UNIVERSITY OF NAIROBI

ENHANCING CLIMATE CHANGE ADAPTATION THROUGH UTILISATION OF SOCIAL AND ENVIRONMENTAL OPPORTUNITIES FOR AGROPASTORAL COMMUNITIES OF KIENI IN NYERI COUNTY

BY

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I85/90641/2013

A Thesis submitted in Partial fulfilment of the requirements for the degree of Doctor of Philosophy (Ph.D.) in Climate Change and Adaptation in the Institute for Climate Change and Adaptation (ICCA) of the University of Nairobi

2018

PLAGIARISM STATEMENT

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DECLARATION

I hereby declare that this thesis titled "Enhancing climate change adaptation through utilisation of social and environmental opportunities for agropastoral communities of Kieni in Nyeri County is my original work and has not been submitted for a degree in any other University.

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DEDICATION

This thesis is dedicated to my husband Mr Peter Mburu, our adorable sons Kayden Mburu, Kylian Ndiritu and my parents Mr and Mrs Nderitu. Thank you for your prayers and encouragement throughout this process. May God bless you abundantly.

ACKNOWLEDGEMENTS

I would like to acknowledge the agropastoral community of Kieni Sub-county for their insightful support throughout the research period. I am forever grateful to the community based organisations (CBOs) leaders and the agricultural officers in charge of the area for their endless support and guidance on key information resources. I acknowledge my local guides Mr Wachira and Mr Mureithi who helped with local logistics. To Mr Njoroge-the Kieni West Agricultural officer I say many thanks for making it possible for me to meet with the other officers, experts and the different commercial village groups. To the officers at the National Drought Management Authority in Nyeri, I say a big thank you. Special thanks to Mr Muriungi-the Hydro-Met Research Assistant at the Centre for Training and Integrated Research in ASAL Development (CETRAD) and Sasini Mweiga Farm Manager for providing me with the climate data.

This work would not have been successful without my supervisors: Dr Christopher Oludhe and Dr Adan Ali. I thank you for your support, encouragement, technical guidance, supervision and availability for consultation throughout this journey. To Dr Maggie Opondo, thank you for your guidance in concept and proposal writing. I would like to appreciate Dr Philip Omondi from the Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre ICPAC for guiding me through the climate extreme indices analysis. To my classmates, Dr Bobadoye, Mary, Mildred, Stellamaris and the late Dorothy Adoyo, I am forever grateful for your encouragement when the journey was tough. I acknowledge and appreciate the support, prayers and encouragement of my entire family- my husband Peter and our sons Kayden and Kylian, my parents Mr. and Mrs. Nderitu and my friends Dr Sarah Gitau of Technical University of Kenya, Faith, Elosy, Murigu, Murimi, Makui and Wangunyu. To you all I say God bless you.

The financial resources for this study were provided by my husband Peter and B&S Group of Companies in Juba, South Sudan. I am forever grateful for your support. Finally I would like to give honour to our Almighty for enabling me to go through this PhD studies in good health and surrounded by love.

ABSTRACT

Climate variability and change pose challenging negative impacts to the livelihood systems of the agropastoral communities in Kieni. However, despite the challenges, climate variability and change do present numerous opportunities that these communities can utilise to enhance their own adaptive capacity. This study was therefore conducted to explore the understanding and use of social and environmental opportunities offered by climate variability and change for agropastoral communities of Kieni Sub-county in Nyeri County. The study adopted a transdisciplinary approach to assess and understand the complexity at local levels and how to overcome barriers to adaptation in the local environmental scenario. Primary data was obtained through Focus Group Discussions (FGDs), field observation, household and community surveys and key informant interviews. A total of 383 households were surveyed, twenty key informants interviews and four Focus Group Discussions conducted. Daily temperature and rainfall data were also analysed for the period 1991-2015 for temperature and year 1985-2015 for precipitation using the WMO-CCI/CLIVAR recommended guidelines where a total of 27 indices were analysed. The climate data was obtained from Kenya Meteorological Department (KMD). Data was analysed using statistical package R software and CRiSTAL tool that was used to analyse qualitative data. Mann-Kendall test was used to test statistically significant climate trends. From the analysis of extreme indices, the maximum and minimum temperature in Kieni shows positive trend, portraying an overall increase in daily maximum and minimum temperature. However, the monthly maximum value of daily maximum temperature (TXx) and monthly maximum value of daily minimum temperature (TNx) showed a decrease over the period 1991-2015. The number of days when TN<10^{th}percentile (cool nights) and number of days when TX<10^{th}percentile (cool days) have increased in Narumoru Gate Park met. This means that the area is cooling, offering an opportunity to exploit growing of crops that do well in cold areas and keeping livestock that can adapt to colder climate. In rainfall, the observed monthly maximum 1-day precipitation (Rx1day), showed significant trend in Sasini Weather Station.

Simple Daily Intensity Index (SDII) which shows days with precipitation amount on wet days with rainfall amount greater or equals to 1mm showed general increase in all the three weather stations with Munyaka Weather Station presenting a significant trend. The Consecutive Wet Days (CWD) with rainfall greater than or equal to 1mm has generally decreased in all the locations with Munyaka showing statistically significant trend.

The study also showed that the area is receiving more successful short rains seasons. This was triangulated with the FGDs where participants indicated that the short rains are proving to be more reliable and the community is utilising it to plant fast maturing crops such cabbages, spinach and kales which they consume in their homes and also sell for an income. The study shows that 91% of the agropastoral community were aware of the opportunities brought by climate variability and change. Those opportunities were seen in livelihood diversification such as poultry farming, dairy goat farming and dairy cow farming; social and environmental entrepreneurship mainly in agribusiness; technological innovation and development; improved land use and land management; improved farm production practices; financial and market services; employment and in education. Of the 350 households that reported to be aware of the opportunities, only 67% had taken up one or more, 33% of those households did not utilise any of the perceived opportunities. The study revealed that despite being the majority who perceived opportunities brought by climate variability and change female headed households had a lower uptake level (48%) as compared to male headed households (52%). Some of the barriers that hinder utilisation of these opportunities include lack of financial capital, lack of knowledge and technological awareness, old age, health problems, unreliable water supply and hindering market services and credit facilities. The study noted that climate change and agriculture policies, ordinances and bylaws that are being implemented in Kieni present an opportunity for Kieni people to enhance their adaptive capacity. For example the Nyeri County Intergrated Development Plan has outlined many projects in irrigation, water provision, tree planting, improving of animal and crop breeds and well as introducing new types to help the community in Kieni adapt better. All these projects presents opportunities in irrigated farming, growing of trees for nutritional values both for livestock and human beings, possibility of engaging in carbon markets, diversification of crops and livestock types and varieties an aquaculture farming,

