CLIMATE VARIABILITY ADAPTATION STRATEGIES FOR AGRICULTURAL PRODUCTION, BIO ENERGY AND FOOD SECURITY IN THE MOUNTAINOUS COMMUNITY OF THE KASIGAU AREA TAITA TAVETA COUNTY

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DECLARATION

This project report is my original work and has not been presented for a degree or any other award in any University.

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Declaration by the University Supervisors

We hereby certify that the candidate under our supervision carried out the work reported in this project report.

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DEDICATION

This work is dedicated to my wife Nancy Kawira and my daughter Natasha Mandela for their unending support and patience.

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I would like to thank everyone who helped me in the course of my study. I thank my supervisors Dr. Francis Mwaura and Professor John Maingi for their invaluable advice at all stages of this research project. I further thank Professor Kimberley Medley and Professor John Maingi for the financial support to undertake this research through National Science Foundation grant coordinated by Miami University USA.

My sincere thanks go to the people of Kasigau ,who received the entire research team with warm welcome, offered their food and drinks , above all, devoted their precious time, knowledge and energy to make the work successfully complete.

Last but not least, I would like to express my sincere appreciation to Joseph Mwamodo and Mzee Juma Zungi of Kasigau for their logistical and moral support during the field study in addition to offering me valuable knowledge of the study area.

LIST OF ACRONYMS

ACM	Adaptive Collaborative Management
NSF	National Science Foundation
CDM	Clean Development Mechanism
FAO	Food Agriculture Organisation
FCCA	Forestry Conservation Communications Association
GHG	Green House Gas
IPCC	Intergovernmental Panel on Climate Change
KAME	Kasigau Mountain Ecosystem
MDG	Millennium Development Goals
NTFP	Non Timber Forest Products
PRSP	Poverty Reduction Strategy Paper
TAR	Third Assessment Report
UNFCC	United Nations Framework Convention on Climate Change
UTM	Universal Transverse Mercator
WHO	World Health Organisation
SRES	Special Report on Emissions Scenarios
NCAPD	National Cooperation Agency for Population and Development
WRI	World Resource Institute
CBOS	Community Based Organisations
NGOS	Non Governmental Organisations
CSCC	Committee on the Science of Climate Change
HA	Hectar
RWH	Rain Water Harvesting
KNBS	Kenya National Bureau of Statistics
WW1	World War 1
ROK	Republic of Kenya
PDD	Project Design Document
KIHBS	Kenya Integrated Household Budget Survey

ABSTRACT

Climate variability has been affecting weather patterns and seasonal shifts with serious repercussions on rural households. Semi arid environments such as Kasigau are extremely vulnerable because their production systems are climate sensitive, and large segment of the population are least able to buffer and rebound from climatic stress.There is a dearth of information on agricultural adaptation strategies embraced by farmers in this region, or whether farmers are aware of the variable climate and its impacts.

This study aimed at assessing climate variability adaptation strategies for agricultural production, bio-energy and food security in Kasigau area. The specific objectives of the study were to establish how increased climate variability are affecting agricultural production, food security & bio energy in the area ; to identify people's perceptions of climate variability and to assess existing coping and adaptation mechanisms and their sustainability in consideration of predicted future climate change.

This study applied a multi-stage sampling method. Purposive sampling was employed to identify Kasigau as the study area, stratified sampling was employed in determining the sample respondents'. The study targeted five villages of Kasigau and a sample of 150 respodents were chosen from the total population.Thirty households were sampled in each of the five villages in order to ensure a wider representation and balanced distribution of respondents in the entire Kasigau. Questionnaires surveys, interview schedules, observations, checklist and data sheet were used as the main data collection instruments. Primary data was collected from interviews with key informants, focus group discussions and household questionnaire surveys using semi-structured questionnaire. Descriptive statistics was used to summarize data which included frequencies, percentages, pie charts and tables.These data were then analyzed using frequencies tables, percentages and Chi-square tests.

The survey results revealed majority of farmers (98.7%) believe temperatures have increased and that rainfall has reduced drastically .These were backed by the available data collected from Voi metrological station. Kasigau people depend on rain-fed agriculture and seasonal variability of precipitation are among the primary concerns of study respondents.The delay in the onset of the rains have significant consequences for the

production of the main food crops and severely affect food security. 96.7% of respondents believe that reduction in agricultural productivity is strongly related to increased climate variability. There is a perception that annual rainfall had reduced overally (42.0%),changes in timing and duration (56.7%), while some respondents (1.3%) believe temperature has reduced .

The study results , implied increased climate variability played apart in the occurrence of vector borne diseases (85.3%) . There existed a wealth of knowledge among the elderly on adaptation and mitigation options for increased climate variability. Some of the elderly, (4.5%) of the total respondents believe in traditional cleansing practices as a requisite to mitigate climate change. Government and local Non-governmental organizations also had projects aimed at providing relief supplies during drought in addition to re- forestation programs to mitigate the effects of climate change. 83.3% of the respondents indicated that forest coverage of the Kasigau has been tremendously reducing. These results reveal that burning of charcoal for commercial purpose (70.2%), sale of timber (22.3%), fuel wood(7.5%) are noted contributors to decreased forest cover. Some respodents reported a decline in the availability of useful trees specific for building such as *M.volkensii* (Mkurumbutu) and *Terminalia pruniodes* (Mshoghoreka). Although we noted existence of little adaptation mechanism like use of improved cooking stoves, more need to be done in terms of educating the locals on its importance as only very few families, less than(10%) had installed this.

This study concludes that there is need to support households during drought .Households need to be provided with information on early warning signs and climate related data.The study recommends more research to be done as knowledge can promote better understanding of climate change and its impacts. National and County Governments should also develop and implement integrated policies and programs that enhance farmer awareness to increased climate variability and change in addition to building resilience, and promoting transition to climate-smart agriculture.

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CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Global climate has been changing since ancient times ,this includes the glacial and inter galicial periods. Prior to industrial revolution ,human influence on the change was minimall however the current increased climate variability in the world is largely due to anthropogenic activities (IPPC, 2001).

Nganga, (2006) notes that within East Africa,there has been large variability in rainfall with occurrence of extreme events in terms of droughts and floods.Some of the major droughts in the last 20 years are namely in 1983/84, 1991/92, 1995/96, 1999/2001 and 2004/2005 .Also El-nino related floods have been experienced in the year 1997/98 and Lanina related drought of 1999/2001 within the same East Africa.

Global climatic models predict that climate change in Kenya during the 21st Century will lead to increased temperatures of about 4°C and rainfall variability by up to 20% by the year 2100 (NCAPD, 2010). One key climate change impact scenario for the ecological zones of Kenya predicts that droughts will occur more frequently with the most severe impacts in the dry lands and relatively modest impacts in the humid highlands ,Mc Sweeney, *et al*. (2010). Consequently, local food security is predicted to be more unpredictable. A recent simulation by Kabubo-Mariara and Karanja (2007), indicates that increased climate variability in Kenya will result in a 22% agricultural productivity decline in the lowland arid and semi arid areas, Zones IV, V, VI and VII as illustrated in Figure 1.1.

Maize and wheat production will be reduced dramatically in ecological zones IV and V, resulting in a spike demand that might not be met from the traditional surpluses in zones I, II and III. In such a case the total value of agricultural land in Kenya will probably be reduced by about two-thirds. The increased aridity in the dry lands could also trigger migrations into the humid highland areas which only account for approximately 20% of the country (Zones I, II and III) but provide vital watershed services to the surrounding lowlands by providing water as an essential ecosystem good.

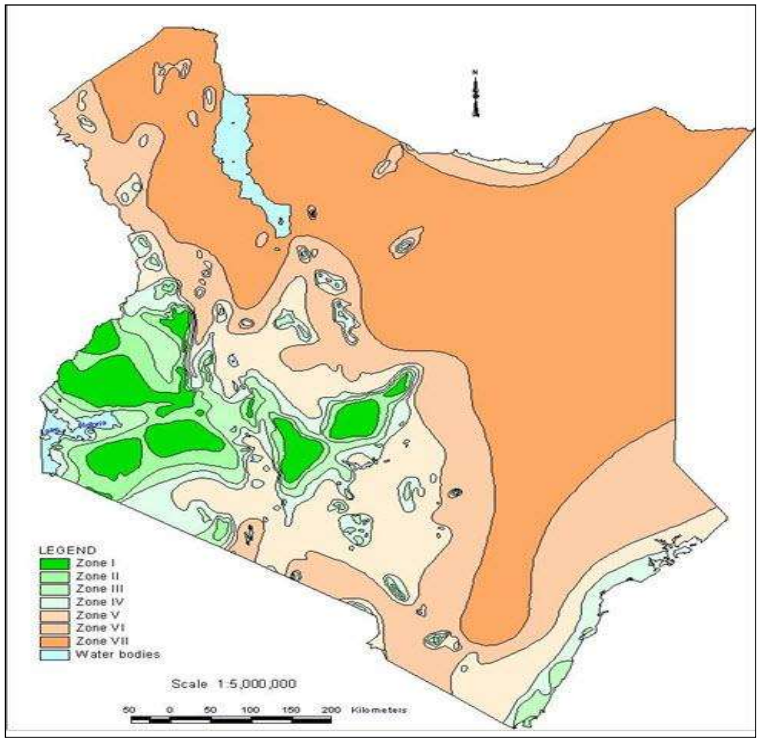

Figure 1. 1 The agro-climatic zones of Kenya: Kenya Soil Survey (2010)

Based on the Intergovernmental Panel on Climate Change (IPCC) report, increased climate variability is also likely to lead to increased bioenergy demand globally . The IPCC scenarios, specifically, scenario A1B predicts climate change would cause nearly 6-times increase in the global demand for fuelwood by 2060. This would result to fuelwood price rising and converge towards the price of industrial roundwood by about 2025 (FAO,2012).This is likely to lead to industrial roundwood,being used in energy production as opposed to its original use for pulp.Wood prices would then continue to rise steadily up to 2060, and the price of manufactured product would increase in concert . The high fuelwood harvest would imply ecologically stressed forests in several countries, even under scenario A2 with a nearly 3-fold increase in fuelwood production by 2060 (IPCC, 2012).

Increased climate variability is thus considered a global problem with threat to food security.The inherent nature of the exposure to increased climate variability and the adaptive capacity that exists will influence the severity of climate change impacts.Over 1.6 billion people living in poverty currently depend on mountain forests for their livelihoods support (WRI, 2005;World Bank 2004), eradicating poverty therefore would be impossible without integrating the concerns

of the 410 million people (including 60 million indigenous people) living in, or at the fringes of tropical forests and who depend on forests resources for their subsistence (Wiersum *et al., 2005*). Future climate change will affect society's ability to use forest resources, hence we need to incoporate studies on increased climate variability in forest management. Society should adjust by changing expectations for the use of forest resources and also identifying best adaptation options to the impacts of increased climate variability on bioenergy and agricultural production for the next 50 to 100 years. It is important for local communities to start developing sustainable adaptation strategies, including assessing forest vulnerability to increased climate variability, revising expectations of forest use, and development of forest policies to facilitate adaptation.

1.2. Research problem

Climate change and variability is affecting weather patterns with serious repercussions on poor rural households and communities in Kenya (ROK, 2010). Global aridity is on the increase, Dai,(2011) notes that global land considered arid used to be 17% in the 1950s and this has since increased to 27% by the year 2000. Since rain-fed agriculture is intimately linked to climate, policy makers have expressed concerns with respect to the possible effects of increased climate variablity on agricultural production .

As a semi-arid region, Kasigau is in the midst of the most drought-vulnerable regions in Kenya. The manifestation of climate change has resulted into unpredictable and depressed crop yields and loss of livestock, leading to recurrent food scarcities and over-reliance on emergency food-based interventions to meet local food shortages (ROK,2005). While small-scale farmers are normally more diversified across crops, maize is the main crop cultivated throughout the area reflecting cultural dependence on it as a staple food.

