation is supposed to be done early in the process. This will go a long way to enhance relations with the communities in the vicinity

of the proposed development and to reduce delays in decision making. He adds that it is through inclusion that the civil society's and the public rights are exercised and projected.

Non-inclusivity in ecosystem planning coupled with limited community involvement in project identification, designing, and implementation was noted in the study area. This was noted by many stakeholders as a glaring omission that risks the ownership of the adaptation projects in the study area. In his previous studies in Mt. Elgon, Ongugo et al., (2014) also note this non-conformity in the Mt. Elgon ecosystem. He observes that such an omission can have serious negative effects in climate change adaptation strategies**.** He concludes that where sense of traditional ownership, responsibility and control of natural resources and their benefits by local communities have been ignored, any conservation effort is likely to be undermined. This make most communities to view government control and management as being negative, causing them to be indifferent to conservation initiatives that are championed by the government.

Ghai, (1994) also observes that it is now internationally recognized that greater community participation in natural resource management can contribute to reduced over-exploitation and degradation of natural resources. Conservation of environmental resources can only be successful if the social factors, which influence people's interaction with the environment, are addressed. These include access to the natural resources, the level of decision making processes and empowerment.

5.3 Natural Resource Governance

5.3.1 Sectoral Approach to Natural Resource Management and Ecosystem Restoration

This research revealed that ecosystem restoration activities geared towards addressing the effects of climate change in the Mt. Elgon Ecosystem often took a sectoral approach. This was associated with an old age common practice in government in which departments are used to working sectorally while enjoying the benefits of selective mandate. In this kind of setup, the departments represented in the study area lobby and direct much effort to oppose any move towards holism. In this arrangement, Mt. Elgon ecosystem restoration activities and its natural resource management has been characterized by sector fragmentation with a number of government departments managing specific resources which focus on specific uses.

It was observed that management regimes of forest, wildlife, water, and land resources in the study area are managed as single units oblivious of their inter-connectedness with each other. For all these resources, there are pieces of legislations that are fragmented at national level and cascaded down to the study area. Here different ministries have specific mandates of managing specific individual resources. Typical cascaded legislations include the Wildlife Conservation and Management Act 2013, the Forest Act 2014, the Water Act 2016, County Government Act 2012, Land Act, 2012, the Tourism Act 2011 and EMCA 1999. Different government departments therefore administer and execute mandates in protected areas, agricultural land, forest areas and water resources; all of which are in the same ecosystem and are inter-connected. This has resulted to the proliferation of

institutions and the associated problems of fragmented administration in the area and lack of coordinated planning and management.

The study findings pointing to the ineffectiveness of sectoral approach to the management of natural resources that are interdependent and are in the same ecosystem have also been observed by Morrison et al., (2004). He notes that governments regularly restructure departments in the natural resource management and environmental arena, sometimes for the purpose of improved policy integration, but most frequently to meet Ministerial and bureaucratic aspirations. He further concludes that fragmentation of policies and their implementation seriously diminishes the overall effectiveness of natural resource management programs. This implies that most climate change adaptation and ecosystem restoration initiatives that are carried out sectorally rarely achieve but rather fail to realize their objectives.

5.3.2 Sectoral Fragmentation, Biodiversity and Adaptation to Climate Change

Restoration and enhancement of biodiversity in a natural system is one of the key pillars of ecosystem-based adaptation to climate change. Biodiversity, land, air and water are the most vital natural resources bestowed in the Mt. Elgon ecosystem. These resources are of vital importance to the livelihoods of the resident community. The aim of the sectoral natural resource management is to sustainably manage and exploit locally available biodiversity. By doing this, the ecosystem resources are supposed to meet the community's livelihood needs throughout the year while conserving and enhancing its quality and quantity. Contrary to this, the management lapses associated with sectoral fragmentation of natural resource management has alarmingly continued to degrade these resources in the

study area and thereby exacerbate the exposure of the community to the effects of climate change.

Ongugo et al. (2014) also reports that sectoral fragmentation of natural resources management can also lead to serious negative impacts on resource sustainability and the livelihoods of people who depend on them. This eventually reduces the ability of these resources to cushion them against the impacts of climate change. He suggests an ecosystem management model that is robust but holistic and considers the conservation of all natural resources that fall in one ecosystem. The author's observation agrees with Morrison (2004) who opines that the problem of compartmentalization of government into departments and agencies pursuing different and often competing objectives can be detrimental to natural resource conservation. He adds that fragmentation has been termed the greatest worldwide threat to biodiversity and the primary cause of species extinction. Fragmented management of natural resources in the study area seems to be inhibiting horizontal coordination by rigorously promoting agency fiefdoms. It has also led to consistent inefficiencies in resource management while encouraging duplication of efforts besides causing contradictions and inconsistencies across policies.

Other consequences of fragmentation that may as well befall the study area are those noted by Mhlanga et al., (2014). They include the lack of continuity caused by almost constant programmatic and structural change and the loss of public confidence in both the processes of governance and government. There is also the risk of rapid shift of natural resource management policies to community-based programs without adequate funding and the requisite support. In most cases, the sectoral approach does overlook the fact that an ecosystem works as a unit. Mhlanga et al., (2014) notes that, if left uncontrolled, sector

fragmentation management approach can lead to localized overexploitation of biodiversity resources. This explains the failure of the management initiatives that have been undertaken but whose outcomes have taken much longer to be realized, albeit in an incomplete way.

Inconsistencies across policies as a result of sectoral fragmentation are clearly illustrated by rivers that traverse the ecosystem and have riverine vegetation. It is expected that the Water resource management sector, the agricultural sector, and forest management agencies work in a well-coordinated structure to ensure that such an environment is well conserved. This is because the quantity and quality of water is influenced largely by the health of the vegetation cover of the catchment and how well the riparian area is shielded against excessive cultivation. Management of the riparian area is largely within the mandate of WRA whereas forest cover enhancement in the Mt. Elgon ecosystem is spearheaded by the Kenya Forest Service. For the water to be of desirable quantity and quality, the two sectors must efficiently work together and coordinate their conservation activities.

More often than not, you find this not to be the case. Natural resources in such an ecosystem are interlinked and depend on each other. Lack of a coordinated management arrangement in such a situation can cause confusion and impact negatively on the efficient management of the natural resources a homogenous ecosystem.

Activities in the agricultural sector might lead to serious and irreversible damage to the natural resources that are managed by another sector. Interactions need attention and close monitoring so that the natural resources in question are sustained even in the long run. This

far, this research is of the strong opinion that challenges related to sustainable management of natural resources in the study area have to a larger extent arisen due to fragmented sector based management that focuses on specific uses. This has given rise to separate governance regimes for each use. The emerging paradigm of ecosystem-based management contrasts with this traditional sector based management effort with the latter being a major threat to the sustainable production of goods and services from a natural ecosystem. This will worsen the vulnerability of people to the effects of climate change.

5.3.3 Sectoral fragmentation, community livelihoods and adaptation to climate change

Clarke and Jupiter, (2010) record that natural resource management regimes largely influence the long-term provisioning of the ecosystem goods and services in light of the emerging danger of climate change and its associated effects. A management regime that is sensitive to addressing vulnerability to climate change effects must be sensitive to community needs by deliberately aiming towards promoting sustainable development. There ought to be deliberate measures aimed at finding how poor rural people can improve their living conditions and the productivity of their resource base through local interventions. Such measures must be able to contribute to local poverty alleviation and livelihood diversification through wage employment and fee revenue. This calls for approaches which must focus holistically on diverse ecological and social contexts, besides emphasizing the meaningful participation of local people in their planning and implementation.

Presence of multiple planning authorities with diverse incompatible interests seems to be a major management challenge facing Mt. Elgon Ecosystems' natural resources. It was

evident that the management approach taken by individual government sectors in the study area does not take a livelihood needs perspective of the poor community who rely on the natural resources for their livelihoods. Recent global studies have emphasized on the need for governance reforms that aim at improving natural resource management and decision-making approaches to be livelihood oriented. This should focus on decentralization of authority for managing resources and delivering services to rural beneficiary subjects (Tyler, 2006).

5.3.4 Sectoral fragmentation and community participation

It was clarified that most resource management institutions have embraced the participatory management approaches of natural resources where the individual resource user groups are identified and involved in decision making. However, this is characterized by weak coordination of other resource user groups that fall in other natural resources sectors. This is despite the fact that they are supposed to work in synergy to achieve a common goal of restoring and maintaining the natural structure of the Mt. Elgon ecosystem for the sole purpose of sustainably supplying the ecosystem goods and services to beneficiary communities. The Water Resource Users Association (WRUA) covering the Mt. Elgon ecosystem should work closely with the existing Community Forest Association (CFA) in order for the rivers to support a high volume and quality water resource. This calls for effective planning and coordination of their conservation initiatives.

The community depends highly on the adjacent forest for fuel wood, timber, medicinal herbs, posts and poles and fodder for grazing their animals. An area of the forest has also been set aside for them to cultivate through the PELIS programme. Under the PELIS programme, the beneficiaries pay some duty to Kenya Forest Service each year. Since their

land sizes are small, this service has tremendously improved their harvests and by extension food security. As good as this approach may sound; a focus group discussion revealed that this practice does not fully involve the Ministry of Agriculture's extension staff who ideally should work closely with the KFS in ensuring that the enhancement of the food security target is achieved while conserving the environment same time. This has often resulted to deployment of practices that degrade these environmentally significant and sensitive areas including riverine vegetation. This eventually aggravates the vulnerability situation of people to the effects of climate change.

5.4 Capacity for Inclusion of Ecosystem Based Adaptation to Climate Change

5.4.1 Introduction

This research was out to establish the role that the Mt. Elgon ecosystem can play in reducing vulnerability of the community to climate change effects. It is on this basis that this research sought to establish how the provisioning function of this ecosystem can be integrated into the climate change adaptation planning and related policies of the County Government of Trans Nzoia. This section therefore analyzed the range of ecosystem goods and services that are offered by this ecosystem, their exploitation trend, the institutional and policy environment that is influencing the sustainable provision of these services, the existing gaps, and how the gaps can be addressed.

5.4.2 Ecosystem Goods and Services obtained from Mt. Elgon Forest Ecosystem

Generally, the benefits obtained from Mt. Elgon ecosystem can be grouped into five main categories. These are provisioning, regulating, supporting, cultural, and recreational services. They are all relevant in contributing to the reduction of vulnerability to the effects

of climate change by the community in the study area. It was confirmed that goods such as food, fiber, fuel wood, freshwater and medicinal plants are obtained from the forest ecosystem. It also emerged that diverse ecosystem services are offered by the Mt. Elgon forest ecosystem. These benefits were enumerated as being; air quality regulation, biodiversity regulation, natural hazard regulation, soil stabilization and erosion control, water quality and flow regulation, and cultural and spiritual values.

Specifically, the provisioning services identified by the respondents included products such as; food (including game, roots, seeds, nuts and other fruit, spices, fodder), fiber (including wood, textiles) and medicinal and cosmetic products (including aromatic plants and pigments). In the regulating services category the identified services include carbon sequestration, climate and water regulation, flood regulation, water and air purification, and disease and pest regulation. The cultural aspects include the various cultural rituals and sacred spots within the forest which meet their spiritual needs. The identified ecosystem supporting services in the Mt. Elgon ecosystem which if sustainably managed can cushion residents against the effects of climate change include the primary and secondary production and biodiversity. Biodiversity resource is increasingly recognized to sustain many of the goods and services that humans enjoy from ecosystems (IPCC,*op cit*). It provides a basis for three higher-level categories of services.

Clarke and Jupiter (2010) observe that natural resource use planning is the basis for sustainable exploitation of all opportunities offered by the ecosystem. The effectiveness of this must be informed by extensive scientific and socio-economic research, as well as local and traditional ecological knowledge. According to Fischlin (2007) a good ecosystem planning and management strategy should focus on maintaining the natural structure of

ecosystems and their productivity, incorporate human use and values of ecosystems in management of the resource, recognize that ecosystems are dynamic and constantly changing, be based on a shared vision of stakeholders and finally it must be based on scientific knowledge, adapted by continual learning and monitoring.