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LIST OF ABBREVIATIONS/ACRONYMS AND SYMBOLS

AEA	American Evaluation Association
ACP	Africa, the Caribbean and the Pacific
ACTS	African Centre for Technology Studies
ALRMP	Arid Lands and Resource Management Project
ASAL	Arid and Semi- Arid Land
ASDS	Agricultural Sector Development Strategy
ATPS	Africa Technology Policy Studies Network
BAU	Business As Usual
CBO	Community Based Organisation
CCAFS	Climate Change, Agriculture and Food Security
CCI	Commission of Climatology
CDKN	Climate and Development Knowledge Network
CDM	Clean Development Mechanism
CEGIS	Centre for Environmental and Geographic Information Services
CFA	Community Forest Association
CGIAR	Consultative Group on International Agricultural Research
CIAT	The International Center for Tropical Agriculture
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIS	Climate Information Services
CLIVAR	Climate Variability and Predictability
CMIP5	Coupled Model Intercomparison Project Phase 5
COP	Conference of Parties
CSPro	Census and Survey Processing System
CRiSTAL	Community-based Risk Screening Tool – Adaptation and Livelihoods
CV	Coefficient of Variance
CWD	Consecutive Wet Days
DMCN	Drought Monitoring Centre in Nairobi
DRSRS	Department of Resource Surveys and Remote Sensing
ECF	East Coast Fever

EMCA	Environment Management and Coordination Act
ENSO	El Niño–Southern Oscillation
ERPARDP	Economic Recovery, Poverty Alleviation and Regional Development Programme
ESP	Economic Stimulus Program
ETCCDI	Expert Team on Climate Change Detection and Indices
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FFEPP	Fish Farming Enterprise Productivity Project
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GE	Green Economy
GESIP	Green Economy Strategy and Implementation Plan
GHARP	Greater Horn of Africa Rainwater Partnership
GHG	Greenhouse Gas
GoK	Government of Kenya
GPS	Global Positioning System
HCMM	Heat Capacity Mapping Mission
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome
ICCA	Institute for Climate Change and Adaptation
ICPAC	IGAD Climate Prediction and Application Centre
ICRAF	World Agroforestry Centre
ICT	Information Technology and Communication
IFAD	International Fund for Agricultural Development
IGAD	Intergovernmental Authority on Development
IISD	International Institute for Sustainable Development
INDCs	Intended Nationally Determined Contributions
IIPFCC	International Indigenous Peoples' Forum on Climate Change
IPCC	Intergovernmental Panel on Climate Change
IPDP	Invasive Pests and Diseases

ITCZ	Inter Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
KACCAL	Kenya-Adaptation to Climate Change in Arid Lands
KCCWG	Kenya Climate Change Working Group
KES	Kenya shillings
KFS	Kenya Forest Service
KFSSG	Kenya Food Security Steering Group
KM	Kilometre
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
KSNC	Kenya Second National Communication
KRA	Kenya Revenue Authority
KTDA	Kenya Tea Development Authority
KWS	Kenya Wildlife Service
MALF	Ministry Of Agriculture, Livestock and Fisheries
MAM	March- April-May
MENR	Ministry of Environment and Natural Resources
MLND	Maize Lethal Necrosis Disease
$MTCO_2$ Eq	Metric Tons of Carbon Dioxide Equivalent
MTP	Medium Term Plan
NAN	Not Available
NAPs	National Adaptation Plans
NCCAP	National Climate Change Action Plan
NCCC	National Climate Change Council
NCCRS	National Climate Change Response Strategy
ND	No Date
NDMA	National Drought Management Authority
NEC	National Environment Council
NEMA	National Environment Management Authority
NET	National Environment Tribune
NGO	Non-governmental Organisation

NIB	National Irrigation Board
NRM	Natural Resource Management
OND	October-November-December
PGC	Petagrams of Carbon
PRA	Participatory Rural Appraisal
REDD	Reduce Emissions from Deforestation and Forest Degradation
SACCOS	Savings and Credit Co-operative; a credit union
SD	Standard Deviation
SEI	Stockholm Environment Institute
SLF	Sustainable Livelihoods Framework
TIST	The International Small Group Tree Planting Program
TUC	Trade Union Congress
UNCSD	United Nations Conference on Sustainable Development
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programmes
UNEP	United Nations Environment Programmes
USAID	The United States Agency for International Development
USD	United States Dollar
WMO	World Meteorological Organisation
WRUA	Water Users Association
WWF	World Wildlife Fund

CHAPTER ONE: INTRODUCTION

1.0 Introduction

This chapter presents the general introduction and background of the research study, gives information on the study area and a brief highlight on climate variability and change on livelihood systems, the problem statement, research questions, objectives, justification and significance of the study.

1.1 Background

Climate variability and change has exhibited impacts on numerous systems and sectors that are essential for human livelihoods. Today, it is one of the major challenges facing communities around the world. Effects of climatic change occur at all levels (global, regional and local) and have the potential to disrupt the ecological systems with serious adverse impacts on water supply, forests, agricultural production, health systems and overall human development (Marschke and Berkes, 2006; GoK, 2010a). This means that communities must be aware and prepared to handle the risks associated with climate variability and change to minimize possible losses. In rural Kenya and especially in the arid and semi- arid areas, the communities are faced with serious environmental risks including climate variability and water scarcity which are normally compounded by other multiple social and economic risk like financial constraints; lack of technological knowhow; fluctuation in input costs and commodity prices; lack of proper institutional support and conversion of farm land to private ranches and conservancies (WWF, 2006). Climate change and variability is also contributing to serious land change in the agropastoral environment. Vulnerable rural communities therefore face an ever-changing combination of factors that fundamentally challenge their livelihoods and way of life in general.

Although climate variability and change denote constraints to human wellbeing, it also presents a wide range of opportunities for communities to exploit for their own good, development and future sustainability (GoK, 2010a; Klein *et al.*, 2014).

An increasing number of countries, regions and communities are embarking on adaptation activities which exploit beneficial opportunities offered by the current climatic conditions. Adaptation to climate change entails a wide range of initiatives and measures aimed at reducing vulnerability to the effects of climate change in different social-ecological systems. However adaptation happens uniquely in different places and is a complex process.