Thorton *etal,* (2009),notes that increased variability will have negative consequences on the productivity of plants. Maximum temperatures increases is also likely to cause yield reduction in cereal crops like maize .During drought conditions, maize crop yield is reduced by 1.7% each degree day spent above 30 °C, Lobell *et al*., (2011). Increase in climatic variability will also affect the prevalence and occurance of pests and diseases, Thornton *et al.,* (2011).

There is a scarcity of information on agricultural adaptation strategies embraced by the farmers in the study region, In addition few studies have reported on the current status of rural and remote

mountain areas in Kasigau with little known about adaptation strategies in use. According to Smit & Olga (2001),we need to examine explicitly the how, when, why and what conditions adaptation actually occurs in economic and social systems .This is crucial in designing and implementing integrated policies that will enable the small-scale farmers to operate sustainable agricultural production systems.

Effects of increased climate variablility tend to be more severe where people rely on weather dependent rain-fed agriculture for their livelihoods. In rural mountain communities with limited livelihood options, adaptive capacity is low due to limited information, poor access to services, and inequitable access to productive assets (Maraseni 2012).

The overall aim of the research was to determine how increased climate variability and change is affecting the Kasigau Mountain Ecosystem (KAME) especially in terms of agricultural and bio-energy production .

1. 3. Research questions

The following research questions were key in motivating the study:

a) Has increased climate variability affected agricultural production, food security, bio energy in the Kasigau Mountain ?
b) How do the mountain community perceive and interpret climate variability and change ?
c) What are the mountain communities' main assets and needs for coping with, and adapting to, environmental changes?

1.4. Research objectives

The objectives of the study were;

a) To establish how increased climate variability is affecting agricultural production, food security, bio energy in the area .
b) To identify people's perceptions of climate variability and change;
c) To assess existing coping adaptation mechanisms and their sustainability in view of predicted future climate change;

1.5. Hypotheses

The following hypothesis was put to test during the study;

$H0_1$: Knowledge on climate change occurrence is indepedent of the age of respondent .
H_1: Knowledge on climate change occurrence largely depends on age of respondent.

1.6. Justification and significance of the study

The importance of this study is evident with regards to increasing uncertainty about future trajectory of climate change as it poses serious challenges on the nature of change and the accompanying consequences, preventing people at different levels from making critical decisions that are necessary to adapt. In this regard, the study does not only allow the assessment of possible outcomes according to the local people in the study area but, it also builds the knowledge base to guide adaptation of people's livelihood systems.

The area of study is of importance, due to institutional constraints, adaptation is slow and populations are most vulnerable to disrupted agricultural production.According to Schozle *et al.*, (2006),the importance of forests to livelihoods support is not fully appreciated in national development plans of many developing countries.Hence we need to increase both public and policy awareness of the role of forests, develop livelihood adaptation strategies on a framework of forests goods and services without jeopardizing the integrity of such forests to future climate impacts.

This study is of significance as it is expected to serve as a model case study for other lowland dry lands that rely on mountains as a source of water and humid conditions for agricultural production in Kenya. It is meant to improve on scientific knowledge and help in formulation and implementation of policies that limit detrimental effects of increased climate variability on the environment. The study points out various adaptation and mitigation measures for the Kasigau community, based on their heavy reliance on the mountain ecosystem for water supply, bioenergy and food production all which might be heavilly affected by increased climate variability.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter discusses the available literature on climate change ,its impact ,adaptation and mitigation strategies.The major themes considered in the literature review include climate change impact ,adaptation and mitigation .The last sub-section presents the research gaps and conceptual framework.

2.2. Climate change impacts

According to, Tol *et al* .,(2004),climate change poses significant challenges to poverty reduction and economic development in many countries. Recent climate-induced disasters have had direct impacts on poor countries and on people; for example, 700 people lost their lives and 550,000 were relocated in 2000 in Mozambique due to floods ,Christie & Hanlon,(2001). Mozambique's annual economic growth rate was reduced from 8% to 2%. Emerging international attention to poverty-climate links focuses on the poor as the most vulnerable to climate change, as they have the least human, financial, and technical resources to adapt (Tol *et al.,* 2004;Sperling 2003; Burton *et al. ,*2002).

The most significant changes in climate expected during the 21st Century are with respect to temperature and temperature related parameters.The impacts of such changes will be felt in multiple sectors including: health, water, biodiversity, agriculture and forestry.In areas with perennially humid air, this has the potential to produce sultriness and the oppressive heat. On the average, vapour pressure may rise by as much as 5 to 8 h*Pa with the potential for a significant increase in atmospheric energy. One would expect from this scenario, an intensification in the intensity and frequency of stormy weather. A general decrease in cloudiness is projected. This could improve the availability of sunlight for primary biological productivity.There are possibilities, however, that the additional water need created by higher temperatures may not be met by the increases in rainfall and uncertainties regarding climate change will most likely be in terms of magnitude rather than of direction.

2.2.1Climate change impact on agricultural production and food security

Nganga, (2006),climate change will have impact on agricultural production to the already poor and small scale subsistence farmers.Change in climate and variability will have substantial

impacts on food security and malnutrition.Longer and intense droughts will be witnessed in the tropics and subtropics (Trenberth *et al.*, 2007). Heavy precipitation events will be more frequent and future tropical cyclones will become more intense (Meehl *et al.*, 2007; Trenberth *et al.*, 2007). It is by way of above impacts that climate change will negatively affect food security.

Kenya is characterized by (78%) arid and semi arid lowlands with very harsh environmental conditions (NCAPD, 2010). Kenya also has a scatter of isolated precious hills and mountains such as the Taita Hills, Chyulu Hills, Nguruman Hills, Mount Marsabit and Mount Kulal. These areas are considered as critical lifeline environments for the people, livestock and wildlife because they serve as sources of water, pasture, food and bio energy. It is therefore expected that the negative effects of increased climate variability on the mountain ecosystems will have a serious impact on people, livestock and wildlife and may create a wide range of conflicts apart from escalating ecosystem degradation. Therefore it is critical to establish how climate change could affect the ecosystem services propagated by such lifeline ecosystems in order to safeguard community livelihoods , food security and ensure environmental integrity.

Increased climate variability will affect food security interms of ,its access ,availability,stability of supplies and food utilization, (FAO, 2003). Developing countries agricultural output is expected to decline by 10-20 percent by 2080, FAO, (2003).

Effects of drought on crops and livestock, will reduce the production potential of developing countries (Hitz & Smith, 2004; Fischer *et al.*, 2005; Parry *et al.*, 2005).Increased climate variability, its resultant impact on food security, and nutrition are a great concern, particularly for developing countries. These changes, will have a major impact on the fulfilment of human rights, in particular on the right to water which is closely linked to the right to food. By 2080, it is estimated that 1.1 to 3.2 billion people will be experiencing water scarcity and 200 to 600 million hunger; (Yohe *et al.*, 2007).

2.3. Adaptation and mitigation strategies

Mitigation strategies are steps taken to reduce adverse effects of climate change.These can be technological solutions or change in societal or economic structure, Swart *et al*. (2003).Adaptation strategies are advances made by people to accustom themselves to the adverse effects of climate change Swart *et al*. (2003)

Mitigation and adaptation needs to be integrated together in all aspects of natural resource management ,Klein *et al*. (2003) and some of the barriers to their integration include limited technical capacity and poverty,(Wilbanks *et al*. 2003;Michaelowa 2001; Yohe 2001).

2.3.1.Climate change adaptation and mitigation,role of indigenous knowledge

Mundy and Compton (1991),notes that indigenous knowledge has usefulness both to the local inhabitants and also to scientist and planners. Indigenous knowledge has been applied in climate change mitigation through emission reduction, carbon sequestration and carbon substitution. Vulnerability assessment and weather forecasting are some of the areas indigenous knowledge has helped in adaptation.Mulching and fallow system of cultivation have been used by farmers in Africa to conserve carbon in soils and embrace forest development,(Schafer 1989; Osunade 1994).

Indigenous information on plants is important in agroforestry projects and in making critical decisions on which trees to grow in certain agro-climatic conditions ,(Floyd 1969). Knowledge gained through tradition is necessary for protecting bio-diversity. The World Bank has developed gene banks to preserve genetic information of local varieties or indigenous species whose genetic traits will be helpfull in future breeding programs, (Warren 1991).

2.4. Research gaps

Thornton *et al*. (2011), notes that much of the climate change impact studies pay little attention to increased climate variability. Expected variations in rainfall and temperature in the future also have high uncertainty, IPCC (2012) provides no assessment of projected variations in extremes at spatial scales smaller than that for large regions.Indeed, the prognosis for robust quantification in the foreseeable future for climate variability over short temporal and high spatial scales is rather gloomy (Ramirez-Villegas *et al*., 2013).

There is limited information in our knowledge of the effects of increased climate variability on biological systems. Craufurd & Wheeler (2009) identified several areas, including the need for more information on crop development and temperature by photoperiod interactions at the higher end of the temperature scale with regards to crops. There are key knowledge gaps with regard to the ways in which climate variability and extreme events may exacerbate multiple stresses for animals and plants, and how these stresses may interact and combine.

Most African countries still have poor data gathering and monitoring instruments ,hence need for more research to improve on collection,dissemination and analysis of climate based data.There is need to put into focus a combination of satellite and land-based information on climate to produce hybrid weather data sets with good potential to improve data problems, (Maidment *et al*., 2013).

More research still need to be done on livelihood support and ecosystem services offered by forest and mountains in general as many people still rely on the materials and ecosystem services provided by forests as sources of food, fodder, medicine, shelter, water, and building materials, and as centres of certain cultural practices (Cunningham, 2001). Also more studies on how societies are likely to adapt to the decline in supply of these all important services i.e. adaptation mechanisms.

Thembele (2008) further notes that, in order to positively influence policies dealing with rural poverty, research needs to refine and improve our understanding of resource value, currently gaps exist in our understanding mainly relating to the lack of contextual analyses of resource value both in social and ecological terms.

2.5. Theoretical framework

2.5.1. Nomenclature of vulnerable situations

Vulnerability' refers to the degree to which a system is likely to experience harm due to exposure to a hazard (Turner II *et al*., 2003). Metzger *et al*. (2005) specifies the vulnerability of ecosystems to global change with respect to a particular ecosystem service, a location, a scenario of stressors, and a time slice. Attribute of concern,system, temporal reference and hazard are mimimum essential components of characterising a vulnerable situation.

2.5.2.Classical Approaches to Vulnerability Research

The conceptualization of vulnerability varies significantly across research domains, and it has evolved over time. For instance, the theoretical evolution of hazards research is generally characterized by the following stages:

a) Pure determinism, assuming that nature causes hazards;
b) A mechanistic engineering approach, emphasizing that technology can be used to reduce vulnerability and losses;

c) The human ecology approach, arguing that human behaviour and perceptions were important; and
d) The political economy approach, arguing that structure not nature, technology, or agency creates vulnerability.

1) Risk-hazard approach/model

The risk-hazard approach is useful for assessing the risks to certain valued elements ('exposure units') that arise from their exposure to hazards of a particular type and magnitude (Kates,1985;Burton *et al*., 1978).Refers primarily to physical systems,and is more difficult to apply to people whose exposure to hazards largely depends on their behaviour, as determined by socioeconomic factors.Hazard is a function of exposure and the sensitivity of the entity exposed ,Turner *et al*., (2003) as illustrated in Figure 2.1.