5.4.3 Quantity and Quality Trends of the Ecosystem Goods and Services

Key informant interviews revealed that almost all natural resources in the ecosystem have deteriorated and are likely to deteriorate further due to various reasons; the most outstanding being the existing conflicting sectoral natural resource management approach in the management of natural resources.

Biodiversity which is essential to Mt. Elgon forest ecosystem's survival is under pressure, and much has already disappeared. Land-use change including agricultural intensification and urbanization, over-exploitation, pollution, climate change, and incoming species that compete with native flora and fauna; have been identified as factors behind the shrinking biodiversity. Once destroyed, it will be either costly or even impossible to restore it. This has complicated nature's ability to buffer the ecosystem dependent community from the effects of climate change. The European Union (2009) records that a society's vulnerability is a function of human development. Human activities have substantially reduced the resilience of this ecosystem and made it and species therein more vulnerable to climate.

It is further observed that the quality of services obtained from this ecosystem is getting poorer. This was attributed to over-abstraction of ecosystem resources. This agree with IUCN (2016) findings which indicate that there has been a marked reduction in forest cover on Mt. Elgon due to anthropogenic factors such as agriculture. Western (2001) also

observes that there has been significant alteration of ecosystem structure, function and processes, including connectivity within and between species. Ongugo (*op cit*) observes that water streams emanating from the Mt. Elgon have in the recent past reduced significantly in terms of volumes and annual discharge due to human activity. The soils too have lost their fertility due to poor soil management practices.

Deterioration of these ecosystem resources has in turn impacted negatively on the on the quality and quantity of the ecosystem goods and services that the community has relied upon for a long time, most at times during times of adverse climatic experiences. This is because the community's livelihood resources, whose existence is closely linked to the ecosystem health, are disrupted. Eventually, the community is exposed to the impacts of climate variability. Western (2001) observes that modification of the Mt. Elgon ecosystem may reduce its health, productivity and resilience. More accurate knowledge is therefore needed to improve an understanding of the connection between biodiversity, the Mt. Elgon Ecosystem and human well-being in order to ensure co-existence in the wake of climate change.

Mt. Elgon ecosystem just as other life supporting ecosystems, are well recognized as critical in supporting human well-being. Their importance and preservation under anthropogenic climate change should not be ignored. As Western (*op cit)* observes, a good management approach for an ecosystem such as Mt. Elgon, must focus on enhancing its long-term productivity as well as provide a strong foundation for the local livelihoods, food security and nutrition.

Fischlin (2007) observes that poor people, notably in developing countries where the study area falls, are most at risk from the loss of biodiversity, since they often rely directly on ecosystem goods and services. IPCC (*op cit*) observes that, because many of these ecosystem goods and services have always been freely available, with no markets and no prices, their true long-term value is not included in society's economic estimates. The true value of the Mt. Elgon ecosystem will be seen if valuing of ecosystem goods and services in financial terms is achieved. This has been a Herculean challenge not only with ecosystem resources but also with most natural resources and environmental services. Promoting better governance and strengthening the rules that help to protect ecosystems is encouraged too.

5.4.4 Institutional Framework and Stakeholder Involvement

Efficient inter-agency collaborative management of an ecosystem is an important ingredient in the proper functioning of ecosystem-based adaptation to climate change. It is against this backdrop that the study established the various formal and informal institutions that have a stake in the management of natural resources in the Mt. Elgon ecosystem, their resource management approaches, and the resource management policies that guide their operations.

There is good institutional representation in Mt. Elgon in terms of the management, development and exploitation of various natural resources. Each of the government institution represented is exercising and executing some specific mandate which is guided by fragmented pieces of policy and law found in different sectors. These sectors have jurisdictional boundaries despite the fact that natural resources are interdependent and often go beyond political and administrative boundaries. The environmental issues in this

ecosystem transcend the boundaries of the existing legal, administrative and institutional structure. In the interest of the future prosperity and utilizing this ecosystem to buffer the riparian community against the effects of climate change, there is need for a system of resource management that fosters sustainable and prudent use of natural resources.

Frequent duplication of efforts and conflicting objectives was noted in the management of natural resources in the study area. This leads to ineffective use of resources characterized with weak coordination of environmental management. There are clear episodes of conflicting efforts among departments such as Kenya Water Towers Agency (WTA), Water Resources Authority (WRA) and Kenya Forest Service (KFS) as relates to restoration of water catchment areas of Mt. Elgon ecosystem. All these agencies are at one point involved in the planting of trees to restore the integrity of the water catchment. This kind of duplication of efforts creates a situation where the already underfunded government departments compete for resources hence making it difficult for some programmes or ideas to be implemented. The ecosystem restoration and maintenance objective that is meant to reduce the vulnerability of the residents against the harmful impacts of climate change can hardly be achieved.

Mt. Elgon's natural resource bases are interactive and interdependent. Solutions to environmental problems therefore require an integrated approach. Legislative and institutional systems must be broadly based. Those which operate only within narrowly defined sectors face serious limitations in dealing with the total environment.

Generally, most of the natural resources sectoral policies and laws at play in the Mt. Elgon ecosystem acknowledge and promote the right of stakeholders to participate in

management of the resources. This is provided for in the Constitution of Kenya 2010, the Environmental Management and Coordination Act 1999, the Forest Policy and Forest Act, the Wildlife Policy and the Water Act. However, these provisions are not comprehensive and are interpreted differently by different stakeholders when it comes to public involvement. This has resulted in each sector determining how communities will participate in resource management. In addition, since there is no specific policy that anchors stakeholder participation in natural resource management in the study area. There is no clear consensus as to what the concept of stakeholder participation entails and what its principles are.

It was observed that there are no distinct stakeholder participation procedures and practices in the Mt. Elgon ecosystem but rather an attempt to involve the community the represented government sectors. Stakeholder participation is more successful when it is incorporated into relevant sectoral legislations as a strategy. In the Mt. Elgon ecosystem, communities have to register several institutions with different requirements to suit different sectors. Mhalanga (2014) observes that the effectiveness of government interventions in natural resource management issues is often undermined by lack of effective coordination, collaborative efforts, fragmentation of responsibilities, and jurisdiction between government agencies.

It is in the view of the above limitations that ecosystem-based management seeks to integrate management efforts across sectoral boundaries and promote synergies between agencies, partner organizations and communities who are represented in the study area. The various sectors represented in the study area each managing individual resource against the best practice should recognize that the health of each resource depends on each

other and that they exhibit interconnectivity. The management approach should involve science, economics, social science, policy and indigenous knowledge. It should aim at encouraging sectors to work together rather than only fostering sectoral interests.

5.4.5 Collaborative Management

For EbA to work and contribute significantly to reduced vulnerability of the local people to the effects of climate change there must be collaborative setting of targets and goals. Respondents argue that despite the presence of the many government sectoral agencies in the study area managing and developing individual natural resources, the ecosystem continues to suffer from degradation and deterioration of the natural resources and leading to lose of livelihoods. From the foregoing discussion, it's apparent that sectoral fragmentation is not working well in the development and management of the various natural resources represented in the Mt. Elgon ecosystem.

Due to the resource interdependencies and interconnectedness, collaborative management seems to be the better approach in managing these resources. This approach also known as an ecosystem concept is necessary to pave way for inter-sectoral coordination. It will also promote a unified policy focus from which specific policies and solutions can be derived to a satisfactory degree of internal consistency. An approach that has territorial jurisdiction and is ecosystem-based is more workable rather than the sectoral approach. The ecosystem approaches promote management of the environment according to ecological principles and often leads to the restoration and maintenance of the ecosystem structure. This eventually cushions the residents against the deleterious effects of climate change.

This collaborative management of an ecosystem resonates well with Mhalanga et al., *op cit)* sentiments who adds that in order to win the community support it's prudent that the sectoral agencies incorporate the resource user communities in the management and development of the natural resource. Further, community representation should be seen in the management structure of the various natural resources that are in the project implementation area. For this approach to succeed, there is supposed to be regular intra-agency and inter-agency consultations. This will offer a collaborative environment which is based on trust and resources may be delivered proactively.

5.4.6 Coherence in Natural Resource Management Policies

Mt. Elgon Ecosystem offers a range of benefits and opportunities for local and national economic development which include improved livelihoods and provision of environmental goods and services. It's worth noting that there are policies and laws which are at play in the study area and which present opportunities for enhanced management of resources for sustainable supply of the ecosystem goods and services. These environmental policies are supposed to be harmonized and integrated in management strategies of individual natural resources found in the study area. In this manner there will be reduced conflicts and vulnerability to effects of climate change.

There are some institutions which are executing some resource management policies in the study area. WRA's main interest in the study area is to ensure that there is rational and equitable allocation of water resources, regularly conduct water quality monitoring by testing and doing surveillance to ensure compliance with drinking water standards. It also monitors standards for various water uses and effluent discharges into public sewers and the environment besides mapping and publishing of key water catchment areas. The same

agency oversees groundwater resources and flood prone areas (Moraa et al., 2012). The National Forest Policy (GoK, 2014), recognizes and allows Kenya Forest Service to focus on the management of forests on public land including forests that are within the the study area. Equally, the Wildlife Conservation and Management Act, 2013 empowers the Kenya Wildlife Service to manage Mt. Elgon's wildlife resources. The ministries of agriculture, tourism and the County Government of Trans Nzoia too have a stake in the same ecosystem and have relevant policies from where they draw their powers.

The presence of a number of resource management policies being implemented by diverse institutions operating in one ecosystem can on the other hand be the basis for conflict of authority. This is especially so when their coordination is poor. Areas of resources management policies that have some conflicting mandates and that are visible in the Mt. Elgon ecosystem were pointed out by key informants. One such example in the study area was where the dry season micro-irrigation farming projects is promoted by the Ministry of Agriculture mainly because it attracts better returns besides boosting food security. It was observed that this kind of farming is done in wetlands and riparian zones due to proximity to water for irrigation. However good this activity might sound, it contradicts another sector's legal mandate of conserving the riverine ecosystem. The resulting ambiguity creates the potential for interagency conflicts that jeopardizes the ecosystem's role in reducing the community's vulnerability to climate change.

The above policy inconsistencies in managing natural resources found in the same ecosystem has also been observed by Plummer and Fitzgibbon (2004), who adds that managing renewable natural resources is difficult because of the complexity occasioned by interlinked social and ecological components. He adds that policy consistency and

coherence is a major factor that determines the ecosystem health and sustainable supply of livelihood goods and services. In this context, co-management, where management responsibility is shared between government and resource-users, may improve the suitability and perceived legitimacy of management rules when there is policy coherence. Co-management of natural resources often becomes difficult when there are glaring policy inconsistencies and is poorly understood (Plummer & Fitzgibbon, 2004).

Mhalanga et al. (op cit) also observes that the existence of various policies and institutional frameworks managing interdependent resources in a homogenous geographical space can lead to weak coordination in basic approaches to resource conservation. This is often exacerbated by institutional rivalries due to overlapping mandates among the ministries and departments. Equally, Ongugo (2014) observed that policy incoherence; ineffective coordination and fragmented management of strategic activities between different actors in Mt. Elgon ecosystem are among the main causes of ecosystem deterioration. This poses a challenge of interfering with institutional frameworks and possibilities of weak enforcement of polices and legislation at all levels of governance.

A major recommendation given in his study is the adoption of an integrated ecosystem management system which requires an active and sustained involvement of all resource users and stakeholders on how the available resources are allocated and managed. Knowledge on how conflicts are mitigated in order to encourage long-term supply of ecosystem goods and services for improved livelihoods is equally necessary. Mhlanga (2014) agrees with this approach but notes that the diversity of statutory instruments if properly coordinated can make the management of an ecosystem's resources very effective.