Although human beings are an adaptable species, not all adaptation measures result into real transformation or smooth transition (Nelson, 2009). Globally, efforts have been made to identify and quantify the effects of climate change on environment, societies and on economies.

In fact many national policies have been put in place for climate change adaptation and mitigation. However, these policies have been met with continued political obstacles which hinder their effectiveness in local settings. Furthermore, the implementation of these policies mostly takes a top-down approach which aggravates the problem because they hardly have real transformational impact on local communities. This is because they have failed to realistically address the local climate change impacts as well as effectively exploit local capabilities to adapt to these impacts (Smit and Pilifosova, 2003; Yarnal, 1998).

Communities and households are not using adaptive measures because they are interested in dealing with climate related shocks and stress as they present themselves in different seasons rather to respond to specific urgent needs. Kenyan experience shows that some of these strategies are influenced, initiated and funded by people who are external to these communities who most of the times have different priorities and vision than that held by local communities. For adaptation strategies to reach fruition, it is paramount to engage the affected vulnerable communities in the adaptation projects from the project conceptualization to implementation. This will improve ownership and contribution by them and hence improved sustainability.

The study was undertaken in Kieni Sub-county of Nyeri County. The county and the larger central Kenya region's minimum temperature has been increasing since 1960 with a magnitude of 0.8-2.0°C while the trend of maximum temperature in the region has been increasing with a magnitude of 0.1-0.7 °C (GoK, 2010a). There is evidence of significant climate change impacts which included highly variable rainfall patterns, invasive species and new pests, flash floods and frost. Significantly affecting the livelihoods of the communities is the erratic and unreliable rainfall pattern.

Most agropastoral farmers depended on the rainfall season of between March and May (normally known as the 'Long Rains') that has been observed to be becoming shorter and heavier than would be normal (Macharia *et al*., 2009). This has led to significant negative impact on crop and fodder production in the study area. The October to December rain season (normally known as the 'Short Rains') has also been erratic with a tendency of extending long into the normally hot and dry period of January and February (Macharia *et al*., 2009). This weather uncertainty makes the communities confused on how to prepare for the seasons.

Kieni Sub-county covers an area of 1,990 square kilometres (km^2) out of which 1,026 km^2 are suitable for both livestock and crop production. The Sub-county comprises of 42% of semi-arid land (Macharia *et al*., 2009). The study site lies between Mt. Kenya and Aberdare Mountains and it is densely populated with farm sizes of 3-5 acres in the high to medium rainfall areas and 20-100 acres in the semi-arid areas (Macharia *et al*., 2009). The area falls under agro-pastoral livelihood cluster and depends largely on agriculture and livestock production which is currently under threat from effects of climate change and its variability (GoK, 2013a). The impact of climate change on the production system of the area has adversely affected the wellbeing of the community with increasing incidences of insecurity, human-wildlife conflict and high food prices being experienced. A study done by Kenya Food Steering Group (KFSSG) in October to December 2013 indicated that food security situation in Kieni was stressed (NDMA, 2014).

Adaptation to climate change has its challenges and opportunities can also be derived from its manifestation and limited understanding of these opportunities make communities more vulnerable to climate variability and change. Climate variability and change presents opportunities in all sectors and in all levels of government. These opportunities lie in the use of technology and innovations (e.g. green house farming technology, irrigation), diversification of crops and livestock, planting drought resistant varieties, agribusiness activities, ecotourism, policy formulation and new approaches to making decisions among others. It therefore requires all stakeholders to adopt an innovative mind-set as well as enhance their technological knowhow in green growth and green production in order to realise the opportunities associated with climate variability and change. Research shows that communities in rural areas use different coping strategies and local innovations (Milton and Ochieng, 2007; Fenta and Assefa, 2009) which in themselves present opportunities.

It is true that local innovations have been disregarded for a long time by the scientific community and development initiatives despite the common agreement that indigenous knowledge and innovations give rise to better coping strategies and better understanding of specific and unique challenges that communities' experience (Maina *et.al,* 2012).This means that there is need to cultivate for an in-depth understanding of how these local innovations can be utilised as an opportunity for wider community adaptation in support of sustainable development.

This research therefore aimed at gaining a deeper understanding of the social and environmental opportunities brought by climate variability and change for the agropastoral communities in Kieni. The study further aimed at helping the communities identify, understand and utilise and implement these opportunities to increase their adaptive capacity through training on small social and environmental businesses start-ups, utilisation of available national and county government policies (Youth fund, Women fund and Uwezo fund). Figure 1.1 presents the map of the study area.