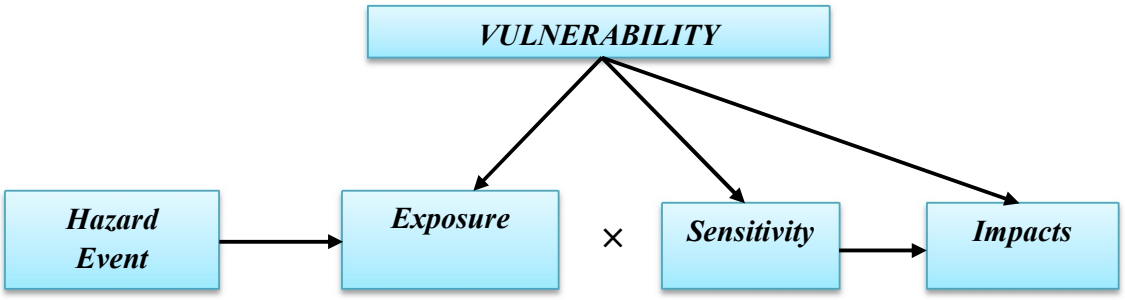

Figure 2. 1 Risk-Hazard model (Adopted from Turner *et al*.,2003)

2) Political economy approach

The political economy approach focuses the analysis on people, asking who is most vulnerable, and why, Adger & Kelly (1999). It is determined by the availability of resources and, crucially, by the entitlement of individuals and groups to call on these resources.'' It bridges the traditional concerns of politics and economics, it focuses on how power and resources are distributed and contested in different contexts, and the implications for development outcomes. It gets beneath the formal structures to reveal the underlying interests, incentives and institutions that enable or frustrate change.

3) Pressure-and-release model

Takes its starting point from the risk-hazard framework, defining risk as the product of hazard and vulnerability (Wisner *et al*., 2004;Blaikie *et al*., 1994). It then presents an explanatory model

of vulnerability that involves global root causes, regional pressures, and local vulnerable conditions.

The model understands a disaster as the intersection between socio-economic pressure and physical exposure. The model distinguishes between three components on the social side: root causes, dynamic pressures and unsafe conditions, and one component on the natural side, the natural hazards itself. Principal root causes include "economic, demographic and political processes", which affect the allocation and distribution of resources between different groups of people. Dynamic Pressures translate economic and political processes in local circumstances (e.g. migration patterns).Unsafe conditions are the specific forms in which vulnerability is expressed in time and space, such as those induced by the physical environment, local economy or social relations as illustrated in Figure2.2.

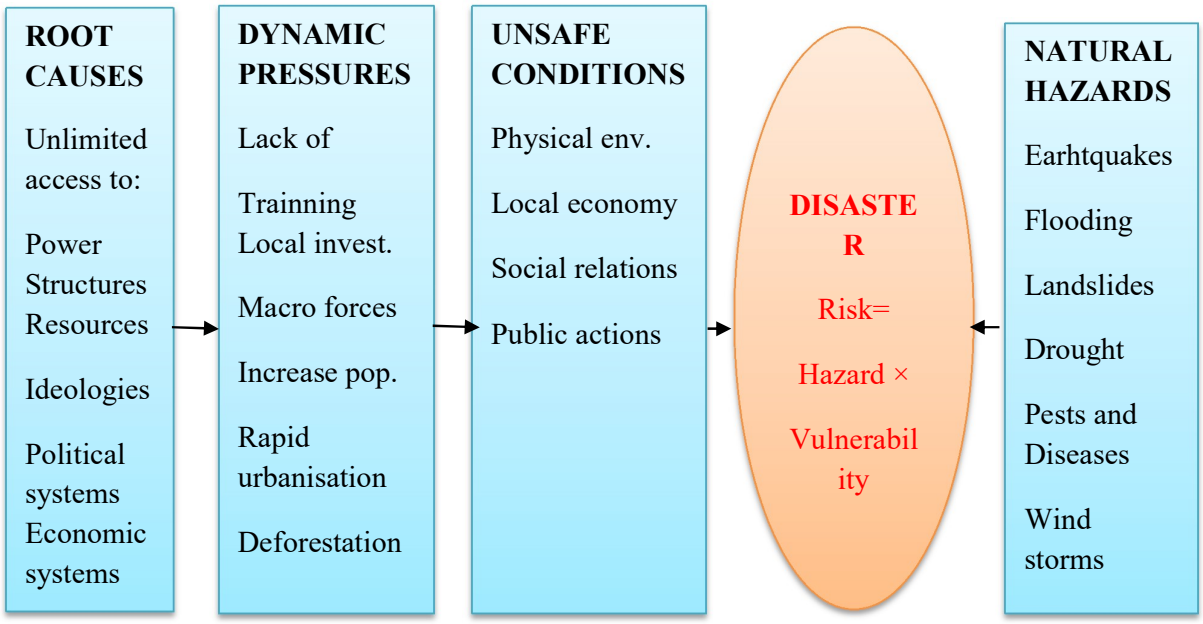

Figure 2. 2 Pressure and Release model (Adopted from Blaikie et al. 1994)

4) Integrated approaches

The risk-hazard approach and the political economy approach have been combined and extended in various integrated approaches, most notably the hazard-of-place model (Cutter, 2003) and the coupled vulnerability framework (Turner II *et al*., 2003).Integrated approaches to vulnerability research have their roots in ''geography as human ecology'' (Barrows, 1923).

5) Resilience approach

Defines vulnerability as ‘‘the propensity of social and ecological systems to suffer harm from exposure to external stresses and shocks’’. It involves exposure to events and stresses, sensitivity to such exposures , and resilience owing to adaptive capacity measures to anticipate and reduce future harm.‘An important feature of the resilience approach is its consideration of the dynamic aspects of vulnerability, as resilience denotes the ability of a system to return to an earlier (meta) stable state after a perturbation (Turner II *et al*., 2003.

2.6. Conceptual framework

Increased climate variability has considerable impact on agricultural output and bio-energy production,this has resultant effect on overall food production and security .The conceptual framework of this study gives a brief history of causes of climate change especially in the pre-historic times when it was majorly caused by volcanic activities and tectonic movements as compared to current causes which are anthropogenic and human induced in nature especially due to industrial revolution and increased emission of green house gases leading to global warming and ozone layer depletion

Increased climate variability and change is expected to result into reduced agricultural productivity especially for societies that wholly or mostly depend on rainfed agriculture.It will also lead to water scarcity due to drought and less rainfall in addition to reduced wood fuel supply leading to increased bio-energy demand .This call for need for adaptation strategies and building resilience for the affectected societies asillustrated in figure 2.3.

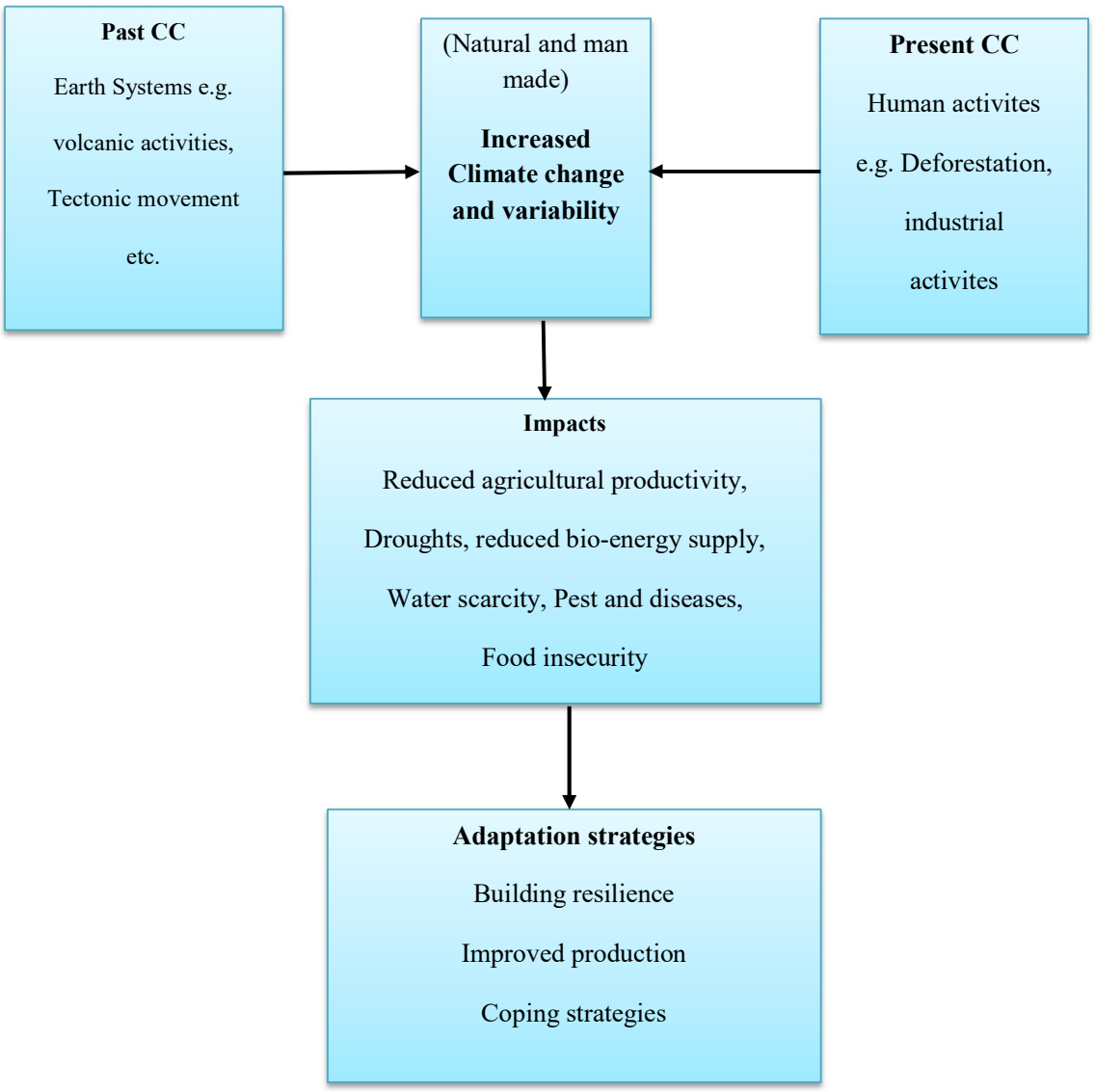

Figure 2. 3 Conceptual framework (Source:Compiled by researcher)

CHAPTER THREE

STUDY AREA

3.1. Introduction

This chapter describes various aspects of the study area. These include; the location, climate, administrative set up, landforms, flora and fauna and socio-economic activities of the study area.

3.2. Study Area

This study was carried out at Mt. Kasigau area, in Taita Taveta county,Voi sub-county. It lies in the Coast Region in southeast Kenya (3˚49'25'' S, 38˚39'40"E) in a corridor of private and communal lands between Tsavo East & Tsavo West national parks (Kalibo & Medley 2007). Located a third of the way between the Taita Hills and the Indian Ocean it rises 1600m above the Taru Desert, with savannah plains below giving way to its high montane forest. Being between Tsavo East and Tsavo West National Parks, this area is an important elephant dispersal area as shown in Figure 3.1. The study was carried out in five villages within the Kasigau including Kiteghe, Makwasinyi, Rukanga, Jora, and Bungule as illustrated in figure 3.2.