Integrated ecosystem management can create synergies between and among various government departments which is necessary for sustainable production and utilization of ecosystem goods and services hence cushioning against the effects of climate change. This imply that if the various institutional policies guiding the natural resource use and exploitation in Mt. Elgon are well coordinated and harmonized they can lead to restoration and maintenance of the natural structure of the ecosystem and thus enabling it to sustainably provide ecosystem goods and services to the resource users. This will be more useful especially in cushioning the residents against the negative effects of climate change.

5.4.7 Towards Ecosystem Based Adaptation in the Mt. Elgon Ecosystem

In view of the foregoing, this section presents a stepwise examination of the Mt. Elgon ecosystem to identify the existing opportunities to be optimized followed by the identification of gaps that need to be addressed for EbA to be actualized in the study area. This approach lays emphasis on EbA principles which strongly advocates for the sustainable management of the Mt. Elgon's natural resources, enhancing its biodiversity, and maintaining the ecosystem structure, processes, functions and services. If achieved, this approach will provide a cost effective way of adaptation to climate change. It will use "nature's infrastructure" provided by the Mt. Elgon forest and associated biodiversity to enhance people's resilience while maintaining ecosystem services and sustainable livelihoods in the face of climate change.

The key steps discussed hereafter are not only relevant for Mt. Elgon Ecosystem but are valid also for other ecological regions, especially where people heavily rely on natural resources for their livelihoods.

i. Identification and involvement of stakeholders and partners

The starting point for an Ecosystem-based adaptation strategy is by addressing the full range of activities affecting the health of an ecosystem and the identification of all relevant stakeholders. This is followed by the development of strategic decisions on how to engage stakeholders in the process of changing from other modes of ecosystem management to EbA. Identification of the stakeholder community will be informed by the nature and scope of the natural resource management process.

Mt. Elgon ecosystem has primary stakeholders drawn from the residents who are represented by the formal institutions and community representatives. Other primary stakeholders include all the sectoral resource management institutions and the County Government of Trans Nzoia. The secondary stakeholders include individuals, groups and organizations with rights, interests or needs that are affected by the resource management regimes, have influence and authority or power relevant to the management process, expertise or resources relevant to the management exercise. These comprised of donor agencies such as the European Union, IUCN, the local NGOs and CBOs. Cultural codes of behavior that may limit decision-making authority to particular individuals or groups are given special attention at this point. This includes the local representatives of the indigenous Sabaot community who are said to have strong cultural and livelihood ties with Mt. Elgon forest. This group's legal powers are only exercised by individuals recognized and authorized by law.

Ecosystem-based Adaptation practice requires that all the above identified stakeholders must be involved in addressing the different demands for the ecosystem services, including land use change and climate change. Importantly, managing the ecosystem to increase the

resilience of people and their associated socio-economic livelihoods to climate change should be among the top priority. Consultation processes on any issue touching on Mt. Elgon's ecosystem resources should be designed in collaboration with all relevant decision-makers to ensure that continuity is maintained between consultation processes and management decisions. It is also important to actively engage with resource users, including the private sector and r ethnic groups such as the indigenous Sabaot that do not have legal or traditional resource tenure as observed by Sobert, (*op cit*).

Such collaborative partnerships will greatly enhance management effectiveness, by bringing together individuals and organizations with diverse expertise, roles and resources. The establishment of partnerships will promote coordination and integration of management activities, improve efficiency and promote shared solutions to ecological challenges. Regardless of the manner in which they will be initiated, it will be essential that natural resource management processes respect the needs, interests, rights and aspirations of local resource owning communities, and contribute to local conservation and development goals, not just national and international targets.

ii. Identification of ecosystem values

Implementation of EbA in the study area calls for an understanding of the interplay between the biological and societal systems in the management area. The entire community and stakeholders in the study area must be aware of the benefits of having a healthy and structurally sound ecosystem. The interplay between the biological and societal systems has given rise to provisioning, regulating, cultural, spiritual and recreational services.

Local understanding and experience when integrated with existing and emerging scientific knowledge will assist to document any emerging ecosystem benefits. In the long-run, this will improve management effectiveness by increasing community participation. Information will be derived from local sources, accepted native expertise, and from scientific research. Natural resource users are regarded exceedingly as important sources of in-depth information about the value of this ecosystem and must be brought on board. Past and ongoing socioeconomic research and participatory planning processes will continually provide invaluable information about the use and management of natural resources, as well as likely costs and benefits of management intervention.

International and local scientists have done and will strive to quantify and value ecosystem goods and services. Millennium Ecosystem Assessment (WRI, 2003) has acknowledged the relevance of ecosystem services for human wellbeing. More evidence will continually be sought on the role of ecosystem services in reducing the vulnerability of society. Information on the costs and benefits of conserving ecosystem goods and services in the context of climate change will as well be generated. Quantification and spatial prioritization of ecosystem services for adaptation will also be identified for climate change adaptation purposes.

iii. Framing the management context

Previous chapters have shown that management of natural resources in the Mt Elgon ecosystem is characterized by sectoral fragmentation. This contradicts the ecosystem management approach that takes into cognizance the ecological interdependencies, interconnectedness and interaction between humans and the environment. Key informant interview and FGDs revealed that residents of the study area largely depend on the

ecosystem goods and services for their livelihoods. This is contrary to findings indicating that the existing resource use planning and management practices in the study area has not captured the role of Mt. Elgon ecosystem in supplying of goods and services that it produces. There are neither deliberate efforts nor commitment to embrace this all-inclusive approach that considers the resource beneficiaries as key stakeholders in the conservation of the Mt. Elgon ecosystem natural resources.

Ecosystem-based Adaptation cuts across jurisdictional and administrative boundaries and may not fit neatly into existing institutional categories represented in the study area. The livelihood activities in the study area depend on climatic factors that are heavily influenced by Mt. Elgon's natural resources. Any degradation in this ecosystem leads to the interruption of the supply of the ecosystem goods and services. This in return impacts negatively on the livelihoods of these residents. For the ecosystem to serve the EbA objective, the practitioners covering the study area are required to have a clear understanding of the management context in which they operate and identify opportunities to link their work with existing laws, policies, programmes, institutions and decision making processes.

Because resource tenure is a fundamental issue for ecosystem based adaptation initiatives, it will be important to gain an in-depth understanding of the legal and actual status of tenure claims in this management area. This must include the cultural claims by the indigenous Sabaot community. Further, the conflicting and overlapping tenure claims in Saboti and Kitalale forests which have led to conflicts between the government and the squatters need to be looked at. This might influence the EbA narrative if it is not handled well. Gaining

a clear understanding of customary and government decision-making processes will enhance the EbA objective in the study area

Recognition of legitimate traditional resource ownership regimes and decision making processes will enhance the effectiveness of collaborative resource management leading to enhanced EbA. Conversely, failure to recognize traditional resource tenure and decision-making processes may lead to resource related tensions. This, when combined with limited government capacity, can result in poor resource management outcomes. A mix of state regulations and community rules in management plans, and development of compliance and enforcement protocols, will enhance management effectiveness and reduce conflict risk while enhancing the EbA agenda.

iv. Identification of Key Management Institutions

Climate change which has been experienced in the Mt. Elgon area, poses a huge challenge to the sustainable supply of ecosystem goods and services in the region. The underlying argument is that there needs to be minimal interruption of the supply of goods and services to the ecosystem dependent communities. With proper planning and coordination of resource management actors, the continued supply might be achieved. Deliberate efforts to anticipate for risks and embracing joint planning for mitigation and adaptation to these eventualities will help reduce the vulnerability of the citizens to these effects that threaten their livelihoods.

Key institutions identified and which must work in harmony the Mt Elgon ecosystem include the KWS, KFS, WRA, KTB, KWTA and the Ministry of Agriculture. Their operations are guided by the Wildlife, Environment, Water, Forest, and Tourism policies

respectively. Due to its cross sectoral nature, EbA will require the involvement of these existing institutions, establish new institutions, re-invigorate existing institutions if need be and strengthening the coordination mechanisms. In each case, it will be necessary to consider the source of the institution's authority or influence, and its interactions with other natural resource management institutions. The inter-play between traditional institutions and government in the study area are important too and must be accorded particular attention. This is especially so with the indigenous Sabaot community cultural sites where traditional leaders exercise greater influence than government agencies. Therefore it is critical that attention be paid to the specific interests of all users.

Effective management of ecosystem resources for EbA success and reduced vulnerability will in some circumstances require the establishment of new institutions. Consideration should be given on whether to design regional, national, and local structures for managing the ecosystem resources using an ecosystem approach. A suggestion is the establishing a regional/local ecosystem coordination committee. Alternatively, the County Environment Committee (CEC) can be established and/or re-invigorated to serve as a coordinating mechanism. This will be a practical way to improve collaboration and integration of natural resource management functions. The institution so formed must recognize that resources and their management have implications on communities upstream and downstream. Thus the coordination of activities is necessary to ensure that the ecosystem provides maximum benefits to all.

The established committee will be required to foster an inter-agency approach, harmonized policies, integrated management, conflict aversion strategies and definition of priorities. This effort will take into account not only the ecosystem management issues but also the

socioeconomic policies and programmes. Before establishing any new management institution, it will be important to carefully consider whether the new entity is really needed, or whether its functions could be performed by existing institutions. It will also be worth considering whether the established institution has the authority to make management decisions. To effectively adopt and implement an EbA approach, it will be prudent to build the capacity of new or existing management entities.

The County Government of Trans Nzoia where the study area falls has a good opportunity to embrace the Ecosystem-based adaptation strategy in cushioning its residents against the effects of climate change. This is due to the fact that the devolved government has the ability to prepare the requisite policies and to legislate relevant laws that promote the mainstreaming of EbA into county's planning cycle.

v. Identify Goals, Targets and Threats

The sectoral fragmentation of resource management in the study area is guided by its sectoral policies. Some of the management goals often conflict with each other and also lead to duplication of efforts. This eventually leads to confusion hence leading to ecosystem degradation. At this point, clearly defined goals and targets which promote ecological restoration and maintenance of the ecosystem structure for enhanced resilience to climate change impacts by the community will need to be formulated. These will provide a basis for identifying threats to EbA in the study area followed by prioritizing of management responses that will promote the adoption of this strategy.

To develop appropriate goals which can contribute to ecosystem restoration and sustenance of Mt. Elgon ecosystem, resource owners, resource users, experts and management

agencies must be engaged in collaborative planning processes. This will to pave way for identifying opportunities, goals and targets that integrate stakeholder concerns and priorities. It will as well utilize the useful scientific and traditional ecological knowledge. The objective of Ecosystem-based Adaptation in this study area focuses on restoring and maintaining the natural structure of the Mt. Elgon ecosystem to sustain its ecosystem services over time.

Biodiversity conservation being the backbone of EbA is a critical target and an important element at planning stage. Its loss is closely linked to loss of ecosystem services, whereas its protection and recovery of populations, species and ecological communities enhance ecosystem productivity and resilience. As the setting of goals and objectives are being developed, scientific principles, knowledge and research methodologies will be given priority.

vi. Establishment of management strategies

Having identified goals and targets to be addressed jointly, development of effective and efficient management strategies in the target area will be of necessity. This will demand that a collaborative approach be developed at the ecosystem level. The deployment of a highly coordinated, interactive, and consultative approach is vital at this stage. The strategy must recognize that an ecosystem works as a single unit and that the ecological processes and systems within the ecosystem are interdependent. It will demand that there is an understanding that Mt. Elgon's ecological systems do not respect the jurisdictional confines of the sectoral mandates of the government departments represented in the Mt. Elgon ecosystem.