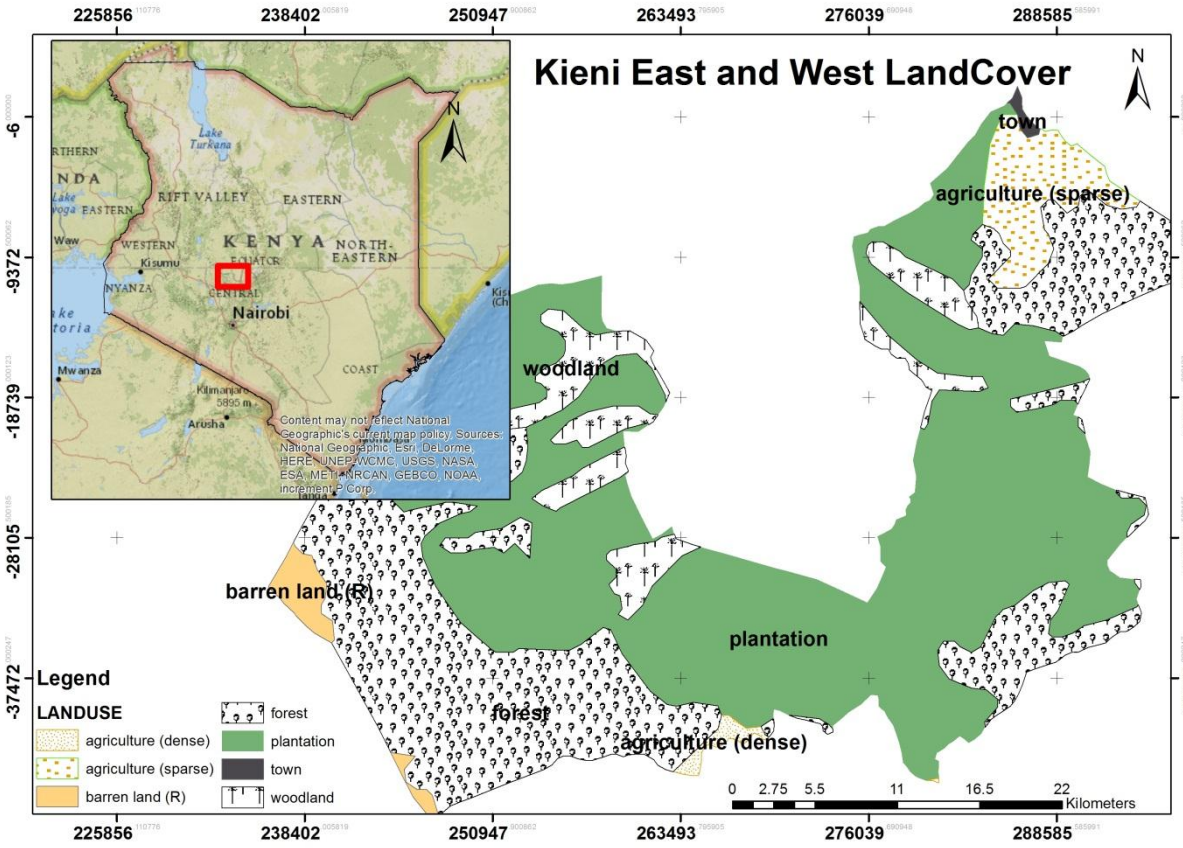

Figure 1.1 Map of the area of study
Map authored by Sweta Leonard, 2016; Regional Centre for Mapping of Resources for Development (RCMRD)

1.2 Problem statement

Lack of awareness of opportunities associated with climate variability and change coupled with low technological innovation is undermining climate change adaptation efforts by vulnerable rural households and communities in Kieni.Climate variability and change including their uncertainty are key concerns for the agropastoral communities in Kieni.

These communities have experienced significant negative impacts of climate variability and change which is compounded by other social and economic factors (Macharia *et al*., 2009; GoK, 2013b). The biophysical environment has been adversely affected leading to serious decline in soil fertility. There is occurrence of erratic rainfall which leave the farmers confused on when to plant and heavy rainfall cause flooding which destroy crops, infrastructure and sometimes injure and kill people. During dry spells, there is scarcity of fodder for animals and water stress which makes the animals produce less in terms of milk and meat.

Socially, as a result of the cumulated impacts of climate variability and change, incidences of conflict over resources are frequently witnessed. Furthermore, the most marginalised in the society (women, children, elderly and people living with disability) are highly affected as the strong people in the community (i.e. men and youth) migrate to the urban areas in search of livelihoods and better life. Loss of biodiversity has led to disappearance of most of the indigenous species including wildlife, occasional human-wildlife conflict and insects such as safari ants and an upsurge of pests such as centipedes, millipedes and birds) (Macharia *et al*., 2009). This phenomenon has reduced traditional livelihood opportunities and adaptive capacity of Kieni agropastoral communities in the recent years.

The adaptive capacity of rural communities is dependent on the livelihood options and strategies that they have. This is determined by a combination of internal and external factors such as the climatic risks, acute shocks, and stress exposed to them, their endowment and entitlements. These include human, social, financial, natural and physical resources and their ability to use it to increase their resilience as well as the institutional support accorded to them (Armitage and Johnson, 2006; De Haan and Zoomers, 2003; De Haan, 2000; De Haan, 2012).

This study therefore sought to examine whether the communities in Kieni Sub-county are aware and understand the social and environmental opportunities brought by climate variability and change in the area.

1.3 Research questions

i. What are the temporal characteristics of rainfall and temperature and perceived impacts on livelihood resources in Kieni Sub-county?
ii. What are the local coping mechanisms available and being utilised by communities in Kieni Sub-county?
iii. What are the social and environmental opportunities brought by climate variability and change for communities in Kieni Sub-county?
iv. What are the climate related ordinances and bylaws that facilitate uptake of social and environmental opportunities and enhance adaptive capacity of the agropastoral communities in Kieni Sub-county?

1.4 Objectives

The study had the general and specific objectives below.

1.4.1 Overall objective

The overall objective of the study was to enhance climate change adaptation through identification and utilisation of social and environmental opportunities offered by climate variability and change for agropastoral communities in Kieni, Nyeri County.

1.4.2 Specific objectives

i. To examine the temporal characteristics of extreme rainfall and temperature indices and perceived impacts on the livelihood resources of the agropastoral communities in Kieni Sub-county.
ii. To establish the coping strategies available to agropastoral communities in Kieni Sub-county.
iii. To determine the social and environmental opportunities brought by climate variability and change for agropastoral communities in Kieni Sub-county.
iv. To evaluate the climate adaptation policies, bylaws and ordinances that facilitate improved uptake of social and environmental opportunities and enhance adaptive capacity for the agropastoral communities in Kieni Sub-county

1.5 Justification and significance of study

Climate driven biophysical environmental change adversely affects the socio economic status of households and communities and reduces the capacity of these households and communities to utilise opportunities associated with climate variability and change and their overall ability to adapt. The livelihood systems for communities in Kieni are directly linked and largely depend on the biophysical environment. Research has been conducted to show impacts of climate change and communities adaptation (Van Aalst *et al.*, 2006; Care International, 2014; Dodman and Mitlin 2013). However, there is lack of research explicitly focussing on opportunities that communities can derive from climate variability and change that can guide communities and policy makers in climate adaptation decision making. It is very useful to incorporate climate change more explicitly in communities'development strategies, planning and product development so that these actions can benefit from any new learning about climate change and emerging opportunities (Dodman and Mitlin, 2013; Mustelin *et al.*, 2010).

This study analysed the characteristics of climate extreme indices to give a clear picture on the shift of individual climate parameter. The study engaged the vulnerable communities and other actors in understanding climate change and livelihood context of the area in a participatory manner to identify the opportunities and barriers that they face. The study highlights opportunities associated with climate variability and change and barriers that hinder uptake of these opportunities in Kieni which policy makers can consider in future planning.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter reviews the literature that was relevant for this study. A detailed examination of climate variability and change and livelihood systems is done. A close look at opportunities associated with climate variability and change that vulnerable agropastoral communities can exploit for enhanced adaptive capacity has been done.