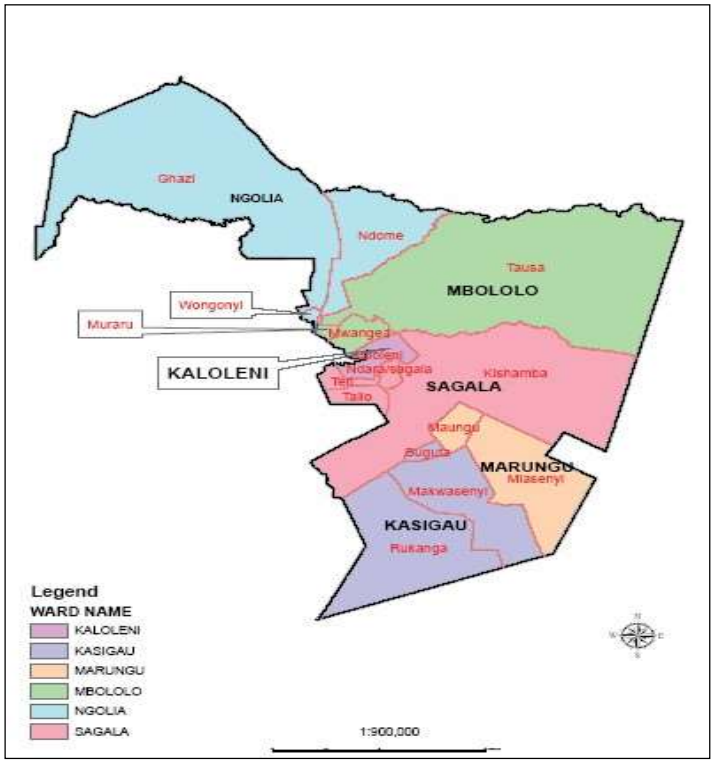

Figure 3. 1 Administrative map of Voi Constituency, Taita Taveta County (Source: Researcher)

Mt. Kasigau is the most north-eastern mountain in the Eastern Arc Mountains as shown in Figure 3.2. A recognized biodiversity hotspot in East Africa. It demonstrate a high occurrence of endemic species, a huge turnover in species among the forest patches, and among the highest densities of endemic species per unit area (Newmark, 2002).

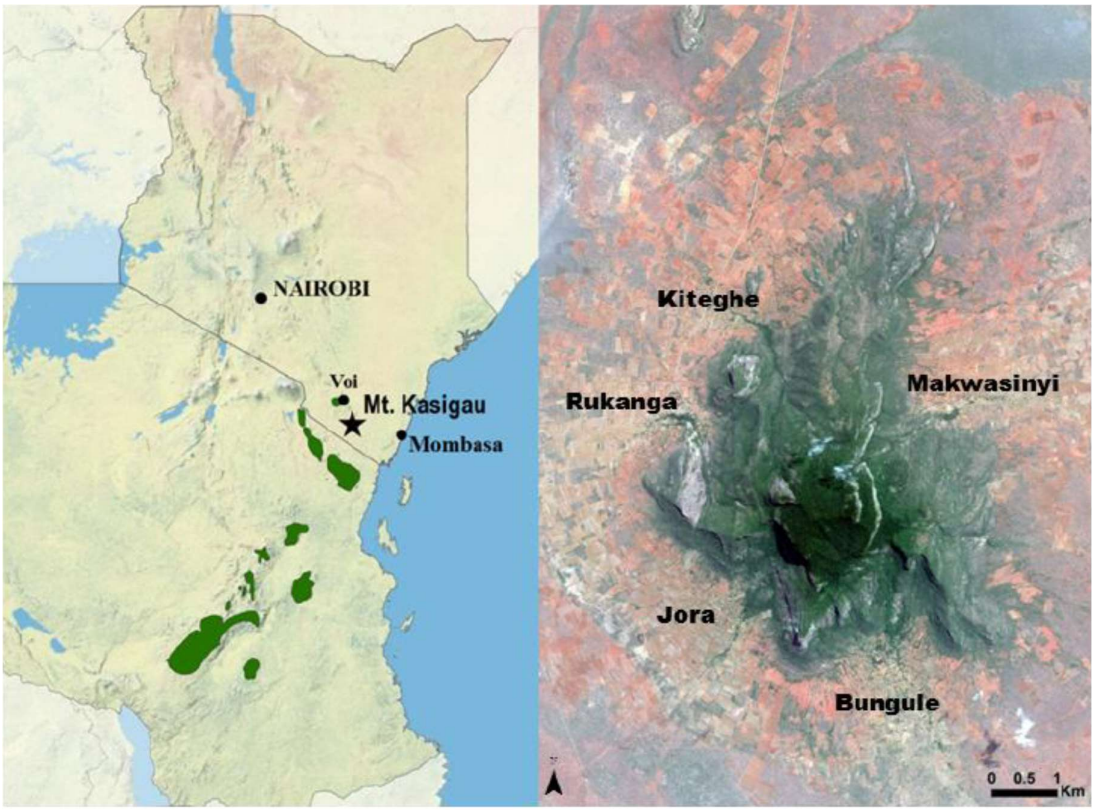

Figure 3. 2(a) Eastern Arc Biodiversity Hot Spots,Mt Kasigau (black star) and (b) Study villages,the world view 2 sattellite true color image (1.8m) resolution, modified from Maingi (2012).

3.3. Physiography

The mountain occurs as an isolated block mountain in the Eastern Arc Mountains, approximately 50 km southeast of Sagala and the Taita Hills and at least 100 km north of the Usambara Mountains in Tanzania. The main peak, Nyangala, at about 1640m exposes very old resistant "basement" granitoid gneiss, which also forms the vertical cliffs above Jora village and a distinctive inselberg to the northeast called Arc. Wasser and Lovett (1993) describe mountains in the Eastern Arc as "discrete islands associated with localised areas of high rainfall surrounded by a sea of comparatively arid woodland" (Wassser & Lovet 1993) as illustrated in Plate 3.1. Kasigau Mountain captures a critical source of moisture from the northeast (short rains in October to December) and southeast (long rains in March to May) monsoon winds flowing from

the Indian Ocean. Rainfall on the surrounding arid plains averages between 300 and 500 mm (PDD, 2011;PDD, 2012). The climate in this region of Kenya is semi-arid, with average annual rainfall in the 300-500mm range .The mountain rises steeply from 600 to 1641m in less than 2 km, and captures enough atmospheric moisture from the Indian ocean to sustain evergreen forest above 1000m (Medley and Kalibo, 2005). Greater precipitation as rainfall or mist and cooler temperatures occur at higher elevations, increasing moisture availability and resulting in distinctive vegetation changes from deciduous bushland (below 650 m) to semi-evergreen and evergreen montane woodland (650–1000 m), and to evergreen forest (>1000 m) near the mountain's summit. Mt. Kasigau has 203 ha of gazetted evergreen forest under the protection of the Kenya Forest Department. Below that zone, there is a continuum of change that includes mixed evergreen and deciduous woodland (>650–1000 m), and a lowland *Acacia-Commiphora* bush land (Medley & Kalibo, 2005).

The study area is approximately 1804 km^2 and includes montane forests on Mt. Kasigau, settlements and utilization areas in the Kasigau Trust Lands, and lowland *Acacia-Commiphora* bushand in the bordering private lands.

Plate 3.1. Kasigau Mountain - an isolated block mountain surrounded by arid woodland
(Source:Medley *et al*.)

3.4. Population

Kasigau is home to a diversity of people and cultures. Acording to the 2009 KNBS census report ,TaitaTaveta County has a total population of 284, 657,Taita sub-county has 54,732 households. An unpublished demographic survey conducted by Chief Pascal Kizaka for the Kasigau Location in 2,000 reported a population of just over 5,000 distributed among 1,040 households in the five villages , (Medley & Kalibo, 2005).

In terms of place of origin, the Kasigau Taita initially settled and farmed on the mountain many years ago, but were relocated to the coast in1914 and during WW1 (1918), when the British accused them of collusion with the German forces. After about a year, they were moved again to sisal estates near Mwatate, which is less than 50 km from Mt. Kasigau, but they were not allowed to return to the mountain until they completed an access road around 1935. Their accounts correspond with ethnographic research by Bennett (1969), colonial records from the Provincial Office for British East Africa, archaeological evidence of the former British fort at Jora and battle trenches on the mountain. According to the elders, human settlements and farms began to shift to the lowlands around 1957, by 1975 people had completely moved from their mountain homes and were fully settled in the lowland (Medley & Kalibo, 2005).

3.5. Economic activities

The Kasigau Taita are mostly small-scale farmers, who clear land in the upper bush land for crop production and maintain gardens near their homes as shown in Plate.3.2.

Plate.3.2. Agricultural farms in Jora village-Kasigau (Source: Researcher)

Staple food crops include maize, beans, cassava, and pigeon peas. Most households also keep chicken and goats and some graze cattle as a productive enterprise in the surrounding bush land. Because of the dry conditions and unpredictable rainfall, food crops often fail and result in food shortages.The sale of locally made handicrafts (woven bags) shown in Plate 3.3 , operation of retail shops ,hotels, and seeking outside employment are important sources of income to the Kasigau Taita. Most young men seek employment in cities such as Nairobi or Mombasa, or in the nearby mines (Medley & Kalibo, 2005).

Plate 3.3. Hand woven baskets in Bungule village-Kasigau (Source:Himberg 2004)

Eco-tourism is being promoted and tourists normally visit sources of rich biodiversity. Most villages have ‘’banda’s’’ which are traditional houses spectacularly perched on the hillside at the foot of the Mountain as shown in Plate 3.4.This eco-tourism project was begun to assist the communities benefit from tourism income, stop deforestation, poaching and mitigate the effects of human-wildlife conflict.

Plate 3.4. Community banda -Kasigau (Source: Kenyan camper files)

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1.Introduction

This chapter describes the study design, study population, sample size, sampling procedure, data collection and data analysis.

4.2. Study design

The research was based on the the case study design. Both qualitative and quantitative data was used.Case study was employed for intensive description of climate variability and climate change adaptation strategies for agricultural production, bio energy and food security.

4.3. Sampling method for village households

The research applied a multi-stage sampling method. Purposive sampling was employed to identify Kasigau as the study area. Stratified sampling was employed to determine the sample villages . Kasigau was first divided into five villages using the already existing boundaries with the help of local village elders and administrative officers on the ground.

A sample of 150 respodents from the total population was chosen from the five villages, one individual was to represent one household. One hundred and fifty households were sampled: thirty households in each of the five villages. The sampling of the households was done systematically in which the first household in the village was chosen randomly and latter every third homestead was chosen for interviewing.

To determine the sample size for the households, I used the Yamane (1967) equation.

$$n = \frac{N}{1 + N * (e)^2}$$

Simplified formula for proportions (Taro Yamane) n - the sample size, N - the population size, e - the acceptable sampling error/level of precision, 95% confidence level and p = 0.5 are assumed.

From this method, the result was a sample size of 289 respodents,however,due to limited financial resources, we could only sample 150 households which was divided equally among all the five villages.

4.4. Data collection

Primary sources of data included in-depth interviews and filling in checklist . Gender disaggregated focus group discussion was also used to collect data like gender based analysis on climate change perceptions and perceived changes in agricultural productivity. The secondary data used was mainly sourced from UN publications, reports, journals and relevant scholarly articles which provided knowledge on the same field of study.

4.4.1. Questionnaire survey

The questionnaires included both structured and semi-structured questionnaires,respodents of different socioeconomic strata were addressed in the in-depth interviews in order to identify potential differences in vulnerability and adaptation capacity.The time frame in which the communities were asked to report perceived changes is between 10 and 20 years or more, depending on the age of the respondent. Communities' perceptions of climate change was compared and validated with existing knowledge in formal literature and available metrological data.

4.4.2. Global Positioning System (GPS)

Interviewed households locations were recorded using hand held GPS which has an added advantage in terms of precision on location and this can be helpful in future if one is to use the same households for comparative study .It can also be used to trace source of data and its authenticity.

4.5. Data processing

The data collected in questionnaires were serialised and feed on a data sheet. Coding was developed that is compatible with SPSS version 20 to enable data entry. All the variables in the sampled data were then inputted ready for analysis.