An effective EbA for the Mt. Elgon ecosystem will require a careful attention to the development and implementation of management rules and actions. Responsibilities and timeframes for implementation of agreed actions must be made clear to each sector that is represented. The management rules will be crafted in a manner that they are responding to pressures by seeking to regulate human activities that are negatively affecting the health and integrity of the Mt. Elgon ecosystem. The links between community-identified management goals and ecosystem management rules must be given emphasis. This will improve compliance by encouraging ownership of the rules, and promoting local environmental self-monitoring and reporting.

Management rules that will promote restoration and maintenance of this ecosystem structure must focus on; spatial planning (including protected areas, management zones and buffers), seasonal restrictions and exploitation limits for resources. It must also regulating the harvesting of particular species, banning of some particular exploitation methods, and regulating developments and all forms of pollution. The Ecosystem-based Adaptation planning process is also expected to identify clear actions to maintain or restore the health of the ecosystem. These actions must add to management targets and seek to address direct threats or contributing factors.

vii. Development of compliance mechanisms

Management rules developed to guide EbA are unlikely to be effective without active efforts to promote compliance. These include awareness raising, monitoring, surveillance and enforcement. Highly deterring penalties for infringement of management rules must be made and are supposed to be highly punitive to deter offences. These penalties must fall

within the framework of both the national and county legislations. Likewise, incentives to encourage compliance to jointly set rules and regulations will be of great importance.

Effective implementation of management rules in the study area; both legislation and customary law will require deliberate action to encourage compliance. It is anticipated that people will comply with the law if they have prior knowledge of the law, understand the reason for the law and respect the source of the law. This will be achieved through education and awareness activities. Communication of management rules will emphasize communities' common interest in sustainable management of natural resources and Mt. Elgon ecosystem as a whole.

viii. Deliver education and outreach programs

A range of communication media and techniques will be identified that will work well in the study area. This will include: key messages to be delivered through informal settings; logos and slogans; newsletters and fact sheets printed in local languages; and verbal communication to reinforce printed material. To avoid failure in effective communication, allocation of adequate time and financial resources to communication activities in project proposals and work plans will be done

ix. Identification of monitoring and research priorities

Ecosystem-based Adaptation monitoring programs should be explicitly linked to management targets and threats and cover a range of biological and socioeconomic indicators across all ecosystem types within the management area. Monitoring programs will be designed so that their scope and nature is in tandem with available resources and technical capacity. Community based monitoring will play a useful role in shaping management to match with the local needs.

A wide range of indicators will be identified to measure ecosystem function, service provision and management effectiveness. Monitoring will take place throughout the management cycle, and be integrated into adaptive management. Other ongoing scientific research will play a role in improving the effectiveness of management interventions, by generating knowledge about social and biological systems and building understanding of ecosystem processes.

x. Establishing review and adaptation processes

To implement an adaptive management approach, it will be necessary to examine the key values and threats in the study area, develop a set of assumptions about what is taking place and what actions might be used to maintain and restore these values. To achieve the desired results, the management actions must be properly executed while maintaining appropriate ecosystem management practices. Appropriate monitoring procedures must also be applied and executed in order to track progress. If the progress will not be as per the set goals, the management actions will have to be changed to reflect information obtained through monitoring, based on agreed process for amending rules and actions.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The purpose of this study was to examine the potential for integrating ecosystem based adaptation to climate change in Mt. Elgon Ecosystem, Trans Nzoia County, Kenya. The study was carried out in four sub-counties of Trans Nzoia County that fall within the Mt. Elgon Ecosystem, namely Kwanza, Saboti, Kiminini and Endebess. This chapter gives a summary of major findings and the major conclusions drawn based on the research findings. The chapter also provides recommendations for further research.

6.2 Summary and conclusions

The summary of the research findings is presented based on the following objectives;

6.2.1 Nature of climate change vulnerability

The study area is a mountainous region that is vulnerable to the impacts of climate change. This is despite the fact that this ecosystem is endowed with numerous natural resources upon which the community and their livelihood activities depend. The economy of the study area is supported basically by rain-fed agriculture, a phenomenon that is heavily influenced by the presence of Mt. Elgon. Though there are pockets of large scale farming, the area is mainly dominated by small scale crop and dairy farming. The income of the residents is narrow and highly dependent on crop and livestock farming. This specialty economy can be good but it depends on the local leaders and entrepreneurial innovations for promoting the locally produced products outside the study area. Land use characteristics were found to largely influence economic activities in the study area. Large scale crop

producers can have a lucky season of harvest which can compensate for a bad season and thus cushion them against the impacts of climate change. However, for the small-scale farmers, the profit margins are not big and cannot to large extent influence vulnerability.

As regards to security of tenure, a significant number of respondents indicated that they own land while other respondents indicated that they do not have title deeds. This has an implication on securing credits from financial institutions to develop their land and agricultural investments. This can determine the patterns of vulnerability to climate change. It was further established that the largest source of household energy for cooking is the forest degrading wood fuel energy. Other factors that were established by this study to be enhancing vulnerability to the impacts of climate change include lack of access to health care and the presence of unpredictable natural resource based conflicts in the study area.

6.2.2 Ecosystem planning and management practices

Though there is room for participatory management in natural resources in the study area, the multi-sectoral approach to resource management has not been fully adopted and practiced. Where it is applied, the implementing agencies still have sweeping powers in decision making. This has been noted in the engagement of WRUAs, CFAs and community tourism wardens. The process is often associated with opacity in community engagements besides the government influencing the groups on the terms of engagement.

It emerged that the current sectoral ecosystem planning and management practices in the study area is confined to jurisdictional mandates which are not fully informed by the existing and accepted scientific knowledge on the interconnectivity of ecological systems. Application of socio-economic research, as well as local and traditional ecological

knowledge to inform management decisions needs to be emphasized. For EbA to be effective, the ecosystem management plan must be reviewed and amended periodically to reflect monitoring results and evolving management priorities.

It clearly emerged that climate change will adversely affect agriculture in the study area. Greater impacts will be felt in the crop and livestock sectors. Therefore, rethinking the likely harmful effects of rising temperatures and increasing rainfall uncertainty should be a priority in the study area. Implementing adaptation measures at national, county and farm levels as well as putting in place policies that prevent destruction of the natural environment will assist in addressing the challenges posed by climate variability and change. There is an urgent need therefore for an environmental policy in the study area that ensures that there is harmonized and integrated approach towards the management of natural resources. This will assure the residents of sustainable provision of goods and services that will culminate in reducing vulnerability to effects of climate change.

6.2.3 Natural Resource Governance challenges and opportunities for EbA inclusion

It was noted that the existence of various policies and institutional frameworks governing natural resources management in the Mt. Elgon ecosystem has led to weak coordination in the management of Mt. Elgon ecosystem. This is exacerbated by institutional conflicts that are fueled by overlapping mandates among the ministries and departments. This has been observed especially with regard to handling of conservation funds by the state and donors.

6.2.4 Suitable Ecosystem-based adaptation strategy

The main study finding is that with devolved governance in Kenya, it is possible for the County Government of Trans Nzoia to embrace and adopt an ecosystem-based adaptation approach to climate change. The Governor, who is the chief executive officer of the county, has the ability to spearhead, formulate and implement the Ecosystem based adaptation strategy which has been proven to be cost-effective.

6.3 Recommendations

Recommendations emerging from this study are provided below;

6.3.1 Diversification of livelihoods

In view of the research findings, the residents of the study area need to diversify animal and crop varieties to include those that have higher tolerance limits to climate variability, crop diseases and pest outbreaks. Residents should be encouraged to shift to mixed crop-livestock systems which can improve land use efficiency by increasing production with the use of lower input. Diversification of income sources too, may be a good strategy to reduce resource dependency and vulnerability of individuals at the household level. Value addition to the farm products to increase employment along the many value chains can also reduce vulnerability to effects of climate change.

6.3.2 Enhanced funding for Mt. Elgon forest ecosystem

Because of its critical importance in providing protection, reducing the impacts of natural disasters, and sustaining the livelihoods of hundreds of millions of vulnerable people, the Mt. Elgon forest ecosystem should be one of the highest priorities for ecosystem-based adaptation intervention and support. There is an urgent need for an immediate halt of the

continuing degradation of the forest resources that are in the study area to allow them to support dependent communities in the face of climate change.

One such way is funding the conservation efforts for purposes of climate change adaptation by using the payment for ecosystem services (PES) approach. Payments for ecosystem services also known as payments for environmental services or benefits, will encompass offering incentives to farmers and landowners in exchange for managing their land to provide some sort of ecological service. The programs will involve encouraging land owners to voluntary and mutually enter into contracts with consumers of environmental services and the suppliers of these services. The challenge to operationalizing PES will be overcome by developing clear legislation to that will prevent undervaluation of ecosystems that eventually result to low resource allocation.

6.3.3 Use existing Mt. Elgon ecosystem's infrastructure first

Natural ecosystems provide valuable protection and other services for free, and we should take advantage of them. Maintaining and restoring "nature's infrastructure" in the study area should be a priority for reducing vulnerability to climate change impacts. As the effects of climate change become more severe, there will be, however, situations where "hard" engineering and physical structures may be necessary, but such structures need be built in sync with nature and its changing patterns.

County governments are asked to take a proactive role in mainstreaming EbA approaches in their planning for adaptation to climate change. If we want effective adaptation and mitigation measures to address climate change and livestock production, these measures should be scaled up through policy. Indeed, though EbA still remains under-utilized by

policymakers and associated stakeholders, it should be considered as a viable strategy for pursuing sustainable development goals at the lowest planning levels simultaneously with climate change adaptation and mitigation targets.

6.3.4 Investment to support action on ecosystem-based adaptation

Their needs be improved access to adequate, predictable, and sustainable financial resources that can enable the successful design, implementation, monitoring, and adaptive management of ecosystem-based adaptation strategies in the study area. Further, development assistance for adaptation should be provided in a coherent and coordinated way to ensure that ecosystem-based adaptation is considered and funded as an integral part of any adaptation project.

6.3.5 Stakeholders involvement in strategy development

The existing ecosystem planning strategies must recognize the role of stakeholders and embrace public participation in policy formulation. Any adaptation intervention introduced into the ecosystem must be owned by the beneficiaries. Ecosystem-based adaptation presents a tangible opportunity to solve climate change problems by aligning conservation, development, and poverty alleviation interests. Such synergies benefit from government collaboration with indigenous and local communities, conservationists, relevant private sector stakeholders, development specialists, and humanitarian aid specialists. Sustainable supply of goods and services should be the aim of all the sectors that manage the resources in the Mt. Elgon ecosystem. Effective coordination of the conservation efforts is required. This calls for the formulation of policies that do not conflict with each other and encourage working in harmony. There is an urgent need to consolidate all policies, legislation and regulations to encourage the conservation of an ecosystem as one functional unit.

6.3.6 Formation of EbA coordination mechanism

Ecosystem-based Adaptation approach promotes collaboration and coordination of various sectors, communities and players that utilize ecosystem services (Muthee et al., 2017). It presents a tangible opportunity to solve climate change problems by aligning conservation, development, and poverty alleviation interests. Bringing together these diverse stakeholders for a common purpose requires a strong coordination framework. County governments can consider establishing the County Environment Committee and consequently use them as a platform to coordinate the collaborative ecosystem conservation efforts geared towards addressing adaptation to climate change.

6.3.7 Adoption of a regional approach

The Mt. Elgon ecosystem being one of the most important biodiversity areas and a water tower for both Uganda and Kenya spans a wide geographical area and many administrative units. It serves as a catchment area for the drainage systems of three lakes: Victoria, Turkana and Kyoga. Therefore, efforts need to be made to design adaptation measures that are not limited by these boundaries. Adaptation measures for a resource shared by multiple states can succeed only through integration of a regional or trans-boundary dimension.

6.4 Areas of further research

This research suggests that further research be done on the following;

i. Possible impacts of specialist farming in the study area as opposed to diversified farming and how this is likely to influence adaptation to climate change

ii. Trend analysis of climate in the Mt. Elgon region from the 1960s to the present

iii. The efficacy of the climate change adaptation infrastructure in addressing vulnerability to climate change in the Mt. Elgon ecosystem.