2.1 Climate variability and change

The fifth report by the Intergovernmental Panel on Climate Change (IPCC)working groups I,II and III provides a detailed report on impacts of climate variability and change which include serious and pervasive effects on the natural and social environment (IPCC, 2014). The future risks that would possibly arise from the changing climate are not only discussed in the report but also highlights the existing opportunities that actors can take advantage of to build their own resilience and that of their ecosystems (Klein *et al.,* 2014).

Climate variability and change will definitely stress the rural livelihoods and especially the agropastoral communities in various ways which include, but not limited to, reduction of harvested produce and death of livestock. These stresses will cause both negative and positive impacts to these communities (Cordona *et al.,* 2012). This therefore means that communities must be able to make informed choices on risks and stresses associated with climate variability and change (Klein *et al.,* 2014; Bryan *et al.,* 2011; Preston *et al.,* 2011). Risk is defined as a probability or a chance that an event will have adverse (ecological, sociological and economic) consequences. Risks stems from vulnerability of communities to extreme climatic events (Klein *et al.,* 2014). Vulnerability is highly associated with lack of preparedness on the part of the communities and societies experiencing it combined with exposure of the community to a stimuli and their capacity to cope with or recover from the effects of a climate event (Adger, 2006, Wisner *et al.,* 2004, Turner *et al.,* 2003).

Different ecosystems and communities are vulnerable to climate variability and change impacts. However, vulnerability varies from one community to another due to different underlying factors such as socioeconomic status, a fragile environment, lack of or low technological knowhow, suppressive political system, poor governance, weak financial systems and low education. The bottom line is understanding the factors that make a certain community vulnerable and managing climate related risks opens opportunities for the communities to overcome the challenges hence increase their resilience (Klein *et al.,* 2014; Hall *et al.,* 2012; Adger *et al.,* 2009). Community resilience can therefore be built through enhancing social economic and political opportunities for increased human security, safety, and prosperity.

While the fact that climate is changing around the globe is indisputable, it is generally agreeable that the question now is how to specifically adapt the environmental and livelihood systems to anticipate the changing climatic conditions and building resilience (TUC, 2009; IISD, 2003; ATPS, 2011). This means that communities must be able to appreciate their challenges and innovatively create solutions to overcome them. These communities must therefore be able to capitalize on adaptation opportunities and opportunities arising from climate variability and change in order to build their resilience (Klein *et al.,* 2014).

2.2 Opportunities arising from climate variability and change

According to IPCC (Klein *et al.,* 2014), opportunities are factors that make it easier to plan and implement adaptation actions; that expand adaptation options; or that provide ancillary co-benefits. Opportunities in climate variability and change can be categorized into two: (i) adaptation opportunities and (ii) potential benefits of climate change or adaptation options (Nobel *et al.,* 2014). The recognition and uptake of these opportunities can go a long way into enhancing the adaptive capacity of communities.

Adaptation to climate variability and change entails taking actions that would reduce communities' vulnerability; creatively and innovatively identifying and utilizing opportunities brought by the changing climate and empowering communities to be able to anticipate, respond to climatic events and rebuild their livelihood systems (IPCC,2012; Tompkins *et.al.,* 2010).

Adaptation opportunities vary from region to region, nation to nation, community to community and household to household depending on their capacities (very *high confidence*) (IPCC, 2012). This means that each community is unique and the biophysical, social and institutional capacities of each and every community must be scrutinized individually to help these communities seize the opportunities presented by climate variability and change (Klein *et al.*, 2014).

The enabling factors for adaptation include empowering vulnerable communities to help them make informed choices in relation to adaptation, sharing knowledge between communities and scientists/experts to help in integration of indigenous knowledge into climate science, nurturing local innovations and technologies and creating innovative ways of sharing information on climate change. The fifth IPCC reported that climate variability and change associated opportunities exist to facilitate communities and actors across sectors and levels to plan and implement adaptation interventions (*very high confidence*). This means that building capacity of vulnerable communities is a necessary adaptation component.

2.3 Climate variability and change and livelihood systems

The adaptive capacity of vulnerable households and communities highly depend on the livelihood capitals they have e.g. arable land, availability of pasture, social support and networks and skill to convert and transform natural capitals into other forms of assets (IISD-IUCN-SEI, 2003; Niehof and Price, 2001). It is very important for planned adaptation intervention to be based on an understanding of the various factors that contribute to individuals and communities' capacity/ability to use livelihood assets to cope when need arise (Nelson, 2010). Some factors are external to the vulnerable communities such as access to information and training, government policies and economic support (Nelson, 2010). Internal factors such as attitudes and perceptions also contribute to ability to cope with climate variability and change.

Many approaches and tools have been used to evaluate communities' adaptive capacity (Fussel and Klein, 2006; Metzger and Schroter, 2006). The most commonly used being the Sustainable Livelihoods Framework (SLF) developed by Ellis in 2000.

Others have used bottom up approach, top down approach and tools such as CRiSTAL that was developed by The International Institute for Sustainable Development (IISD). Both LSF and CRiSTAL put the community at the core of adaptation process and they use participatory methods to understand pertinent issues in community climate change adaptation efforts. Livelihood approach helps us to understand the priority areas of development and what communities and individuals' interests are in relation to coping with climate variability and change (Ellis, 2000; IISD, 2012). The approach is critical in identification of people's access and use of resources and opportunities brought by climate variability and change in their locality (Chambers and Conway, 1992; Odero, 2008; IISD, 2012). Livelihood systems are normally categorised into: natural, socio-political, human, physical and financial capitals. These livelihood systems are as elaborated in the sections below.

2.3.1 Natural capital

These are livelihood assets that are built on natural resources such as land, water, forests and grazing pasture. A livelihood that is dependent on the natural capitals involves direct use of the resource or conversion of these resources to other types of assets such as financial and physical assets (Ellis, 2000). In agropastoral livelihood system, the natural capital is majorly used for production of food and animal products. These products are then consumed in the households or converted into financial capital through the market services (IISD-IUCN-SEI, 2003). The financial capital can then be converted into physical assets through purchase of farming machinery and equipment or in puts.

2.3.2 Socio-political capital

Social capital include relations and bonds upon which people in a community are able to use in pursuit of their livelihoods (CEGIS and FAO, 2006; IISD-IUCN-SEI, 2003). These relations support collective action against perceived threat such as climate variability and change. The relations form a bridge and a link through which information, skills and resources are accessed and controlled (Woolcock, 1998). Social capital includes relations based on trust and shared experiences, contact networks, membership in community or farmer groups all which are important in the process of gaining and carrying out livelihood activities in a society.