4.6. Data analysis

Data were first cleaned, then coded for subsequent analysis. The analysis generated summary statistic for variables as well as test the emerging relationships between variables in order to answer the research questions. The sampled data were analysed using descriptive statistical techniques to show the distribution tendencies in the variables. Chi square test was used to test the significance of relationships between variables.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1. Introduction

This section presents the key findings and discussion of the study.The section is divided into demographic characteristics,land tenure ,climate variability occurance and its impacts.Food insecurity,wood fuel supply trends and drought coping mechanism are also discussed.The section on hypothesis testing explains the results of statistical test.

5.2. Household demographic characteristics

During this study ,a total of one hundred and fifty respondents were interviewed as shown in table 4.1 , 62 were male while 88 were female,more female respondents were sampled than the males, this could be attributed to the fact that more females stay in rural areas as as compared to males who normally go to urban centres to seek for employment as suggested by Nhemachena and Hassan (2007).

48% of the respondents interviewed were household heads while 52% were not. Genderwise, more household heads were male than females. Female household heads in Rukanga, Makwasinyi, Jora, Kiteghe & Bungule were 25 %, 19%, 15%, 22.2% and 35.3% respectively. Majority of the family members were between 6-7 members.

76% of respondents in study area were married, 12% divorced, 8% single which comprises of youths and only 4% were widowed as illustrated in Table 5.1.

Table 5.1. Household demography & marital status of respondents (Source: Field data)

Gender	Frequency	Percent(%)
Male	62	41.3
Female	88	58.7
Total	150	100.0

	Frequency	Percent(%)
Single	12	8.0
Married	114	76.0
Divorced	18	12.0
Widowed	6	4.0
Total	150	100.0

5.2.1 . Average education and literacy levels

The study established that majority of respondents (51.3%) have primary education, followed by non-formal (30%), 14.7% have secondary education while only 4% of those interviewed have tertiary education as illustrated in Figure 5.1. Education and human capital endowments are household characteristics that might have significant impact on adoption decisions as they are often assumed to increase the likelihood of embracing new technologies as they intensify the capacity of farmers to recognize change in climate (Nkonya *et al.,* 2008).

Similarly, education enables households to access and conceptualize information relevant to making innovative decisions (Shiferaw *et al*., 2012;Gbegeh, *et al*., 2012; Okello, *et al*., 2009; Daberkow, *et al*., 2003; Adesina *et al*., 1995). However, higher educational attainment can present a constraint to adoption because it offers alternative livelihood strategies, which may compete with agricultural production. Gender disparities in the attainment of education at different levels of schooling in Kasigau region was significant . Male respodents had attained more years of schooling than their female counterparts.

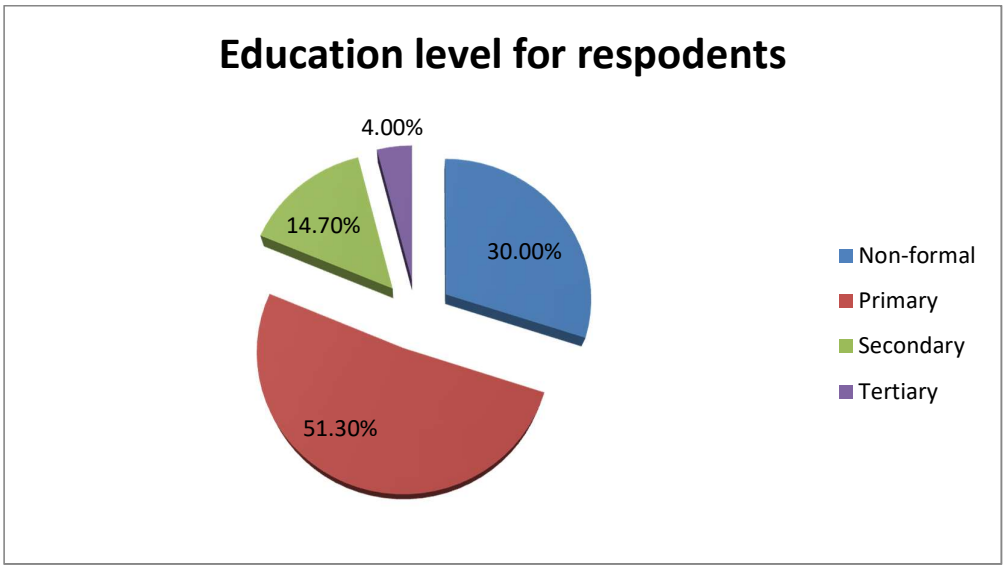

Figure 5. 1 Literacy levels (Source: field data)

5.3. Land tenure system

From the study findings , Kasiagu is a trustland which is communually owned . Land tenure security can contribute to adoption of technologies such as irrigation equipment or soil conservation practices. Farmers lack economic incentives to invest their time or money if they cannot capture the full benefits of their investments, this condition may prevail when they have

insecure rights to land or when the natural resource is governed by open access property regime. Studies in other regions have also noted that farmers who don't own land rarely adopt alternatives adaptation strategies as compared to those who own the pieces of land they settle in ,Bezbaruah and Roy (2002).

5.3.1. Land ownership comparison by gender

72.6% of the total number of males interviewed were owners of the pieces of land they settle in, while more than half of the number of females interviewed did not own the pieces of land they currently occupy as illustrated inTable 5.3.1. Hence it can be concluded that gender has a positive role in land ownership.

It is important to note that gender equity and equality has a great influence in the way natural resources are utilised and managed. Thembele (2008) carried out similar studies in South Africa's rural areas, two axes of social difference; gender and wealth emerged as key factors in determining value, through mediating, firstly, access to and control over ecological zones ; and secondly use and labour required for collection and utilisation. Hence in order to enhance the contribution of plant resources to poverty alleviation, policies should recognize the fact that resource value is primarily socially constructed.

Table 5.3.1. Land ownership comparison by gender (Source: Field data)

	Male			**Female**		
	Yes	**No**	**Total**	**Yes**	**No**	**Total**
Frequency	45	17	62	43	45	88
Percent (%)	72.6	27.4	100.0	48.9	51.1	100.0

5.3.2. Average farm size

The study established that average farm sizes are more than 3 acres,this indicates no land shortage in Kasigau, only 9.3% of those interviewed had less than one acre of the land they settled in as illustared in Table 5.3.2.These were mainly those staying in the shopping centre and dealing in small scale business,majority of who, were not natives of Kasigau like those staying in Rukanga.

Table 5.3.2. Land sizes (Acres)

Farm size	N	% of total N
Less than 1 acre	14	9.3
2 acres	39	26.0
3 acres	37	24.7
More than 3 acres	60	40.0
Total	150	100.00

Farm size influences both the access to information and the adoption decisions. More crop acreage is likely to enhance the information exposure to site-specific crop management technologies because these technologies would likely be marketed to larger farms (Marenya & Barrett, 2007; Daberkow & McBride, 2003). Given the uncertainty and the fixed transaction and information costs associated with innovation, there may be a critical lower limit on farm size that prevents smaller farms from adapting (Gbegeh & Akubuilo, 2012; Gbetibouo, 2009;Daberkow & McBride, 2003).

5.4. Household wealth status

From the research findings 0.7% of those intervied were considered rich, 26% were average, 54% poor, and 19.3% very poor as illustrated in Table 5.4, there is no significance difference in all the five villages. Hence it can be concluded that majority of the respondents are poor. This almost matches the poverty level for the TaitaTaveta from the Census that was conducted in 2009, which is 56.9% hence one of the poorest region within the country. Also according to the Kenya Integrated Household Budget Survey *(*KIHBS) of 2009, TaitaTaveta county has a poverty rate of 54.8% and an urban population of 22.6% which means the rest (77.4%) of the population live in rural areas within the county.

Similar studies by Thomas and Twyman (2004) have noted that ,real concerns exist over the dual threats of poverty and land degradation, as they increase the vulnerability of communities to environmental changes and reduce the resilience of ecosystems (Thomas *et al*. 2000).

Table 5.4. Household wealth status (Source: field data)

	Rich	Above Average	Poor	Very Poor	Total
Frequency	1	39	81	29	150
Percent (%)	0.7	26.0	54.0	19.3	100.0

5.4.1. Major occupation of house hold head

Majority (40%) of households heads depend on more than one source of income as shown in Table 5.4.1, ranging from offering labour, doing business and depending on relief supplies. Second major source of income is agriculture/farming at 37.3%, about 12.7% of the respondents are formally employed while 10% are businessmen /women. This has an effect of influencing access and affordability to coping mechanism during extreme events .

Table 5.4.1. **Occupation of household heads** (Source: Field data)

	Farming	**Business**	**Employed**	**More than one Source**	**Total**
Frequency	56	15	19	60	150
%	37.3	10.0	12.7	40.0	100.0

5.4.2. Household Livelihood Systems

The main livelihood systems was mining (33.3%) mainly in the neighbouring quarries where they look for precious metals followed closely by farming (30.3%) as shown in Table 5.4.2. The situation was found to be similar between villages. Subsistence agriculture being one of the main livelihood systems has an effect of increasing their vulnerabilities to adverse weather effects hence need for adaptive mechanism for resilience to such events.

Table 5.4.2. Household livelihood system (Source: Field data)

	Village name					
	Rukanga%	Makwasinyi%	Jora%	Kiteghe%	Bungule%	**Total%**
None	3.3	-	3.3	-	-	3.3
Farming	30.0	60	33.3	43.3	63.3	30.3
Herding cattle	3.3	-	-	-	10.0	3.3
Mining	33.3	36.7	56.7	53.3	23.3	33.3
More than one act.	30.0	3.3	6.7	3.3	3.3	29.7
Total %	100.0	100.0	100.0	100.0	100.0	100.0

5.5. Perception on climate variability Occurance

This study found out that climate variability in the last decade had occurred at Kasigau (98.7%) of respondents confirming occurance. When respondents were asked what specific changes had been noticed, majority had noticed a change in timing, duration and rainfall amounts had reduced drastically. Annual rainfall in the surrounding plains, measured at nearby Voi metrological

station was as low as 210mm (2003) and as high as 800mm (2004), and varied much from year to year as illustrated in Figure 5.5.

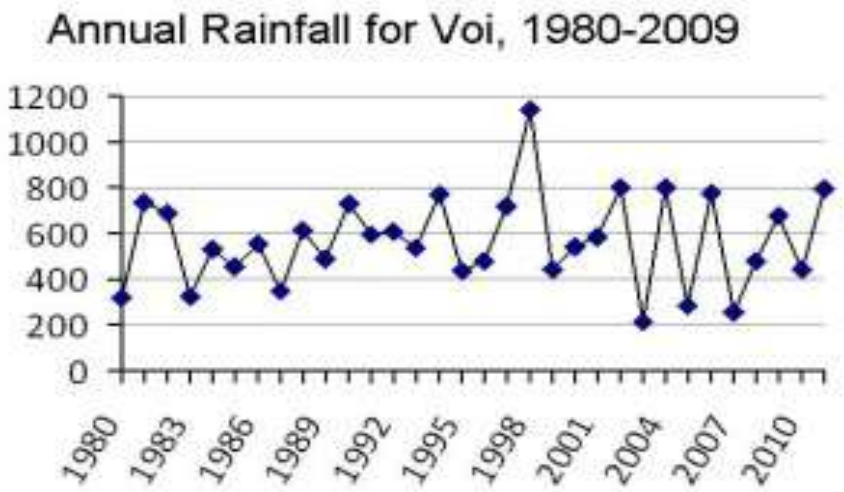

Figure 5. 2 Annual rainfall for Voi area for 30 year period (Maingi & Medley 2014)

Total monthly rainfall between 2001-2011 at Voi shows distinct seasonality and varied inter-annually (Figure 5.5.1). Annual rainfall averaged 603 mm and ranged from a high of 800 mm in 2004 to a low of 255 mm in 2007 (Table 5.5). The dry season for all years, occurred in February after the short rains, and in June, July and August after the long rains. Monthly rainfall was typically highest during the short rains (October to December) rather than during the long rains (March to May). This observation is clearly illustrated for the years 2001, 2002, 2006, 2009, and 2011 (Figure 5.5.1). In contrast, during drier years such as 2003, 2004, 2005, 2007, 2008, and 2010 rainfall amounts were similarly lower during both rainy seasons. The timing of when the rains begin and when they are at maximum also varied for the years examined. For the long rains, rainfall usually begins in February, but maximum rain occurred in March 63.63% of the time (2001, 2003, 2005, 2007, 2008, 2010, and 2011), April 27.27% of the time (2004, 2006, and 2009), and in May 9.1% of the time (2002). The short rains can begin as early as July 9.1 % of the time (2002), but reach maximum amounts in October 9.1% of the time (2007), November 45.45% of the time (2004, 2005, 2008, 2010, and 2011) or December 36.36% of the time (2001, 2003, 2006, and 2009). Based on this rainfall data, rainfall in the surrounding lowlands at Kasigau is highly variable in its timing and magnitude.