REFERENCES

Adger, W.N., Pulhin, J. Barnett, G.D., Dabelko, G.K., Hovelsrud, M., Levy, Ú., Oswald S, and Vogel C.H. (2014). *Human security.* In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 755-791.

Andrade, A., Pérez, A., Herrera, F., B. and Cazzolla, G. R. (eds.) (2010). *Building Resilience to Climate Change: Ecosystem-based adaptation and lessons from the field.* Gland, Switzerland: IUCN. 164pp.

Andrade, A., Córdoba, R., Dave, R., Girot, P., Herrera. F. B., Munroe, R., Oglethorpe, J., Paaby, P., Pramova, E., Watson, E., Vergar, W., Suarez, I. (2012). *Principles and Guidelines for Integrating Ecosystem-based Approaches to Adaptation in Project and Policy Design.* IUCN- CEM, CATIE. Turrialba, Costa Rica. 4p.

Ayamga, M., Yeboah, R., Ayambila, N. (2016). *An analysis of household farm investment decisions under varying land tenure arrangements in Ghana*. Journal of Agriculture and Rural Development in the Tropics and Subtropics Vol. 117, No. 1 (2016), 21–34

Awudu, A., Owusu, V., Renan, G. (2010) *Land tenure differences and investment in land improvement measures: Theoretical and empirical analyses*. Journal of Development Economics Vol.96 (2011) 66–78

Baig, S. P., Rizvi, A., Josella, M., Palanca-Tan, R. (2016). *Cost and Benefits of Ecosystem Based Adaptation: The Case of the Philippines*. Gland, Switzerland: IUCN. viii + 32pp.

Bailey J. (2008). *First steps in qualitative data analysis: Transcribing*; Fam Pract. 2008 Apr; 25(2):127-31. doi: 10.1093/fampra/cmn003. Epub 2008 Feb 27.

Bamberger, M. (1986). *The Role of Community Participation in Development Planning and Project Management.* An EDI Policy Seminar Report No. 13. Report of a Workshop on Community Participation held in Washington D.C., September 22-25, 1986

Boon, E., Ahenkan, A. (2012). *Assessing Climate Change Impacts on Ecosystem Services and Livelihoods in Ghana: Case Study of Communities around Sui Forest Reserve.* Journal of Ecosystem and Ecography.

Bucciol, A. Cavasso, B., Zarri, L. (2014). *Social status and personality traits*. Netspar discussion papers, Netspar

Cambridge University (2018). *Cambridge Advanced Learner's Dictionary and Thesaurus* Cambridge University Press

Campbell B. M.,Vermeulen S. J., Aggarwal, P.K., Dolloff, C.C., Girvetz, E., Loboguerrero, A.M., Villegas, R. J., Rosenstock, T., Sebastian, L., Thornton, P.K., Wollenberg, E.,(2016). *Reducing risks to food security from climate change.* Global Food Security, Volume 11, December 2016, Pages 34-43

Charles, J.,Gary, M. (1989). Data Analysis. *Harcourt Brace Jovanovich).*

Chan, K.M., Shaw, M.R., Cameron, D.R., Underwood, E.C., Daily, G.C. (2006). *Conservation planning for ecosystem services.* Center for Conservation Biology, Department of Biological Sciences, Stanford University, Stanford, California, USA.

Clarke, P., Jupiter, S., (2010). *Principles and Practice of Ecosystem-Based Management: A Guide for Conservation Practitioners in the Tropical Western Pacific*. Wildlife Conservation Society, Suva, Fiji.

Denton, F., Wilbanks, A.C., Abeysinghe, I. Burton, Q., Gao, M.C., Lemos, T., Masui, K.L., O'Brien, E. & Warner, K. (2014). Climate-resilient pathways: Adaptation, mitigation, and sustainable development. In [Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., & White,

L.L. (eds.)] (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1101-1131.

Ebba B. E. & Wamsler, C (2017). *Collaborative Governance for Climate Change Adaptation: Mapping citizen–municipality interactions*. Environmental Policy and Governance published by ERP Environment and John Wiley & Sons Ltd

EU (2009). *Ecosystem Goods and Services.* Retrieved on 13/06.2018 at 13.38hrs from *ec.europa.eu/environment/nature/info/pubs/docs/ecosystem*

Fabricius,C., Koch, E., & Magome, H. (2010). *Towards strengthening collaborative ecosystem management: Lessons from environmental conflict and political change in southern Africa,* Journal of the Royal Society of New Zealand, 31:4, 831-844, DOI: 10.1080/03014223.2001.9517679

FAO (2012). *Food and Agriculture Organization of the United Nations*. FAO Land Tenure Studies, 3; Rome, 2002

FAO. (2011). *World Livestock 2011: Livestock in food security*. Rome, FAO.

Fisher, S., Garside, B., Van Epp, M., Dodman, D., D'Errico, S., Anderson, S. & Carlile, L. (2016). *Planning and implementing climate change responses in the context of uncertainty: Exploring the importance of social learning and the processes of decision-making.* IIED Working Paper. IIED, London.

Fischlin, A., Midgley, G.F., Price, J.T., Leemans, R., Gopal, B., Turley, C., Rounsevell, M.D.A., Dube, O.P., Tarazona, J., Velichko, A.A. (2007). Ecosystems, their properties, goods, and services. In Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. & Hanson, C.E., (Eds). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of*

the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, 211-272.

Fussel, H.M. (2010). *Review and Quantitative Analysis of Indices of Climate Change Exposure, Adaptive Capacity, Sensitivity, and Impacts, Development and Climate Change: Background Note.* Potsdam Institute for Climate Impact Research (PIK), Germany

Gardener, A. (2017). *The purpose of adaptation*. Inerface Focus, October 6th 2017;7(5). doi:10.1098/rsfs.2017.0005.Epub 2017 Aug 18

Ghai, D. (1994). *Environment, Livelihood and Empowerment; Development and change.* International Institute of Social studies; Vol 25, Issue 1

Ghai, Y. (2013). *History and objectives of devolution.* Retrieved from https://www.The-Star.Co.Ke/News/2013/04/20/History-And-Objectives-Of-Devolution

Gok (2009). *National Environment Action Plan Framework 2009-2013*. Nairobi, Kenya

Gok (2010). *Constitution of Kenya 2010*. Government Press, Nairobi, Kenya

GoK (2010). *The 2009 Kenya Population and Housing Census.* Government Press, Nairobi, Kenya

Gok (2012). *County Government Act, 2012.* Government Press, Nairobi, Kenya

GoK (2013). *National Environment Policy*. Nairobi, Kenya

GoK (2013). *National Climate Change Action Plan 2013 – 2017. Executive Summary*. Nairobi Kenya.

GoK (2013). *Trans Nzoia County Integrated Development Plan 2012 – 2017*. Government Press, Nairobi, Kenya

Gok (2015). 2015/16 *Kenya Integrated Household Budget Survey.* Government Press, Nairobi, Kenya

GoK (2015). *Participatory Forest Management guidelines*. Nairobi,Kenya

GoK (2015). *Kenya's Intended Nationally Determined Contribution (INDC).* Nairobi,Kenya

GoK (2016). *Climate change Act, 2016.* Government Press, Nairobi, Kenya

GoK (2016). *Policy on Devolved system of Government*. Nairobi, Kenya.

GoK (2016). *Sessional Paper No. 3 of 2016 on National Climate Change Framework Policy.* Nairobi,Kenya

Granados, R. Soria, J. & Cortina, M. (2017). *Rainfall variability, rainfed agriculture and degree of human marginality in North Guanajuato, Mexico.* Singapore Journal of Tropical Geography. Vol. 38, Issue 2. Accessed on 31st January 2018 at 2:16pm

Girot, P., Ehrhart, C., Oglethorpe, J. (2012). *Integrating Community and Ecosystem-Based Approaches in Climate Change Adaptation Responses.* Retrieved from: http://www.careclimatechange.org/files/adaptation/ELAN_IntegratedApproach_150412.pdf

Haines, A., Smith, K., Anderson, D., Epstein, P., Michael, A., Roberts, I., Wilkinson, P., Woodcock, J., Woods, J. (2007). *Policies for accelerating access to clean energy, improving health, advancing development, and mitigating climate change.* The Lancet:Vol. 370, Issue 9594, 6–12 October 2007, Pages 1264-1281

HLPE, (2011). *Land tenure and international investments in agriculture: A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*, Rome 2011.

Herrero, M., Ringler, C., van de Steeg, J., Thornton, P., Zhu, T., Bryan, E., Omolo, A., Koo, J. and Notenbaert, A. (2010). *Climate variability and climate change and their impacts on Kenya's agricultural sector.* Nairobi, Kenya. ILRI.

Herrero, M., Thornton, P.K., Gerber, P. & Reid, R.S. (2009). *Livestock, livelihoods and the environment: understanding the trade-offs.* Current Opinion in Environmental Sustainability, 1(2):111-120.

Harmeling, S., & Bals, C. (2008). *Adaptation to Climate Change – Where do we go from Bali? An analysis of the Cop13 and the key issues on the road to a new climate change treaty.* Germanwatch e.V office, Bonn.

Harmeling,S. & Bals, C. (2008). *An Analysis of the Cop13 and the Key Issues on the Road to a New Climate Change Treaty*. Germanwatch E.V.Office Bonn.

Hoffmann, A.& Sgrò, C.M.(2011). *Climate change and evolutionary adaptation*. Nature. 2011 Feb 24;470 (7335):479-85. doi: 10.1038/nature09670.

IIED (2016). *Ecosystem-based adaptation: a win–win formula for sustainability in a warming world?* London, WC1X 8NH United Kingdom.

IPCC (2001). *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*.Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211, USA

IPCC (2007). *Climate change: Impacts, adaptation and vulnerability. Contribution of WG II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University press, Cambridge, UK.

IPCC (2007). Climate Change 2007: Working Group II: *Impacts, Adaptation and Vulnerability:* IPCC Fourth Assessment Report: Climate Change 2007

IPCC (2014). Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In: *Climate Change 2014: Synthesis Report.* Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 117-130.

IUCN (2008). *Securing the sustainability of the Mount Elgon forest ecosystem*. Bangkok, Thailand

IUCN (2009). *Position paper: Ecosystem-based Adaptation.* UNFCCC Climate Change Talks, 28th - September – 9th October 2009, Bangkok, Thailand.

IUCN, (2016). *Ecosystem-based adaptation: a win–win formula for sustainability in a warming world, Briefing. July 2016.* Retrieved on 5th July 2017 from http://pubs.iied.org/17364IIED.

Jerry,H. L.& Prueger, H (2015). *Weather and Climate Extremes.* Elselvier; Volume 10, Part A, December 2015, Pages 4-10

Kagombe, J. (2013). *Payment for environmental services in Kenya: Status and opportunities in Kenya.* Conference Paper. July 2014. Retrieved on 22/06/2018 at 2.16pm from www.researchgate.net/publication/275270805

Kamugisha J.R. (1993). *Management of natural resources in Uganda: Policy and legislation landmarks, 1890–1990.* SIDA Regional Soil Conservation Unit, Nairobi.

Kataria,K., Curtissand J., Balmann A.(2012). *Drivers of Agricultural Physical Capital Development Theoretical Framework and Hypotheses.* Factor Markets. Working paper No. 18, February 2012.

KNBS (2018). *Basic Report on well-being in Kenya*. English press Herufi House, Lt. Tumbo Lane, Nairobi.

KNBS (2017). *Economic Survey 2017*. English press, Herufi House Nairobi.

KNBS (2015). *Spatial dimensions of well-being in Kenya: Where are the poor?* Herufi House, Lt. Tumbo Lane, Nairobi.

KNBS (2007). *Basic report on well-being in Kenya – KIHBS 2005/06*. Herufi House, Lt. Tumbo Lane, Nairobi.