These relations are a strong pillar in any community as they determine access to various services and facilities such government services, markets, credits and training (CEGIS and FAO, 2006). Research shows that social capital plays a critical role in adoption of sustainable agriculture e.g. (Webb and Cary, 2005; Compton and Beeton, 2012). Political capital go hand in hand with institutional assets and are seen a factors that make it possible to access and acquire other types of capitals (Ellis, 2000). Networks with people of greater influence in the society such as the governors, Member of Parliament, chiefs and other opinion leaders may contribute a great deal on how a community is able to leverage use and conversion of resources. Communities differ in representation for instance in government offices and this has a great influence on how such communities are able to adapt to perceived or actual threats.

2.3.3 Human capital

This includes stable health, skills and knowledge and ability to use physical strength to attend to various livelihood activities without hindrances (IISD, 2003; Krantz, 2001). In a household for instance, the number of able bodied and productive individuals directly affects the output in their livelihood activities. Old age and poor health for instance reduces the ability of individuals to work hard on the farms hence reduced production.

2.3.4 Physical capital

These include infrastructure such as good roads that farmers can use to transport their produce to the markets, availability of water systems and management (irrigation and piped), tools and equipment that help individuals pursue their livelihood activities (IISD, 2003; Krantz, 2001). In many cases these assets are provided by the government or through private -community partnerships.

2.3.5 Financial capital

These include the financial services that people can access to help them improve and support their livelihood systems. They can be in terms of availability of financing institutions, bank deposits and savings, credit facilities, insurance for agricultural production, remittances from household members working in urban areas (Jacobs, 2015; IISD, 2003; Krantz,2001). These assets provide an option to vulnerable communities especially in case of total loss of harvests or death of livestock. They are crucial in recovery and reconstruction after the disaster.

2.4 Kenya climate development experience

The turning point for debating the links and relationships between environment and human development was laid during the Rio Summit of 1992 with an output of Agenda 21 and Johannesburg World Summit Sustainable Development 2012. As a country, Kenya has been part and parcel of the IPCC process since its inception. The IPCC was set up to help in assessment of all climate change science in the world to assist generate knowledge and experience that will support global policy decision. It is a key process that provides policy makers with regular updates of scientific research on climate change, current and predicted risks scenarios, mitigation and adaptation options. Kenya has committed to achieve sustainable development goals by way of putting in place several guidelines, regulations, policies and flagship projects that shape the country's goal of becoming a newly industrialising, middle income economy by the year 2030 while maintaining the balance between natural capital and economic growth (GoK, 2007).

Research estimates that Kenya could incur a cost of up to 2.6% of the country's GDP per year as a result of climate variability and change affecting different aspects of economy (GoK, 2013b). This means that the country must be prepared to tackle climate change threats politically, economically, socially and technologically in order to increase levels of resilience. The country has developed climate legal frameworks and institutions to help address climate change challenges.

Since the enactment of Environmental Management and Coordination Act (EMCA) in 1999 and the inauguration of the Kenya's Constitution in 2010, the country has put emphasis on the need to preserve the natural environment for the benefit of Kenyans. EMCA has created agencies such as the National Environment Management Authority (NEMA) to monitor and coordinate all matters related to the environment hence ensuring a clean and health nature for all (GoK,1999). The Kenya's Vision 2030 has also envisioned achieving a 'green' economy through the major flagship projects such as the rural electrification, development of geothermal power generation, green procurement system implementation, increased funding of eco-innovation through research, and restoration programmes at national and local level.

The National Climate Change Response Strategy (NCCRS of 2010) (GoK, 2010a) and the National Climate Change Action Plan (NCCAP of 2013-2017) (GoK, 2013b) are also government efforts to respond to issues of climate change.

The NCCRS aims at integrating climate change issues into development matters. For the agropastoral sector, the NCCRS identifies the need for adaptation and mitigation. NCCRS calls for accelerated investment in weather information systems and dissemination, improved research on crop varieties that are drought tolerant, water and soil management, water conservation, harvesting and storage and pests and diseases control and management among others (GoK, 2010a). On mitigation in agricultural sector, the Kenyan government has identified innovative carbon projects such as agro-forestry and biogas production as key in enabling the country to cut its emissions. Through the NCCAP, the country clearly sets out its vision for low carbon economic development pathway. The action plan has also recommended enabling policy and regulation framework that would help in creating a climate resilient development (GoK, 2013b). Through the NCCAP the government of Kenya acknowledges that climate change presents challenges and opportunities for adaptation.

In 2016, the country enacted its Climate Change Act that gives a framework for promotion of low carbon development by way of mainstreaming climate change in planning, designing and implementation of development interventions, enhancing adaptive capacity, reinforcement of climate disaster risk reduction, mainstreaming of intergenerational and gender equity, incentivising private sector to help them participate progressive climate change responses and promotion of low carbon technologies among others (GoK,2016). The Act can be seen as the ultimate ways of ensuring that all Kenyan's engage in responsible climate sensitive development by enhancing awareness, capacity building, partnership, innovation and technology transfer.

Other substantive policies and guidelines supporting climate change resilience include; The Kenya's Agricultural Sector Development Strategy (ASDS) which makes climate adaptation a priority (GoK,2010); the Second Medium Term Plan 2013-2017 (MTP); the Agriculture(Farm Forest) Rule 2009 that puts a mandatory agro-forestry practices for all farms (GoK,2009); The Energy Policy and Energy Act of 2006 that encourages development and use of renewable energy (GoK,2006); Tourism Act of 2010 that promotes eco-tourism with conservation measures and co-benefits for adaptation (GoK,2011), the Sessional Paper on Integrated National Transport Policy (GoK,2009b) and the Nairobi Metro,2030 (GoK,2008) Strategies that support sustainable, efficient and accessible integrated transportation network.

CHAPTER THREE: DATA AND METHODS

3.0 Introduction

This chapter presents the specific methods and conceptual framework used in the study. The methodological approach, data used, sampling process, data collection methods and analysis techniques used in the study are also highlighted.

3.1 Data sources and description

The climate data used was obtained from three Kenya Meteorological Department (KMD) weather stations i.e. Sasini Farm Estate, Munyaka NRM Met station and Narumoru Park Gate Met station. The observed precipitation and minimum and maximum temperature daily readings were used. RClimDex software was used for quality control and homogeneity test (Peterson *et al*., 1998, Zhang *et al*., 2009). Data quality control is important because indices of extremes are highly sensitive to changes in exposure, location of the weather station and human errors (Haylock *et al.,* 2006).