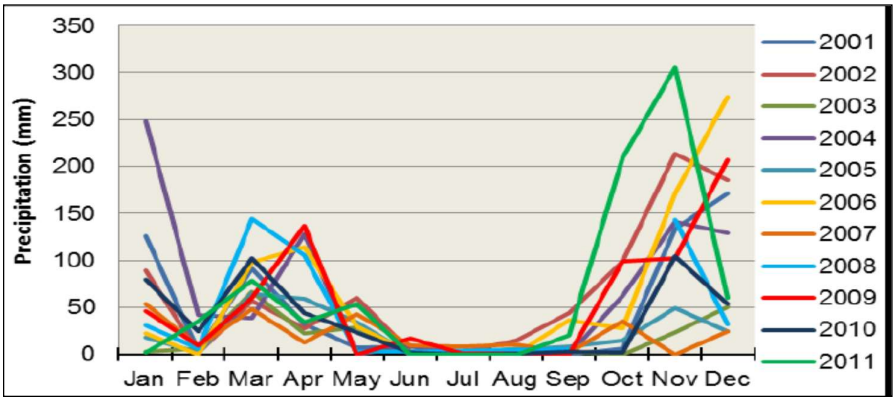

Figure 5. 3 Mean monthly precipitation at Voi (2001-2011)

Table 5.5. Annual total precipitation at Voi (2001-2011)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total(mm)	579.5	798.5	210.4	799.4	281.2	778	255.1	479.3	679	438.5	795

These study results confirm that Kasigau region has been experiencing less rainfall and multi-year droughts as a result of climate variabilty .This has a major impact on small-scale farmers whose livelihoods depend on natural resources. Although most households have developed various adaptation measures to climate variablity, the choice of such measures varies across space and is largely determined by socio-economic and institutional factors.

5.5.1.Rainfall patterns and trends

Rainfall was characterised by large intra-and inter-annual variability (Figure 5.5.2) with a significant negative trend of 36 mm per year ($y = -36.272x + 691.82$, $R2 = 0.5264$, $P < 0.001$) in mean annual values.

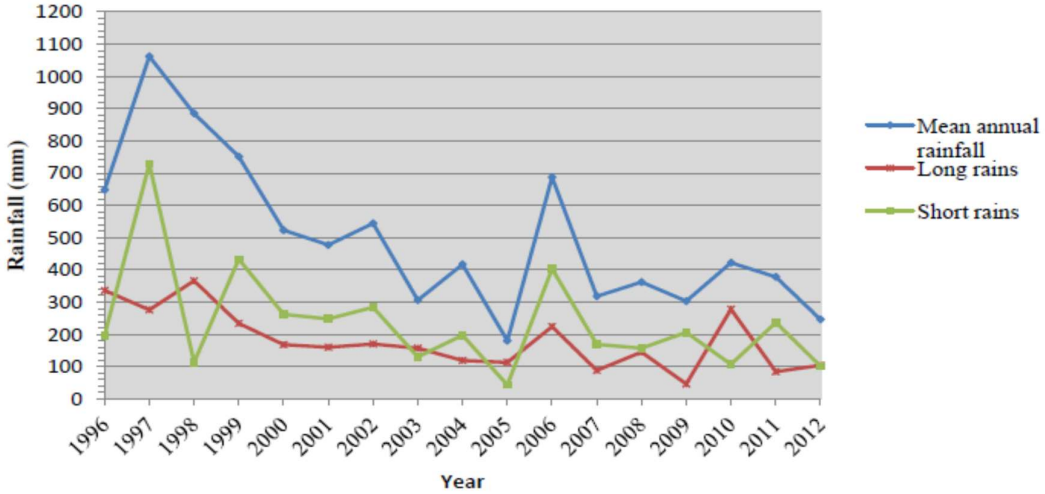

Figure 5. 4 Annual rainfall trends for Kasigau region (Source Field Data)

This trend was true for both long and short rains. Between 1996 and 2012, a mean annual rainfall of 510mm was recorded. This included 190 mm for long rains and 240 mm for the short season.Considering the study period above average rains were recorded for six years and below average for eleven years.

5.5.2. Climate variability indicators

The respondents were asked to rank the main aspect of climate variablity they had observed. Results on climate variabilty indicators per village are shown in Table 5.5.2.

Gender wise comparison : 43.95% of male respondents indicated that there was reduced rainfall, 53.24% indicated there being change in timing/duration/intensity and frequency of rainfall,1.61% reduced temperature and 1.2% showing no change in weather. Female respondents, 59.01 % indicated change in timing, duration, intensity and frequency of weather patterns, 38.11% experiencing reduced rainfall, as 1.4 % indicated reduced temperature and 1.4 % reported no change in climate.

Table 5.5.2. Climate variability indicators (Source: Field data)

Climate change indicator	Percentages (%) per village					Global
	Rukanga %	Makwasinyi %	Jora%	Kiteghe%	Bungule%	
Reduced rainfall	56.7	30.0	46.7	23.3	53.3	42.0
Increased rainfall	0.0	0.0	0.0	0.0	0.0	0.0
Reduced temperature	3.3	3.3	0.0	0.0	0.0	1.3
Increased temperature	0.0	0.0	0.0	0.0	0.0	0.0
Change in timing/duration	40.0	66.7	53.3	76.7	46.7	56.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

Studies by other scholars have also noted that increased incidences of droughts and unpredictable rainfall patterns are some of the indicators of increased climate variability in kasigau and other parts of the country Kenya, Nganga (2006).

5.5.3. Climate variability impact on agriculture

Majority (98%) of respodents indicated noticing increased climate variabilty impact on agriculture. Respondents indicated that there had been changes in agricultural calendar mostly

caused by delayed rains hence the time of planting/sowing was also delayed in recent times as shown in Table 5.5.3.

This finding is similar to other studies carried out by World Wide Fund which indicated that Taita Taveta County have experienced drought and livestock deaths as a result of increased climate variabilty (WWF, 2006). Odi (2009) also indicated that spatial and temporal variation of precipitation and increased temperatures are the main climate change related drivers, which impact on agricultural production.

Increased temperature levels is likely to cause additional soil moisture deficits, crop damage and crop diseases in addition to unpredictable and more intense rainfall; and higher frequency and severity of extreme climatic events (Boruru, Ogara & Oguge, 2011). Similarly, the drivers of climate change have the potential of altering plant growth and harvestable yield through carbon dioxide fertilization effects (UNDP 2012).

Table 5.5.3. Climate change impact on agriculture & agricultural calendar change (Source: Field data)

Climate change impact on agriculture			**Agricultural calendar change**		
	Frequency	**Percent(%)**		**Frequency**	**Percent(%)**
Yes	147	98.0	Yes	143	95.3
No	3	2.0	No	4	2.7
Not sure	0	0	Not sure	3	2.0
Total	150	100.0	Total	150	100.0

In Voi Region,maize crop yield between 1997 and 2007 declined from 10800 – 360 tonnes (Figure 5.5.3). During the same period rainfall had declined from 1,100 – 390 mm. The results show high positive correlation between rainfall and maize yields . Between 1996 and 2012, maize crop yield declined with a significant trend of 295 tonnes per year ($y = -295.22x + 5277.6$, $R = 0.819$, $P < 0.001$).

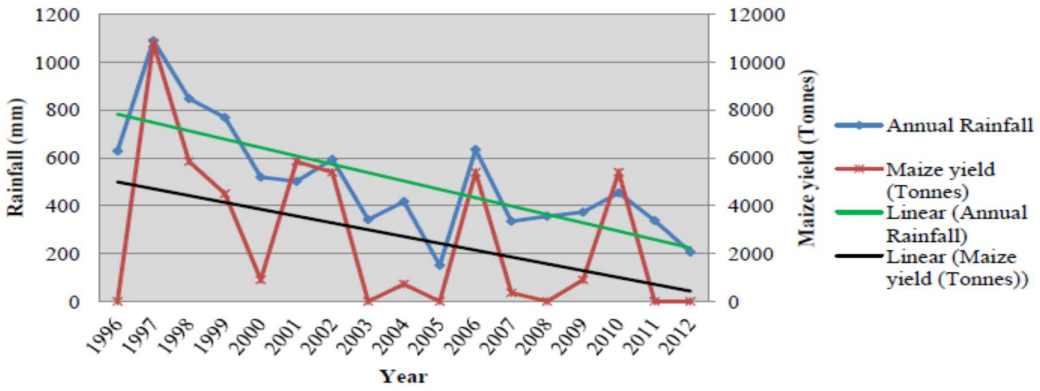

Figure 5. 5 Annual rainfall and maize yield for Voi Region (Source: Field data)

5.5.4. Changes in food crop variety

Change had been noticed in crop varieties mostly attributed to unpredictable weather, some respondents also attributed this to change in tastes, tradition and also attack by wild animals' whereby elephants do destroy certain crops hence they no longer grow them. But the greatest contributor was unpredictable climate as illustrated in Table 5.5.4. There have been numerous claims by elderly residents that they have been experiencing a reduction in the availability of some food crops, and cited a corresponding increase in the dangers associated with wild animals on the mountain especially during droughts. They recalled that in the past, there was abundant rainfall that supported growth of potatoes, sugarcane and maize at their mountain farms (Kalibo & Medley 2007).

Table 5.5.4. Factors contributing to crop variety change (Source: Field data)

	Frequency	%
No change	51	34.0
Change in taste	23	15.3
Change in tradition	9	6.0
Change in weather patterns	53	35.3
Wild animals	14	9.3
Total	150	100.0

5.6. Household food security

More than 60% of families interviewed had almost 100% of their farmland cultivated every planting season, hence decrease in food productivity could either be due to poor weather conditions or decreased soil nutrients but not farmers failing to cultivate their lands. More than half of those interviewed had also confirmed that food secure months had reduced.

The main food crops grown by the respondents include maize, pigeon peas, beans and cassava. When asked on alternatives sources of food during dry months, 44.6% bought food from the market, 38.7% dependent on NGO relief supplies, 12% on government donations, while 2% collected edible roots and leaves from the forest as illustrated in Table 5.6. More than half of respondents also agreed that they had less than half of the year as their food secure months mostly 3-6 months during the rainy season and immediately after the harvest season.

According to respodents interviewed, planting seasons used to be standard and predictable. There were two planting seasons which would produce enough harvest to last till the next harvest. Presently, planting season has become unpredictable, resulting into depressed and unpredictable crop yields. The number of food deficient months in a year is similar across the five villages.

Maize was noted as the only main food crop during prolonged drought and famine. Despite consistent campaigns in favour of drought resistant crops such as millet and cassava, people's attitude and taste have not changed with preference for maize and pigeon peas being dominant. Other challenges of food production include limited alternative use of traditional food crop and poor storage.Hence need for encouragement of older people to pass local traditional adaptation strategies like the crops to grow during drought to the young ones. Government intervention and even Non- Governmental Organisations need to do more capacity building and train locals on the variety of crops they can grow during drought. This will greatly help in reducing the vulnerability during dry weather conditions.