Kosolapova, E. (2018). *Doha Amendment Reaches 122 Ratifications*: SDG Knowledge Hub; Retrieved on 21st July 2018 at 2113Hrs GMT from https://sdg.iisd.org

Latta P.A., (2009). The Tragedy of the Commons" By Garrett Hardin, 1968. In Bell, D.V.J & Yuk-kuen, A.C. (Eds.), *Introduction to Sustainable Development(pp98-110*); Encyclopedia of Life Support Systems' Eolss Publishers Company Ltd/UNESCO, Oxford, United Kingdom.

Locatelli B., Brockhaus, M., Buck A., Thompson I. (2010). Forests and Adaptation to Climate Change: Challenges and Opportunities. In Mery G., Katila P., Galloway, G., Alfaro, R.I., Kanninen, M., Lobovikov M., Varjo, J. (eds.). *Forest and Society: Responding to Global Drivers of Change.* IUFRO World Series vol. 25, Vienna, pp. 21-42.

Lubale, G. (2012). *An Introduction to the County Governments of Kenya*. Retrieved on 1st August 2017, from http://gabriellubale.com/an-introduction-to-the-county-governments-of-kenya/12th September 2012

Ludena, C.E., & Yoon S.W. (2015). *Local Vulnerability Indicators and Adaptation to Climate Change: A Survey.* Inter-American Development Bank, Technical Note No. 857 (IDB-TN- 857), Washington DC.

Lynne, H., Meliane, I., Sandwith, T., Hoekstra, J.M., (2009). *Ecosystem-based Adaptation in Marine and Coastal Ecosystems.* Renewable Resources Journal · January 2009.

Magnan, A. K., Schipper, E.L.F., Burkett, M., Bharwani S., Burton, I., Eriksen, S., Gemenne, F., Schaar J.,J. & Ziervogel, G. (2016). *Addressing the risk of maladaptation to climate change.* Wires Climate change. Vol.7, Issue 5, pp 646-665.

Martek, I. (2016). *The challenges of regional development: In pursuit of a way forward*. Australian Regional Development Conference, at Canberra, ACT; *Retrieved on 20th September 2018 at 1030hrs GMT from https://www.researchgate.net/publication/309414186*

Medard, C. (2010). Indigenous land claims in Kenya: A case study of Chebyuk, Mount Elgon District. In Anseeuw, W., & Alden, C. (Ed). *The struggle over land in Africa: conflicts, politics and change.* Pages 19-36, HSRC Press, South Africa.

Melina F.L., Gibbs P.J. (2007). *Ecosystem Loss and Fragmentation: Synthesis. Network of Conservation Educators and Practitioners.* Center for Biodiversity and Conservation, American Museum of Natural History. Lessons in Conservation, Vol. 1, pp. 72-96.

McDowell, J.Z., Moe, C.L., Jeremy J., Hess, J.J.(2010). *Adaptation or Maladaptation: Vulnerability to Competing Economic and Climatic Exposures in the Bolivian Highlands.* Retrieved at 0041Hrs GMT from *www.icarus.info/wp-content/uploads/2010/06/Julia-McDowell.doc.*

Mhlanga L., Nyikahadzoi K., Haller T. (2014). Fragmentation of Natural Resources Management: Experiences from Lake Kariba *Volume 2 of Defragmenting African resource management*. LIT Verlag Münster.

Miller, M (2013). *Making Sense of Climate Finance: Linking public finance and national climate change policy in the Asia-Pacific region,* UNDP, Bangkok.

Millennium Ecosystem Assessment (2005). *Ecosystems and human well-being: Synthesis.* Washington, DC: Island Press.

Moraa, H., Otieno, A, & Salim, A. (2012). *Water governance in Kenya: Ensuring Accessibility, Service delivery and Citizen Participation*.

Morrison T. H., Mcdonald G. T., & Lane M. B. (2004). *Integrating Natural Resource Management for Better Environmental Outcomes.* Australian Geographer, 35:3,243-258, DOI: 10.1080/0004918042000311304.

Mugenda M.O., & Mugenda, G.A. (2003) *Research Methods: Quantitative and Qualitative Approaches*. Nairobi; Kenya- Acts Press

Munang,R., Thiaw, I., Alverson, K., Mumba, M., Liu, J., & Rivington,M.(2013). *Climate change and Ecosystem-based Adaptation: a new pragmatic approach to buffering*

climate change impacts. Journal Environment: Science and Policy for Sustainable Development, Vol. 56, 2014 - Issue 1

Muthee , K.., Macharia, G., Mbow , C., Filho, W.L. (2017). *Ecosystem-Based Adaptation (EbA) as an Adaptation Strategy in Burkina Faso and Mali*. Springer International Publishing AG 2017.

Murphy P.A (1984). *Regional Planning: Purpose, Scope and Approach in New South Wales, Australian*. Planner, 22:4, 16-19, DOI: 10.1080/07293682.1984.9657226

Mwikali, P., & Wafula, M.K.(2015). *Effects of devolved governance on organizational performance: A case study of Mombasa county Government*. International Journal of Scientific and Research Publications, Volume 5, Issue 6, June 2015.

Neil, L. and Jyoti, K. (2007). *Climate Change Vulnerability and Adaptation in Developing Country Regions: Draft Final Report of the AIACC Project*. A Global Environment Facility Enabling Activity in the Climate Change Focal Area Project No. GFL-2328-2724-4330.

Netherlands Environmental Assessment Agency (2015). *Climate action outside the UNFCCC: Assessment of the impact of international cooperative initiatives on greenhouse gas emission.* PBL Publishers, Hague.

Ngare, I., Koech, M., Gichuki,D., Karanja., C. J. (2016). *The Trend of Climate Variability Effects on Dairy Farming in Masaba North, Nyamira County Kenya*. Journal of Environment and Earth Science Vol.6, No.11, 2016.

Nguru, S. (2012). *Constitutions of Kenya.* Retrieved on 21st January 2018 at 12.33pm from http://www.ustawi.info.ke/index.php/devolution/devolution-under-the-new-constitution.

Nyametso, J.K. (2012). *The link between land tenure security, access to housing, and improved living and environmental conditions: A study of three low-income settlements in Accra, Ghana,* Norsk Geografisk Tidsskrift - Norwegian Journal of Geography, 66:2, 84-98, DOI: 10.1080/00291951.2012.665079.

O'Brien, E. (2011). *Irregular and illegal land acquisition by Kenya's elites: Trends, processes and impacts of Kenya's land-grabbing phenomenon.* International Land Coalition, Kenya Land Alliance, CIRAD, Kenya.

OECD, (2006). *Adaptation to Climate Change: Key Terms*. 2 rue André Pascal, 75775 Paris Cedex 16, France.

Ogendi G.M., Ong'oa M.I. (2009).*Water Policy, Accessibility and Water Ethics in Kenya*, 7 Santa Clara J. Int'l L. 177 Retrieved from http://digitalcommons.law.scu.edu/scujil/vol7/iss1/3.

Olago,D., Owino, P.J. & Odada, E. (2015): *Building Resilience to Climate Change on Mt. Elgon: Policy Implications and Recommendations*. ACCESS/IUCN, 13p.

Ongugo, P.O., Langat, D., Oeba, V.O., Kimondo, J.M., Owuor, B., Njuguna, J., Okwaro, G. & Russell, A.J.M. (2014). *A review of Kenya's national policies relevant to climate change adaptation and mitigation: Insights from Mount Elgon.* Working Paper 155. Bogor, Indonesia: CIFOR.

Osano,P.M., Said,Y.M., Leeuw, J., Moiko,S.S, Kaelo,D. Schomers, S., Birner, R. & Ogutu, J.O (2013). *Pastoralism and ecosystem-based adaptation in Kenyan Masailand.* International Journal of Climate Change Strategies and Management Vol. 5 No. 2, pp. 198-214.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press, New York

Ostrom, E. (1998). *Coping with Tragedies of the Commons. Workshop in Political Theory and Policy Analysis:* Center for the Study of Institutions, Population, and Environmental Change Indiana University, Bloomington.

Paavola, J. (2008). *Livelihoods, Vulnerability and Adaptation to Climate Change in Morogoro, Tanzania*. Environmental Science & Policy, 11, 642-654. ttp://dx.doi.org/10.1016/j.envsci.2008. 06.002

Pinson, G. (2007). *Urban and regional planning*. Encyclopedia of governance. Vol. 2, Sage Publications, pp.1005-1007, 2007. halshs-00393580

Plummer,R. & Fitzgibbon, J. (2004). *Co-management of Natural Resources: A Proposed Framework.* Environmental Management, June 2004, Vol. 33, Issue 6, pp 876–885

Reid, H. (2011). *Improving the evidence for ecosystem-based adaptation. Lessons from adaptation in practice*. IIED/JICA, 80–86 Gray's Inn Road, London WC1X 8NH, UK.

Rutherford, M. E., Dockerty, J.D., Jasseh, M., Howie, S.R.C., Herbison, P., Jeffries, D. J., Leach, M., Stevens, W., Mulholland, K., Adegbola, R., Hill, P.C. (2009): *Access to health care and mortality of children under 5 years of age in the Gambia: A case–control study*. Bulletin of the World Health Organization 2009;87:216-224. doi: 10.2471/BLT.08.052175.

Santiago, O. (2001): *Vulnerability and Adaptation to Climate Change: Concepts, Issues, Assessment Methods.* A paper presented to the Climate Change Knowledge Network.

Shamoo, A.E., Resnik, B.R. (2003). *Responsible Conduct of Research*. Oxford University Press.

Smith, S., Rowcroft, P., Everard, M., Couldrick, L., Reed, M., Rogers, H., Quick, T., Eves, C. and White, C. (2013). *Payments for Ecosystem Services: A Best Practice Guide.* Defra, London.

Sobett,G.K (2017). *The Sabaot Cultural Centre; Sido News Network*. http://www.sabaots.com/Sabaots_Cultural_Center.html 12th Dec 2017 at 5.09pm

Stolton, S. & Redford, H.K. (2014). *The Futures of Privately Protected Areas*. IUCN WCPA with the CBD and UNEP-WCMC 2014

TEEB, (2009). The Economics of Ecosystems and Biodiversity: Responding to the Value of Nature 2009. Summary for National and International Policy Makers. In Turner, W.R., Oppenheimer, M. and Wilcove, D.S. (2009). *A force to fight global warming*. Nature, 462:278-279.

Tenaw, S. K. & Parviainen, T. (2009). *Effects of Land Tenure and Property Rights on Agricultural Productivity in Ethiopia, Namibia and Bangladesh.* University of Helsinki Department of Economics and Management, Discussion Papers n:o 33 Helsinki 2009.

Thornton, P.K., van de Steeg, J., Notenbaert, A. & Herrero, M. (2009). *The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know.* Agricultural Systems, Elsevier, Vol. 101(3), pages 113-127, July.

Tyler, S. (2006). *Communities, Livelihoods, and Natural Resources. Action Research and Policy Change in Asia*. Intermediate Technology Publications Ltd, Schumacher Centre for Technology and Development, Bourton on Dunsmore, Rugby, Warwickshire CV23 9QZ, UK.

United Nations (2011). *From Brussels to Istanbul: Key development challenges facing the Least Developed Countries.* New York and Geneva.

United Nations (1992). *United Nations Framework Convention on Climate Change*. Geneva.

United Nations Development Programme (2015) *Making the Case for Ecosystem-Based Adaptation: The Global Mountain EbA Programme in Nepal, Peru and Uganda*. New York.

UNFCCC (2006). *United Nations Framework Convention on Climate Change: Handbook.* Climate Change Secretariat, Bonn, Germany.