The RClimDex software performs several procedures to ensure that the data is homogenous and void of outliers. For example it replaces the missing values using a predefined value that is internally embedded and which the software recognises i.e. code -99.9 which the system recognises as not available (NAN). In addition values that do not make sense e.g. daily rainfall less than zero millimetres and daily maximum temperature which could be recorded as less than daily minimum temperature are flagged off for confirmation. The software also allows the user to set a range of the daily value therefore any figure running outside this range is detected as outlier which helps the user to rectify the anomalies (Zhang and Yang,2004).

Climate data type used in the study included the daily and monthly average precipitation recordings for year 1985- 2015 and the daily and average monthly minimum and maximum temperature recordings daily recordings of temperature for the period 1991-2015.

The rainfall and temperature data were collected from Kenya Metrological Department (KMD). Table 3.1 shows the list of the weather stations and their GPS coordinates.

Table 3.1: List of weather stations

Station	Longitude	Latitude	Precipitation Period	Temperature Period
Munyaka NRM Met station	E 0°10’59.71’’	S 37°03’34.48’’	1990-2015	1990-2015
Narumoru Park Gate Met station	E 0°10’27.99’’	S 37°08’53.95’’	1985-2015	1985-2015
Sasini Farm Estate-Mweiga	E 0º 22' 50'	S 36º 22' 5'	1985-2015	NA

Figure 3.1 shows the location of weather stations on the map picked from Google Earth, 2018.

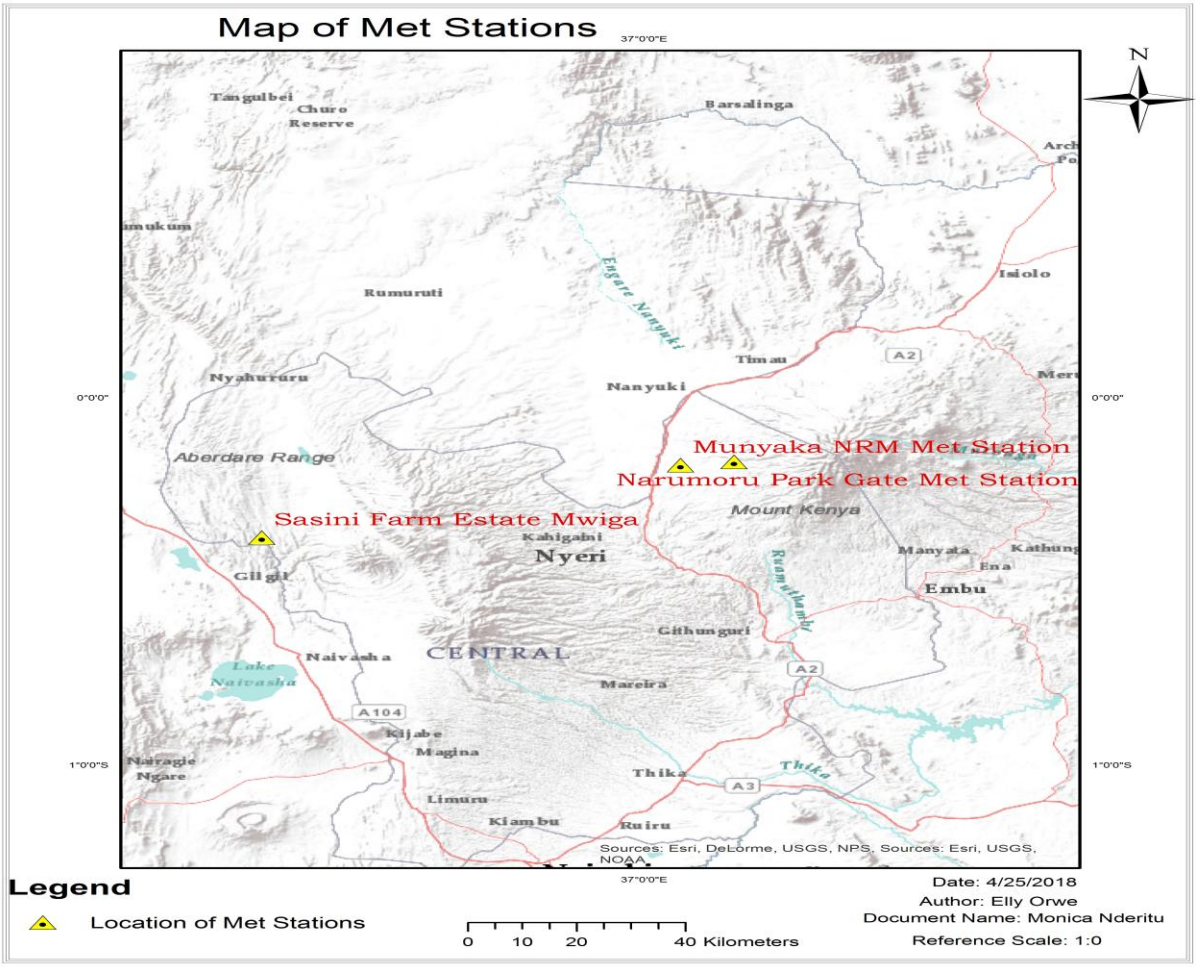

Figure 3.1: Location of the weather stations in the study area from google earth (2017)

The house hold level data used in the study were collected from 383 households in the area. The survey collected data on demographic characteristics i.e. gender, age, education level and time lived in the area; perceived opportunities associated with climate variability and change; livelihood systems in the area and barriers to uptake and utilisation of the opportunities associated with climate variability and change. Ranking of extreme climate events in terms of how hard it is to cope with them, how frequent they occur and severity of the events.

Focus Group Discussions were used to gain insight on the communities understanding of climate change, their perception on opportunities brought by climate variability and change, level of uptake of these opportunities, barriers encountered during uptake and their perception on the policies and ordinances that are related to agropastoral sector.

3.2 Data collection and analysis methods

3.2.1 Sampling methodology

Cochran's sampling formula was applied to get the household sample size (Yamane, 1967; Cochran, 1963).

Cochran's sampling formula is given by equation (1)

$$n = \frac{N}{1 + N(e)^2} where; \text{ Equation (1)}$$

$$n is the sample size$$
$$N is the population size$$
$$e is the sampling error$$

$$* 0.05 \text{ is the assumed margin of error}$$

Individual households were randomly selected. A household in this case was taken to be people who live together and feed from the same pot. Semi structured questionnaires, focus group discussions (FGDs) and in-depth key informant interviews were used to collect information in the selected wards.