Table.5.6. Food insecurity alternatives & duration (Source: Field data)

Food insecurity alternatives	**Percentage(%)**	**Food security duration**	**Percentage(%)**
Government donations	12.0	0-3 Months	40.7
NGO relief supplies	38.7	3-6 Months	56.0
None	2.7	6-9 Months	3.3
Purchase	44.6	9-12 Months	-
Collet non-timber forest products	2.0	More than 12 months	-
Total	100.0	Total	100.0

Policy actors in the area had indicated that food insecurity has been a major problem among locals. Food scarcity worsens during periods of prolonged droughts as a result of this, households have devised coping strategies such as engaging in intensive public works (for food or cash),

mining in nearby quarries, rationing food intakes, reliance on food relief and sale of livestock to purchase food commodities.

5.7. Wood fuel supply trend

Table 5.7, shows majority had noticed a reduction in the availability of fuel wood over time, this they alluded to reasons of over exploitation for commercial purposes especially charcoal burning and clearing land for cultivation purposes. Both male and female had also noticed a decline in wood fuel supply trend.There was no link however of reduced woodfuel supply to increased climate variability.

Table 5.7. Wood fuel supply trend (Source: Field data)

	Village Name					Global %
Fuel supply trend	Rukanga	Makwasinyi	Jora	Kiteghe	Bungule	
No change	16.7	6.65	16.66	20.0	10.01	14
Reduced availabity	76.6	86.7	83.33	80.0	83.33	82
Increased availabilty	6.7	6.65	-	-	6.66	4
Total%	100.00	100.00	100.0	100.00	100.00	100.00

5.7.1. Household energy sources

There are two main sources,i.e; fuel wood and charcoal. Fuel wood comprises the major part (85.3%) and charcoal takes the lowest proportion, that is, 14.7%. Firewood is the main source of fuel for cooking.

There was no relationship between mean monthly income and household choice of cooking fuel. Women are responsible for fuel wood collection.They showed us places where they collect fuel wood from. During this time, they expressed that they go too far places,for example, women from Rukanga said they walk up to 8 hours to get dry and good quality wood, which means going into rangelands far away from where they stay.

They indicated (iti), (mchemeri) and (mzuzi) as the major disappearing wood fuel species as illustrated in Table 5.7.1. Fuel wood is collected from nearby bushes, only partly 12.7% collect from the forest, hence destruction of forest can also be attributed to other factors other than for fuel wood collection.

Table 5.7.1. Preference ranking of energy sources (Source: Field data)

Local Name	Scientific Name	No. of counts	Rank
Iti	*Acacia mellifera*	6	1
Mchemeri	*Acacia nilotica*	5	2
Mzuzi	*Diospyros consolatae*	4	3
Mshoghoreka	*Terminalia prunoides*	3	4
Ndashi	*Combretum exalatum*	2	5
Mkurumbutu	*M. volkensii*	1	6

5.8. Existing coping adaptation mechanism and their sustainability

From data in table 5.8, its evident that majority don't have options to even migrate when faced with unfavourable effects of change in climate and vagaries of adverse weather conditions (76%), 20.7% consider moving into the Kasigau forest, and 3.3% out of the Kasigau area to nearby towns to seek employment opportunities. Those who consider moving into the Kasigau forest (20.7%), do so most probably because of the potential benefits they would derive by extracting forest resources. This includes extraction of forest resources for food,fodder,income generation through illegal charcoal and timber sale.Local plants are also used for dyes in basket weaving ,all these are clear contributions to their 'short-term' security.

Table 5.8. Household migration options due to increased climate variability (Source: Field data)

	Frequency	**%**
Out of Kasigau to nearby towns	5	3.3
Into Kasigau forest	31	20.7
No alternative	114	76.0
Total	150	100.0

There is extra-local support from wildlife works which runs conservation project in the area, hence need for more asset based support . Rain water harvesting,soil conservation practices, and change in time of planting to fit into the current weather patterns are some of the coping mechanisms employed by farmers.

A significant finding that also emerged is the re-introduction of traditional drought resistantl crops like cassava and sorghum. In addition, the community has adopted the cultivation of early-maturing crops such as pigeon peas and improved varieties of maize

5.8.1. Gender based analysis-drought coping strategies

This study analysed the measures that were identified as farmers' responses to increased temperatures and reduced precipitation based on gender and the findings indicated (48.86%) of the females, had more than one strategy, (2.27%) believed in migration to nearby towns, (18.18%) in relocating their livestock to other areas, (3.41%) in changing crop varieties/sowing period ,(2.27%) in getting help from neighbouring villages ,(4.55%) in traditional cleansing, (12.5%) would rely on prayers while(7.95%) had no strategy. The responses were not very much different from the males as illustrated in Figure 5.8.1..These findings depicted a society that does not have enough coping mechanism hence highly vulnerable to disasters although many respodents reported ongoing adjustments whenever there is drought.

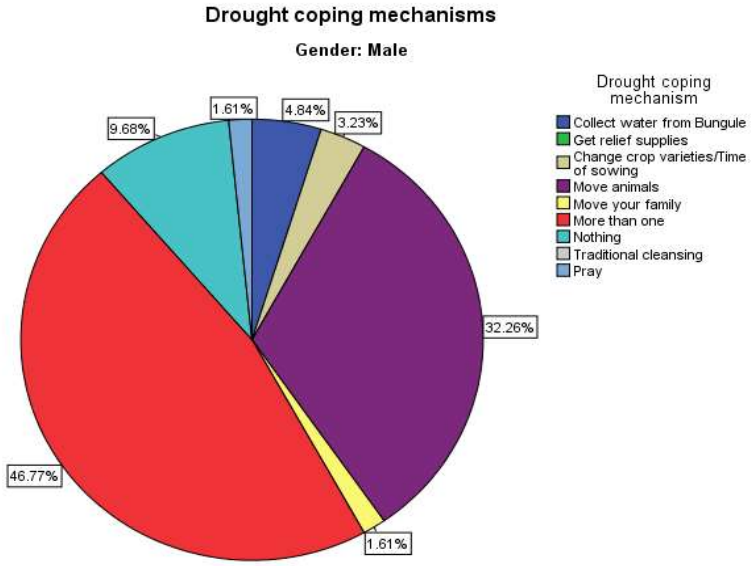

Figure 5. 6 Drought coping mechanism in Kasigau-male (Source :Field data)

5.8.2. Suitability of drought coping strategies

Of those interviewed 89.% indicated that the existing drought coping strategies are not suitable for the long term.There is need for funds to be channelled through local institutions to facilitate practical community-based climate change adaptation strategies in addition to capacity building for the local households.

5.9. Hypotheses testing

The Chi-squire test was used to determine if respondent age could have significant influence on knowlege about climate change occurance , two-sided asymptotic significance of the chi-square statistic was 0.975 to the displayed precision, as shown in Table 5.9. Since the significance value is clearly more than 0.05, you can conclude that there is no significant relationship between the age of respondent and their knowledge on climate change occurance. Hence knowledge on climate occurance could be influenced by other factors like level of education and even awaress and not necessarily their age as a factor.

Table 5.9. Correlation between respondent's age and knowledge on climate change occurance (Source: Field data)

Correlations			
		Respondent age	**Climate change occurrence**
Respondent Age	Pearson correlation	11	-.003
	Sig. (2-tailed)		.975
	N	150	150
Climate change	Pearson correlation	-.003	1
	Sig.(2tailed)	.975	
	N	150	150

We fail to reject the H_0,since the H_0 cannot be rejected ,and that is there is no significant relationship between the age of respondent and knowledge on climate change occurance was not adopted.

CHAPTER SIX

SUMMARY OF FINDINGS CONCLUSION AND RECCOMENDATIONS

6.1. Introduction

This chapter is divided into three sub sections**.** The first sub-section provides the summary of results, the second sub-section provides the conclusion from the findings while the last sub section outlines the recommendations for further research.

6.2. Summary of findings

The study examined farmers' perceptions of short- and long-term variability in climate, their ability to discern trends in climate and how the perceived trends converge with actual weather observations in Voi Metrological Station.The area is semi-arid with high intra- and inter-annual variability in rainfall.Rainfall records for the survey locations were obtained from the Kenya Meteorological Department and were analysed to compare with farmers' observations. Farmers' responses indicate that they are well aware of the general climate in their location, its variability, and the effects of this variability on agricultural production.

Farmers observations in our study area that rainfall patterns are changing, corroborated well with reported perceptions from other places across the region and were supported by the observed trends in rainfall data from the metrological station.

This study revealed that the locals had already anticipated impacts of increased climate variability on their livelihoods and surrounding environment and they had started to adapt in various ways. Respodents in the study area depend on rainfed agriculture as a source of livelihood support,hence if rainfall fails or becomes unpredictable,this will have significant effects on the production of food crops and ultimately affecting food security.

Food security is diminished when food systems are stressed. Such stresses may be induced by a range of factors in addition to climate change and/or other agents of environmental change and may be more severe when these factors act in combination.

One of the essential 'safety net' when crops fail is livestock rearing. Sorghum and cassava also complement family food needs when maize crops fail.Interestingly some respodents admitted

to‘doing nothing’ when it gets too dry, but waiting until the weather improves while some reported a range of adaptation strategies, with diversification of the farm portfolio leading to diversified farm income and helping them to adapt to climate variability.

Most homes reported less food production from the April-May ‘long’ rains, predicting food shortages and a reliance on purchases for at least four months. From the findings ,it was noted that there was a decline in the availability of useful building trees like *M. volkensii* (Mkurumbutu) and *Terminalia pruniodes* (Mshoghoreka) around homesteads. The bushland has also become increasingly important as the main source of building materials and wood fuel supply.

Mombasa city also provides seasonal employment for farmers. During the study ,there was existence of little adaptation mechanism to reduction in wood fuel supply like use of improved cooking stoves using fuel wood but more need to be done in terms of educating the locals on its importance as only very few families (less than 10%), had installed this. The study continues to document, a diversity of extractive products from the forest that support their livelihoods, especially for food(2%),’wild honey’(3%), construction projects(60), fuel(30), fodder(2%), local medicines(1%), and(2%) fruits.

6.3. Conclusion

Local knowledge and statistical analysis indicated a trend of current intra-annual variation in temperature and rainfall and the incidence of extreme events was common. Farmers in Kasigau are exposed to climate variability at intra-and inter-annual and decadal time scale. The increasing climate variability and reduction in precipitation have serious implications for food production and availability. Farmers perception indicate that they are aware that the region is experiencing more incidences of drought.

Most of farmers who perceived a change in climate occurance indicated having a means of adaptation. The trend also shows forest coverage of the Kasigau has been reducing. According to the farmers of the area, the reduction is due to the rapidly increasing population with its resultant effect on settlement and farmland expansion. Also burning of charcoal for commercial purpose and sale of timber plus fuel wood are noted contributors to decreased forest cover .

Increased climate variability will most likely increase the percentage of individuals facing hunger(FAO,2005). In sub-Saharan Africa, climate variability and extreme weather events are

among the main risks affecting agricultural productivity and hence rural household food security. A failure of the rainy season is directly linked to agricultural failure reducing food availability at household level as well as limiting rural employment possibilities.

Most farmers have embraced at least one adaptation strategy . However, the fact that most farmers have taken up adaptation measures to their agricultural practices does not imply that those adaptations are suitable to local contexts. While farmers in Kasigau have, for a long time, developed local strategies to cope with erratic environmental shocks, increased variability and extreme weather events have exceeded the present coping range and adaptive capacity. Enhancing adaptive capacity is therefore indispensable to strengthening resilience and reducing vulnerability.