UNDP (2018). *Mitigating Impact of Climate Change in Kenya's Arid Lands.* Retrieved on 10/07/2018 at 4.20pm from *http://www.ke.undp.org/content/kenya*

UNDP (2017). *Financing Solutions for Sustainable Development: Payments for Ecosystem Services.* Retrieved on 27th June 2018 at 8.47pm from http://www.undp.org/content/sdfinance/en/home/solutions

UNEP (2014). T*he Adaptation Gap Report 2014.* United Nations Environment Programme (UNEP), Nairobi.

UNDP (2015). *Making the Case for Ecosystem-based Adaptation: The Global Mountain Ecosystem-based adaptation Programme in Nepal, Peru and Uganda*. New York.

UNDP (2012). *Climate Risks, Vulnerability and Governance in Kenya: A review.* Nairobi, Kenya.

UoN (2015). *European settlers in the Trans Nzoia District: A case study of racial domination in the Kenya white highlands, 1920 – 1946.* http://erepository.uonbi.ac.ke:8080/xmlui/handle/123456789/23836.

Vaidya Nita (2012). *The Importance of Environmental Policy.* Northeastern university political review, April 2012. Accessed on 15/01/2018 http://www.nupoliticalreview.com

Vignola, R., Locatelli B., Martinez C. & Imbach, P. (2009). *Ecosystem-based adaptation to climate change: what role for policy-makers, society and scientists*. Springer Science + Business Media B.V. 2009.

Vignola,R., Harveyb,C.A., Solisa, P.B., Avelinoa, J., Rapidela, B., Donattib, C., Martinez, R. (2015). *Ecosystem-based adaptation for smallholder farmers: Definitions, opportunities and constraints*. Elsevier: Agriculture, Ecosystems and Environment 211 (2015) 126–132.

Wang, J., Huang, J., and Rozelle, S. (2010). *Climate Change and China's Agricultural Sector: An Overview of Impacts,Adaptation and Mitigation*. ICTSD–IPC Platform on Climate Change, Agriculture and Trade, Issue Brief No.5,International Centre for Trade and Sustainable Development, Geneva, Switzerland and International Food and Agricultural Trade Policy Council, Washington DC, USA.

Wanjiru E. (2015). *Arms Control and Conflict Management: The Case of Kenya Defence Forces.* Published on Institute of Diplomacy and International Studies

http://idis.uonbi.ac.ke) on Sat, 01/03/2015 at 14:36, esther.wanjiru, http://idis.uonbi.ac.ke/node/2299

Western D, (2001). *Human-modified ecosystems and future evolution*. Proceedings of the National Academy of Sciences May 2001, 98 (10) 5458-5465; DOI: 10.1073/pnas.101093598.

WHO (2017). *Broader impacts of household energy*. Accessed on 30th Nov 2017 at 12.09 pm http://www.who.int/indoorair/impacts/en/.

Worldbank (2009). *Convenient Solutions to an Inconvenient Truth: Ecosystem-based Approaches to Climate Change.* The World Bank, 1818 H Street NW, Washington, DC 20433, USA.

World Bank, IFC, & MIGA (2016). *World Bank Group Climate Change Action Plan 2016–2020.* World Bank, Washington DC. License: Creative Commons Attribution CC BY 3.0 IGO

World Resources Institute (2003). *Ecosystems and human well-being: A framework for assessment.* Millennium Ecosystem Assessment. Island Press, 1718 Connecticut Avenue, N.W., Suite 300, Washington, DC 20009.

WWF (2016). *Nature and Nature-based flood Management: A Green Guide.* Washington, DC. World Wildlife Fund. http://envirodm.org/flood

Yarnal, B. (2017). *Human Vulnerability to Climate Impacts.* The Pennsylvania State University

APPENDICES

Appendix I: Household Questionnaire

Dear respondent,

I am **Jusper Maranga Omwenga**, a postgraduate student at the University of Eldoret, School of Environmental Studies - Planning. I am conducting a research on the "**Potential for Integrating Ecosystem Based Adaptation to Climate Change in Kenya: *A Case Study of Mt. Elgon Forest Ecosystem***". This is in partial fulfillment for the award of a Doctorate degree in Environmental Studies – Environmental planning and monitoring. The information will be treated as confidential and is for academic purposes only.

Please tick or fill in where applicable.

Section I: Respondent's details

1. Gender

   Male [ ] □ Female [ ] □

2. Age

Below 18 [ ] □ 18-25 [ ] □ 26-32 [ ] □ 33-38 [ ] □ 39 and above [ ] □

3. Level of Education

Primary [ ] □ Secondary [ ] □ College [ ] □ University [ ] □ A-level [ ] □

4. Marital status

   Single [ ] □ Married [ ] □ Separated [ ] □ Widowed [ ] □

Section II: Nature of climate change vulnerability in Mt. Elgon ecosystem

5. Kindly indicate who the household head is.

Father [ ] Mother [ ] Grandfather/mother [ ] Son/Daughter [ ]

6. Kindly give a breakdown of your household members in the table below

Relationship	0 -18 Yrs	18 – 45yrs	45 -60 yrs	60 and above
Spouse				
Children				
Grandchildren				
Relatives				
Others				
Total				

7. Please indicate the academic qualification of your household members currently staying with you.

Relationship	**No formal education**	**Primary**	**Secondary**	**College**	**University**
Spouse					
Children (18 yrs and above)					
Grandchildren (18 yrs and above)					
Relatives (18 yrs and above)					
Others (18 yrs and above)					
TOTAL					

8. Does your family own this dwelling

   Yes [ ] No [ ]

9. Tick (√) the type of dwelling you live in

Stone walled with iron sheets [ ] Mud-walled with iron sheets [ ] Mud-walled with iron sheets [ ]. Other …….

10. Please give a breakdown of your household income in the table below

Source of Income	**Regular salary**	**Wages**	**Pension**	**Social fund**	**Self employment**	**Total**
No of household members						

11. In a scale of 1 – 6, kindly rank the following sources of income to your household, 1 being the highest source of income and 6 being the lowest

Income source	**Rank**
Family business	
Crop farming	
Livestock farming	
Formal employment	
Casual employment	
Others (Name source	

12. Please indicate by ticking (√) the approximate distance to the following government medical facilities that serve residents of your locality

i. **Dispensary** 1-5km [ ] 5 – 10Km [ ] 10 – 20Km [ ] 20 – 30Km [ ] Over 30Km [ ]

ii. **Sub/District hospital** 1-5km [ ] 5 – 10Km [ ] 10 – 20Km [ ] 20 – 30Km [ ] Over 30Km[ ]

iii. **District hospital** 1-5km [ ] 5 – 10Km [ ] 10 – 20Km [ ] 20 – 30Km [ ] Over 30Km [ ]

iv. **Referral hospital** 1-5km [ ] 5 – 10Km [ ] 10 – 20Km [ ] 20 – 30Km [ ] Over 30Km [ ]

13. Do you belief that the climate has changed within the Mt. Elgon Forest Ecosystem?

(1) Yes (2) No

If yes, what indicators support your answer?

i. …….

ii. ……

iii. ……..

iv. …….

14. Below are statements which could possibly describe the trend of climatic factors for the last ten years in your district. Your position on each statement could be one of the following;

i. Strongly Agree (SA)

ii. Agree (A)

iii. Neutral (N)

iv. Disagree (D)

v. Strongly Disagree (SD)

Please indicate your position on each statement by ticking (√) under the right abbreviation.

		SA	A	N	D	SD
15.	Rainfall unpredictability has increased hence lowering crop yields					

		SA	A	N	D	SD
16.	The frequency of dry spells has increased and has impacted negatively on agriculture					

		SA	A	N	D	SD
17.	The average daily temperatures has increased in Mt. Elgon region					

		SA	A	N	D	SD
18.	This region has lately started having unusual climatic experiences such as flooding, lightening, heavy storms, and landslides					

Section III: To establish the current ecosystem planning strategies in Mt. Elgon.

19. Are there projects that have been initiated by the government or CBOs/NGOs to cushion the Mt. Elgon Ecosystem residents against the effects of climate change?

    Yes [ ] No [ ]

20. If yes, who has initiated them?

    Government [ ] NGO [ ] Individual [ ] Any other …….

21. Are any of the projects listed below part of what has been initiated;
    I. Hand dug wells
    II. Borehole
    III. Water pans
    IV. Dam
    V. Irrigation project
    VI. Flood control projects
    VII. Water supply schemes
    VIII. GMO crops and animals
    IX. Fast maturing crops
    X. Drought resistant crops

22. Was the public involved in the identification and prioritizing any of the above interventions as climate change adaptation measures?

    Yes [ ] No [ ]

23. Below are statements which could possibly describe the ecosystem management experiences in Mt. Elgon. Your position on each statement could be one of the following;

    i. Strongly Agree (SA)

    ii. Agree (A)

    iii. Neutral (N)

    iv. Disagree (D)

    v. Strongly Disagree (SD)

Please indicate your position on each statement by ticking (√) under the right abbreviation

		SA	A	N	D	SD
24.	The government's resource management style is sensitive to the livelihoods derived by the community resident in the Mt. Elgon Ecosystem					

		SA	A	N	D	SD
25.	There is strong leadership support for the conservation of the Mt. Elgon Ecosystem's natural resources					

Section IV: Efficiency of existing ecosystem management systems in addressing climate change related challenges of Mt. Elgon ecosystem residents

26. In your own opinion, can the projects that have been initiated to cushion the community against the effects of climate change succeeded in the long-term under the current ecosystem management system?

    Yes [ ] No [ ]

Reason

……

……

……

Below are statements which could possibly describe the ecosystem management experiences in Mt. Elgon. Your position on each statement could be one of the following;

vi. Strongly Agree (SA)

vii. Agree (A)

viii. Neutral (N)

ix. Disagree (D)

x. Strongly Disagree (SD)

Please indicate your position on each statement by ticking (√) under the right abbreviation

		SA	A	N	D	SD
27.	Un-coordinated management of the Mt. Elgon ecosystem has affected continued supply of adequate ecosystem goods and services to the community					

		SA	A	N	D	SD
28.	There is a strong link between the decline in quantities and qualities of ecosystem goods and services to the ongoing degradation of the Mt. Elgon ecosystem					

		SA	A	N	D	SD
29.	Adaptation actions are identified top –down instead of bottom up					

Section IV: **Cross-sectoral policy coherence in the management of Mt. Elgon forest Ecosystem to enhance community resilience to climate change impacts.**

30. What is the mandate of your sector/dept/organization as relates to Mt. Elgon ecosystem?

    ……

    ……

    Do you belief the climate has changed within the Mt. Elgon ecosystem?

    Yes [ ] No [ ]

31. Is there any collaboration between the various stakeholders in the management of the Mt. Elgon Ecosystem?

    Yes [ ] No [ ]

32. How often do you witness the government agencies having joint management meetings with other stakeholders for the sake of managing the Mt. Elgon ecosystem natural resources?

    i. Weekly
    ii. Monthly
    iii. Bi- monthly
    iv. Quarterly
    v. Yearly
    vi. Never
    vii. Any other
    i. Last year
    ii. Any other

Please indicate your position on each statement by ticking (√) under the right abbreviation

		SA	A	N	D	SD
33.	Mt. Elgon ecosystem benefit the community by being a source of wild food, fiber, medicinal aromatic plants and pigments					
34.	Mt. Elgon ecosystem offers ecosystem regulating services such as influence on rainfall, flood regulation, disease and pest regulation, creation of a microclimate					
35.	Mt. Elgon ecosystem support soil formation, photosynthesis and nutrient cycling, which underpin growth and production.					
36.	Local community have strong cultural ties with the Mt. Elgon's forest, caves, and general landscape					
37.	There is joint ecosystem planning and goal setting					
38.	There is joint development of ecosystem management rules and joint means of enforcing the rules					
39.	There are well spelt-out compliance mechanisms such as punishments for inappropriate ecosystem practices					
40.	There are regular ecosystem conservation awareness activities in the Mt. Elgon Ecosystem through local radio and Tv programmes					

Appendix II: Government Department and Civil Society Questionnaire

Dear respondent,

I am **Jusper Maranga Omwenga,** a Doctor of Philosophy candidate at the University of Eldoret, School of Environmental Studies - Planning. I am conducting a research on the "**Potential for Integrating Ecosystem Based Adaptation to Climate Change in Kenya: *A Case Study of Mt. Elgon Forest Ecosystem***". This is in partial fulfillment for the award of a Doctorate degree in Environmental Studies – Environmental planning and monitoring. The information will be treated as confidential and is for academic purposes only.

Please tick or fill in where applicable.

Section I: Respondent's details

1. Gender

   Male [ ] □ Female [ ] □

2. Age

   Below 18 [ ] □ 18-25 [ ] □ 26-32 [ ] □ 33-38 [ ] □ 39 and above [ ] □

3. Level of Education

   Primary [ ] □ Secondary [ ] □ A-level [ ] College [ ] □ University [ ] □ □

Section II: Nature of climate change vulnerability in Mt. Elgon ecosystem

4. How can you rate the population growth rate in the Mt. Elgon Forest Ecosystem?

   Fast growing [ ] Slow growing [ ] Stagnant [ ] Declining [ ]

5. Is there a squatter problem in this area? Yes [ ] No [ ]

6. If yes, how do they derive their livelihood?

   ……

   ……

   ……..

7. Do you belief that the climate has changed within the Mt. Elgon Forest Ecosystem?

(1) Yes (2) No

6. If yes, what indicators support your answer?

i…….

ii ……

iii ……..

iv …….

7. Below are statements which could possibly describe the trend of climatic factors for the last ten years in your district. Your position on each statement could be one of the following;

vi. Strongly Agree (SA)

vii. Agree (A)

viii. Neutral (N)

ix. Disagree (D)

x. Strongly Disagree (SD)

Please indicate your position on each statement by ticking (√) under the right abbreviation.

		SA	A	N	D	SD
8.	Rainfall unpredictability has increased hence increasing crop failure					

		SA	A	N	D	SD
9.	The frequency of dry spells have increased and have impacted negatively on agriculture					

		SA	A	N	D	SD
10.	The average daily temperatures have increased in Mt. Elgon region					

		SA	A	N	D	SD
11.	This region has lately started having unusual experiences such as flooding, lightening, heavy storms, and landslides					

Section III: To establish the current ecosystem planning strategies in Mt. Elgon Forest Ecosystem

12. Who determines how water, forest, NFTPs, recreational, aesthetic values, and medicinal resources in Mt. Elgon are managed
    i. Line ministry/department [ ]
    ii. County government [ ]
    iii. Co-management [ ]
    iv. Private [ ]
    v. Any other ……..
13. Please tick below the ecosystem goods and services that the community is obtain from the Mt. Elgon forest ecosystem and indicate whether they are increasing **(I)** or decreasing (**D**) within the Mt. Elgon ecosystem

	Goods	**Tick**	**Trend**		**Services**	**Tick**	**Trend**
	Food				Air quality regulation		
	Fiber				Biodiversity regulation		

	Fuel wood				Carbon storage		
	Freshwater				Natural hazard regulation		
	Medicinal plants				Nutrient cycling		
					Soil stabilization and erosion control		
					Water quality and flow regulation		
					Cultural and spiritual values		
					Educational		
					Pollination		
					Aesthetic		

14. How accessible are the above goods and services from the Mt. Elgon ecosystem?

Very easy [ ] Easy [ ] Difficult [ ] Very difficult [ ] Not at all [ ]

15. Are there projects which have been started within your area to cushion the residents against the effects of climate change?

Yes [ ] No [ ]

16. If yes, who has initiated them?

Government [ ] NGO [ ] Individual [ ] Any other ……..

17. Are any of the projects listed below part of what has been initiated;

XI. Hand dug wells

XII. Borehole

XIII. Water pans

XIV. Dam

XV. Irrigation project

XVI. Flood control projects

XVII. Water supply schemes

XVIII. GMO crops and animals

XIX. Fast maturing crops

XX. Drought resistant crops

18. Is public involved in the management of the ecosystem/adaptation decisions

    Yes [ ] No [ ]

19. In your own opinion, can the projects that have been initiated to cushion the community against the effects of climate change succeed in the long-term under the current ecosystem management system?

    Yes [ ] No [ ]

    Reason

    ……

    ……

    ……

Section III: Efficiency of the current ecosystem management strategies in addressing climate change adaptation related challenges

20. Below are statements which could possibly describe the resource management experiences in the Mt. Elgon ecosystem. Your position on each statement could be one of the following;

    xi. Strongly Agree (SA)

    xii. Agree (A)

    xiii. Neutral (N)

    xiv. Disagree (D)

    xv. Strongly Disagree (SD)

Please indicate your position on each statement by ticking (√) under the right abbreviation

		SA	A	N	D	SD
21.	Improper management of the Mt. Elgon ecosystem has affected continued supply of ecosystem goods and services to the community					

		SA	A	N	D	SD
22.	There is a strong link between the decline in quantities and qualities of ecosystem goods and services to the ongoing degradation of the Mt. Elgon ecosystem					

		SA	A	N	D	SD
23.	Adaptation actions are identified top –down instead of bottom up					

Section IV: **Cross-sectoral policy coherence in the management of Mt. Elgon forest Ecosystem to enhance Ecosystem based adaptation to climate change.**

24. Do you observe any collaboration between the various stakeholders in the management of the Mt. Elgon Ecosystem?

    Yes [ ] No [ ]

25. Have you observed areas of interagency conflicts over resource management in the Mt. Elgon Ecosystem?

    Yes [ ] No [ ]

26. In your own observation is there interagency consultation when they are setting up their organizational goals over the management of resources in Mt. Elgon?

    Yes [ ] No [ ]

27. Below are statements which could possibly describe the management style of government departments managing resources within the Mt. Elgon Ecosystem. Your position on each statement could be one of the following;

xvi. Strongly Agree (SA)

xvii. Agree (A)

xviii. Neutral (N)

xix. Disagree (D)

xx. Strongly Disagree (SD)

Please indicate your position on each statement by ticking (√) under the right abbreviation

		SA	A	N	D	SD
28.	All organization's resource management style recognizes all ecological systems and interactions within the Mt. Elgon ecosystem					

		SA	A	N	D	SD
29.	The management systems cater for the natural fluctuations in the ecology of the Mt. Elgon ecosystem					

		SA	A	N	D	SD
30.	There is a smooth interagency cooperation in the management of the resource of our interest in Mt. Elgon ecosystem.					

		SA	A	N	D	SD
31.	The resource management styles are sensitive to the livelihoods derived by the community resident in the Mt. Elgon Ecosystem					

		SA	A	N	D	SD
32.	There is strong leadership support for the conservation of the Mt. Elgon Ecosystem					

Appendix III: Interview schedule for Focus Group Discussion and Key Informant

1. Kindly identify yourself.
2. How far is your residence from this interview venue?
3. Is there any role you play in the management of the Mt. Elgon's natural resources?
4. What are your livelihood activities?
5. What are the common agricultural activities that are being undertaken in this area?
6. Name the main crops that are grown in the area.
7. Which is this area's staple food?
8. Is there a potential for growing other crops in this area?
9. Name the different livestock practices that are common in this area.
10. Mention the main livestock breeds that are reared by farmers in this area
11. In order of predominance, name the common income sources for residents of this area.
12. Are you employed? If yes, in which sector?
13. How can you rate poverty in this area and who are affected most?
14. What's the average land size per household?
15. In your opinion, does land size owned by a farmer determine the type and scale of farming activity to be undertaken?
16. Name the most common household energy types in this area.
17. What is the source of household fuel wood energy in your area?
18. How long does your household take to fetch a headful of fuel wood?
19. Do you readily obtain fuel wood from the forest or you venture deep into the forest to get quality fuel wood?
20. Does the community's overreliance on fuel wood pose danger to the existence of the Mt. Elgon forest?
21. How easy is it for the residents to access healthcare?
22. Say something about conflict occurrence, their frequency and its effect on the local economy.
23. Do you believe that the climate has changed in this area? If yes, what is the evidence of climate change?

24. Are there projects that have been initiated to cushion the community against the effects of climate change?
25. Is the community being involved in the identification of climate change adaptation projects?
26. Say something about the sustainability of these projects.
27. Name the institutions involved in natural resource management in this area.
28. Say something about the inter-agency cooperation, coordination and collaboration.
29. Say something about the trend in the quantity and quality of the goods and services that have historically been obtained from Mt. Elgon forest.
30. Is the natural resource management style sensitive to your community's livelihoods that you have historically obtained from the Mt. Elgon forest?

Appendix IV: Determination of the Cronbach's alpha coefficient

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.812	.832	5

Cronbach's alpha coefficients

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Rainfall unpredictability	7.00	8.737	.753	.933	.745
Increased dry spell	6.80	7.326	.843	.788	.697
Increased daily temperatures	6.00	8.632	.563	.359	.787
Unusual climatic experiences	6.50	9.316	.296	.338	.880
Increased food insecurity	6.90	7.989	.689	.936	.748

Appendix V: Mean monthly temperature in the Mt. Elgon ecosystem

(FROM 2009 TO 2017 RECORDED AT KMD, KITALE STATION)

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2017**
January	28.3	26.9	28.6	28.6	28.0	28.1	29.3	27.4
February	29.0	27.7	29.7	28.6	27.8	30.70	26.4	30.8
March	30.6	26.3	28.4	29.9	29.2	29.96	30.71	29.5
April	26.7	26.8	28.0	26.5	26.3	26.2	26.2	28.6
May	25.4	26.1	26.4	25.5	26.7	25.7	26.0	26.2
June	26.4	25.4	25.4	25.1	25.3	25.2	24.93	26.4
July	25.4	26.6	25.5	24.1	25.1	24.8	25.9	25.0
August	25.7	25.2	24.8	25.3	25.2	24.2	26.3	25.2
September	26.4	25.7	25.1	25.9	25.8	26.45	27.1	25.7
October	25.6	26.1	25.9	26.5	26.1	26.4	26.7	25.9
November	26.3	26.3	24.9	26.3	25.7	25.59	25.7	26.2
December	26.	27.2	26.0	26.1	34.1	27.3	26.4	28.3

Appendix VI: Mean monthly rainfall in the Mt. Elgon ecosystem

(FROM 2009 TO 2017 RECORDED AT KMD, KITALE STATION)

YEAR / MONTH	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	36.7	45.3	2.8	0	41.2	10.6	0.0	26.1	26.1	0.3
February	6.0	137.4	18.2	21.8	12.8	40.2	15.3	11.9	64.5	1.2
March	24.1	159.3	180.8	45.2	127.4	100.9	24.8	43.8	55.0	207.8
April	258.9	217.1	133.1	260.8	257.5	74.0	171.4	266.7	72.5	326.1
May	141.8	216.7	176.7	189.8	123.9	144.4	278.8	179.0	188.3	283.7
June	35.1	91.2	93.8	110.6	48.4	132.7	201.1	140.6	103.3	186.8
July	100.4	197.3	110.2	193.7	165.2	183.2	115.0	168.0	183.7	122.3
August	118.4	88.9	265.3	74.7	189.4	191.2	63.3	119.8	238.2	157.5

September	95.4	112.4	141.1	258.3	208.7	49.6	122.8	78.5	181.7	X
October	136	163.1	76.3	158.2	144.6	251.3	141.9	74.0	169.7	X
November	78.7	53.0	301.8	158.2	78.1	83.1	133.8	85.1	73.8	X
December	233.2	20.3	33.4	71.4	80.0	13.8	72.4	12.4	16.6	X

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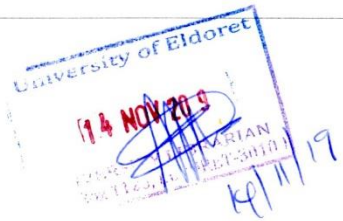

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