Some of the adaptation startegies employed by farmers include plating different crop varieties ,crop diversification, having different planting dates with regards to changing weather conditions, changing from crops to livestock and change from farming to non-farming activity. There is also an attempt to increase use of water conservation techniques, tree planting and offering prayers or ritual offering.

6.4.Recommendations

This study recommends urgent need for identifying the vulnerable communities in Kasigau and assessing their vulnerability from different perspectives that climate change might expose in the future. It also recommends implementing the present pro-poor policies of the government in an effective way to improve the socio-economic conditions of the poor and vulnerable communities in the country.

Although most residents in Kasigau demonstrated strong self-interest in adapting, numerous obstacles constrain their options. Other interventions for the community and individual households to take up appropriate adaptation options include:

- Enhance opportunities for small-scale irrigation, and water harvesting. However, irrigation investment should guarantee high water use efficiency , besides building farm level managerial capacity. This will require revision of existing policies and institutional frameworks in water and agricultural sectors.

- Promote formation of local rural institutions and farmer groups, and create more opportunities for livelihood diversification.
- Encourage transition to climate-smart agriculture that take an agro-ecological approach, rely less on natural rainfall, invest in long-term soil health, and use fewer external inputs, but guarantee food security.
- The county government through its department of the environment should promote alternative sources of energy; initiate aggressive campaign on tree planting and reforestation; increase surveillance and enforcement of existing regulation on charcoal trade; increase education on integrated pest management and the extension services; promote an integrated approach of conservation initiative in addition to promotion of afforestation activities in forests and farm.

6.4.1: Recommendations for further research

(1) Good rural development practices, particularly where landscape approaches are applied, and ways to integrate climate-change adaptation and mitigation into rural development;

(2) Appropriate incentive systems to promote agroforestry and indigenous species, as options for addressing mitigation and adaptation simultaneously in a landscape applying incentive- based approaches and

(3) Environmental indicators for monitoring the impacts of integrating mitigation and adaptation on farms and in agricultural landscapes and to act as the basis for targeted incentives.

Further research should also be promoted to:

- Improve the availability and quality of meteorological monitoring data, enhance climate modelling with robust articulation of uncertainties, and promote farmer awareness to the impacts of climate change through extension services.
- Review farmer extension systems and design farm management adoption programmes based on the socio-economic characteristics, such as years of schooling and membership to social groups of smallholder farmers.
- Considerable attention should be put to bridge the knowledge and data gaps in our understanding of effects of increased climate variability on biological systems,like those regarding the impacts on the prevalence, incidence and severity of crop and livestock diseases.

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APPENDICEX: QUESTIONNAIRE

Appendix 1: Questionnaire For The Community
SECTION A
RESIDENTIAL INFORMATION
This section is to be filled with the help of research assistants

Date; Day……Month…Year… Questionnaire number…….

Name of the village? - Tick as appropriate

(a) Rukanga (b) Makwasinyi (c) Jora

(d)Kiteghe (e) Bungule

2. GPS readings on the ground (coordinates) ……

3. Elevation (m) ……

4. Distance from KAME - i.e. distance from the forest edge

(a) 50m (b) 100m (c) 200m

(d) 1km (e) >1km

SECTION B

As you stay near Kasigau Mountain Ecosystem, I would; like to have a very frank opinion about how it affects you and your daily lifestyle activities.

HOUSEHOLD CHARACTERISTICS

Kindly give your household details

1. Name of respondent (optional) …….

What is your age? ……

Marital status; (a) Single (b) Married

Gender (tick as appropriate)

(a)Male (b) Female

Education level

(a) No formal education (b) Primary

(c)Secondary (d) Tertiary

6. Farm size (acres)……what is the size of your farm in acreage

Less than 1 acre

2 acres

3 acre

More than three acres

7. Does the land which you currently settled in belong to you?

(a)Yes (b) No

If the above question is yes, did you,

Inherit it as ancestral land?

'Buy it?

Others i.e. communal land owned by the community

8. For how many years have you settled in the farm?

1-5 years

5-10 years

10-15 years

More than 20 years

9. Are you the household head?

(a) Yes (b) No

10. What is your role within the family?

Mother

Father

Child

Others i.e. Relative

11. What is the size of the family you currently live with in terms of numbers ……?

How many males are in the household? ……

How many females are in the household? ……

12. What is the main Source of income for the household?

Agriculture alone

Remittances

Other e.g. salary/business

Agriculture and labour

13. What is the occupation of the household head?

(a) Farmer (b) Businessman (c) Formal employment (c) Others i.e. offering labour

14. How would you rate the status of your family in terms of wealth?

Rich

Above average

Poor

Very poor

****

HOUSEHOLD AGRICULTURE AND FOOD PRODUCTION -

Could you please describe your daily activities? , What are your main activities from the morning when you get up until the evening when you go to bed?

(a) Farming (b) Herding cattle (c) Others i.e. providing labour and other services

What is the total % of land owned by the family that is put under cultivation

100 % (b) 50 % (c) Less than 20 % (d) None

Is there any other land that is under cultivation .i.e. rented?

(a)Yes (b) No

What are the main types crops being grown in the area

(a) Subsistence crops (b) Cash crops

Per each growing season, what is the percentage of the crop that is being sold in the market for commercial purpose?

(a)More than 90 % (b) More than 50% (c) Less than 20 % (d) None

Does crop production meet the food requirements for the family per crop?

(a)Yes (b) No (c) Not sure

List the crops for which additional food is required from other sources other than those grown by the family;

(b) (c) (d)

What are the other sources of food for the household apart from agriculture?

Have you been facing problems with agriculture in the recent past?

(a)Yes (b) NO (c) Not sure

If yes can you list them

(a)Decreased crop productivity (b) Increased crop yields (c) Increased pest and diseases

12. When you think back, have there been any major changes between now and 10/20 years ago in terms of agricultural production,

(a)No (b) Yes (c) Maybe (d) Not sure

Kindly explain?

HOUSEHOLD ENERGY AUDITS

What is the main type of energy that is being used by the family for cooking

(a) Electricity (b) Wood fuel (c) Biogas (d) Others

How many times per week do you collect firewood

(a)Daily (b) After every two days (C) Weekly (d) After more than two weeks

What is the main source of the firewood that is used by the family

(a)Kasigau forest (b) Nearby bushes (c) Neighboring rangelands

Kindly list a few of the types of firewood and charcoal trees

(b) (c)

If the family were to buy wood fuel or charcoal from the market, how much would it cost?

(a) Per week (b) Per month

When you think back, have there been any major changes between now and 10/20 years ago in terms of wood fuel supply and availability?

(a) Yes (b) No (c) Not sure

Kindly elaborate

Has the availability and abundance of any major tree type for fuel wood or charcoal changed?

Yes (b) No (c) Not sure

How has it changed?

How does this affect your household fuel demand?

Increased (b) Decreased (c) No effect

HOUSEHOLD CLIMATE CHANGE PERCEPTION ANALYSIS –

Please describe the main weather events that happen during the year (e.g. rainy season, dry season, cold season and so forth)

When do these events occur ? …… How long do they last ?

Have you observed any changes in the past 10/20 years in terms of occurrence of these events? …….

What kinds of changes have taken place?

(a)Timing (b) Duration (c) Intensity (d) Frequency

What kind of climate changes have taken place in the last 5-10 years in the farm

(a)Reduced rainfall amounts (b) Increased rainfall (c) Increased drought

(d)Reduced drought (e) Increased temperature (f) Reduced temperature

When you think back, have there been any major climate changes between now and 10/20 years ago within the Kasigau Mountain Ecosystem?

(a)Yes (b) No (c) Not sure

Kindly elaborate' ……

When you think back, have you experienced changes in precipitation patterns i.e. either erratic or lack of it?

(a) Yes (b) Not sure (c) No

Kindly elaborate?

T o the best of your memory ,has your area been experiencing decline in agricultural productivity in the recent past that might be related to changes in weather patterns?

Yes (b) No (c) Not sure

8. To the best of your memory, have there been changes in agricultural calendar within the area, i.e. like changes in plantation time or delayed sowing period?

(a)Yes (b) No (c) Not sure

9. When looking back in the last 20-25 years, do you think you there have been changing crop variety types within the Kasigau area?

(a)No (b) Yes (c) Not sure

If yes, what could be the contributing factor?

(a)Change in tastes

(b) Change in tradition

(c) Change in weather patterns

10. How do these changes influence your daily lifestyle and activities?

IMPACT OF CLIMATE CHANGE ON FOOD SUPPLY AND MITIGATION OPTIONS

Have you observed any new diseases affecting your livestock and crops over the past 10/20 years?

(a) Yes (b) No (c) Not sure which ones? …….. When did they occur for the first time? …… Do they occur every year? …….. Why do you think they occur? .....

Have you observed any new pests affecting your livestock and crops? (a)Yes (b) No .Which ones? ……

When did you notice them for the first time? …….. Do they occur every year? ……. Why do you think they are occurring? …….

Have you observed any new health problems that have affected you and your family? (a)Yes (b) No If the answer is yes, which ones? …….. Are there any health problems which have diminished or disappeared? (a)Yes (b) No If the answer is yes, which ones? Why do you think they have diminished or disappeared?

Do the changes you have mentioned impact on the availability of food for your household throughout the year? (a)Yes (b) No (c) Not sure

If yes, in what way?

(a)Less food (b) More food (c) No change (d) Uncertain

Has your overall food production changed? (a)Yes (b) No (c) Uncertain If yes in what way and why?

((a) Less harvest output (b) More harvest output (c) No change (d) Uncertain

For how many months a year does your family have enough food?

0-3 months (b) 3-6 months (c) 6-9 months (d) 9-12 months

Has this changed over the last 10/20 years? (a)Yes (b) No (c) Not sure

If yes, how and why? .....

Has there been any change in terms of food diversity?

(a)Less diverse (b) More diverse (c) No change (d) Uncertain

What are the expected changes in household food production in the next 10-20 years

(a)Increased production (b) Reduced production (c) No change

What are the household plans to deal with the expected changes in food supply, and budget?

How do you expect the availability of food in the village to change in the next 10-20 years? (a)Reduced availability (b) Increased availability (c) No change

By how much will the household increase the farming area for higher food production?

Which are the available alternative food crops in drier conditions?

(a) (b) (c) (d)

Which are the alternative food sources for the household?

(a) (b) (c) (d)

.Which are the alternative farming practices?

(a) (b) (c) (d)

Will household consider migrating into other areas for better access to food i.e.

Migrate out of Kasigau to another area

Migrate into the Kasigau Forest

Etc

IMPACT OF CLIMATE CHANGE ON ENERGY SUPPLY AND MITIGATION OPTIONS

What are the household plans to deal with the expected changes in bio energy supply, and budget?

Which are the alternative firewood and charcoal trees?

(a) (b) (c) (d)

Can you consider migrating into other areas for better access to firewood if conditions get worse

Migrate out of Kasigau to another area

Migrate into the Kasigau Forest

Etc

CAPACITY ANALYSIS; COPING AND ADAPTATION MECHANISMS

What do you do when there is too little rain/water or there is an unusually long dry period?

What do you do with your crops during such events i.e.

(a) Do you change varieties (b), timing of sowing/planting or harvesting, (c) irrigate the land?

What do you do in your household/in the community? Who is dealing with this problem

(a)You (b) Your husband/wife, (c) Other family members, or (d) Community as a whole

5).Are these strategies still useful today? Or what, in your view, needs to be done? Who could help you?

7). what do you do when there is a flood?

(a) (b) (c) (d)

8) How do you protect your crops, your animals, your children, and your houses and personal belongings?

9) Are these measures still sufficient today? Or what, in your view, needs to be done?

10) Who is responsible for which measures? Do you help each other out within the community? Do you get support from outside? What kind of support would you need?

Thank you.