A total of three hundred and eighty three (383) household questionnaires were administered, four focus group discussions conducted and twenty (20) key informant interviews conducted with community members and experts in the area between June 2015 and June 2016.

The data was entered and processed using Census and Survey Processing System (CSPro). The quantitative data was summarised using descriptive statistics, frequency tables and mean, minimum and maximum values. Statistical analytical approaches are used to detect temporal trends in climate. Coefficient of variation was used to calculate the degree of seasonal and inter-annual variation of climate data at the two sites of the study area using the formula in equation (2):

$$C.V = \frac{Standarddeviation}{Mean} \text{x} 100\% \quad \text{---------- Equation (2)}$$

Comparative values of C.Vs between the two sites were conducted to determine the spatial differences in variability between sites of the study area.

3.2.2 Mann- Kendall test

This is a non-parametric test approach that is rank based used to test statistically significant trends (Mann, 1945). Unlike parametric tests, the advantage of using Mann- Kendall approach is that it tolerates skewed distributions and outliers (Sneyers, 1990; Kendall, 1975; Tabari *et al*., 2011; Onoz and Bayazit 2012; Karmeshu, 2012). It is ideal to test inhomogeneous data because it has low sensitivity to abrupt breaks (Karmeshu, 2012). With Mann-Kendall, the null hypothesis (H_0) assumed that there is no trend while the alternative hypothesis H_1 assumed that there has been either an increasing or a decreasing trend in temperature and rainfall overtime.

In this analysis, the null hypothesis was tested at 95% confidence level. The decreasing trend is significant if Z-value is negative and the computed probability is greater than the level of significance. Similarly, the increasing trend is significant if the Z-value is positive and the computed probability is greater than the level of significance. Where the computed probability is less than the level of significance, there is no trend detected.

3.3 CRiSTAL tool

CRiSTAL stands for "Community-based Risk Screening Tool – Adaptation and Livelihoods. It is a community based risk screening tool that support climate variability and change adaptation activities (IISD, 2012).

It is used in development projects that are aimed at directly benefiting the vulnerable communities in a sustainable manner. It has the component of livelihood and adaptation that help users to identify the livelihood resources that are of top importance and that require adaptation within a community (IISD, 2012). CRiSTAL has four main modules including (i) setting the climate context (ii) livelihood context where resources required by communities to help them cope with climate variability and change are identified (iii) screening of project activities and coping strategies and (iv) managing risks which help in project adjustment to enhance resources available for better adaptation (IUCN-IISD-SEI-IC,2006). The tool was used to understand the community's perception of the climate and livelihood context, local coping strategies as well as get the social and environmental opportunities available in Kieni.

To make the participation of the agropastoral communities in Kieni inclusive and effective, consultations were done in the afternoon from around 4pm when the community members were sure of attending after their days work in their farms and tending to their livestock. The study involved a group of 20 agropastoral community members with a representation of nine men and eleven women.

In the first part of the discussion, i.e. establishing the climate context of Kieni, participating members were asked to give suggestions on the extreme climate events (hazards) that they considered to have a great impact on them and the community as a whole. Out of this exercise, climate hazards were listed down. Out of the many hazards highlighted, the participants through consensus were asked to choose the top three hazards in their view. After choosing the most important hazards, the participants were then asked to identify most important impacts and their coping mechanism/ strategy which they and the community depends on as a response to each impact.

The next step was identification of livelihood context which was begun by the facilitator with a discussion in which the participating members were asked the resources they deemed key when conducting their livelihoods. The facilitator at this point explained using examples the five categories of livelihoods i.e. physical, natural, financial, socio-political, human resources/assets (Cochrane, 2006; Odero, 2008).

The facilitator then asked the participants to list resources upon which the communities depended on. At the end of this task, a list of important resources for the agropastoral communities in Kieni was highlighted. The identified important resources in each of the five categories were then placed alongside the hazards identified in climate context discussion. Participants were then asked to assign weight in terms of numbers to represent the extent in which the resources were affected by each of the three hazards where 0 depicted not affected while 5 depicted very affected.

In the next step, participants discussed the extent to which livelihood resources are important or their influence to coping strategies that were identified earlier in the climate context. Again the participants were asked to rank between 0 and 5(0 being not important while 5 depicted very important)

3.4 Conceptual framework

The conceptual framework in Figure 3.2 integrates the social constructionist, collective action and social practice theories and the three transdisciplinary complexities i.e. generative, social and dynamic complexity. The framework shows a holistic approach to understand social and environmental opportunities brought by climate variability and change for Kieni agropastoral communities.

Constructivist paradigm helps in transdisciplinary research where we try to have a deeper understanding of the world as a complex whole and hence a deeper understanding of the different realities and complexities is essential (Nicolescu, 1997; 2001; Voss, 2004). To better understand different realities, the communities were engaged right from the project design. It was important because these communities interact and utilise social and environmental resources for their livelihood each in their own way shaped by their own realities.

This means that interacting with the communities helped in understanding what they perceived as opportunities associated with climate variability and change and why or why not they did not take up the opportunity to enable them adapt better.

The conceptual framework identifies climate driven biophysical environmental change as adversely affecting the socioeconomic status of households and communities. In turn, it highly reducing the households and communities capacity to utilise the climate variability and change associated opportunities which they could have used to adapt. This conceptual framework considers collective action which occurs when there is a need to involve more people or groups of people to contribute to a common good (Ostrom, 2000). The agropastoral community in the area of study use natural resources as their main source of livelihood therefore they engage in collective action almost on a daily basis. For adaptation to take place, the ability of individuals and communities to act collectively is highly required (Pellin and High, 2005). The study involved the community and other stakeholders to understand their socioeconomic activities, interaction with the physical environment and how best they can expand opportunities in terms of social, environmental and economic services. Integration of various sources of knowledge from different stakeholders and actors was key in this concept.

To understand the choices made in terms of utilisation of perceived climate variability and change associated opportunities, social practice theory was applied (Reckwitz, 2002). This theory helped the study in the understanding of how households and communities shape their world and how climate change impacts are shaping their choices as they try to adapt. The study was designed to understand the communities' perception on social and environmental opportunities emanating from climate variability and change as well as understand whether these households and communities are utilising them.

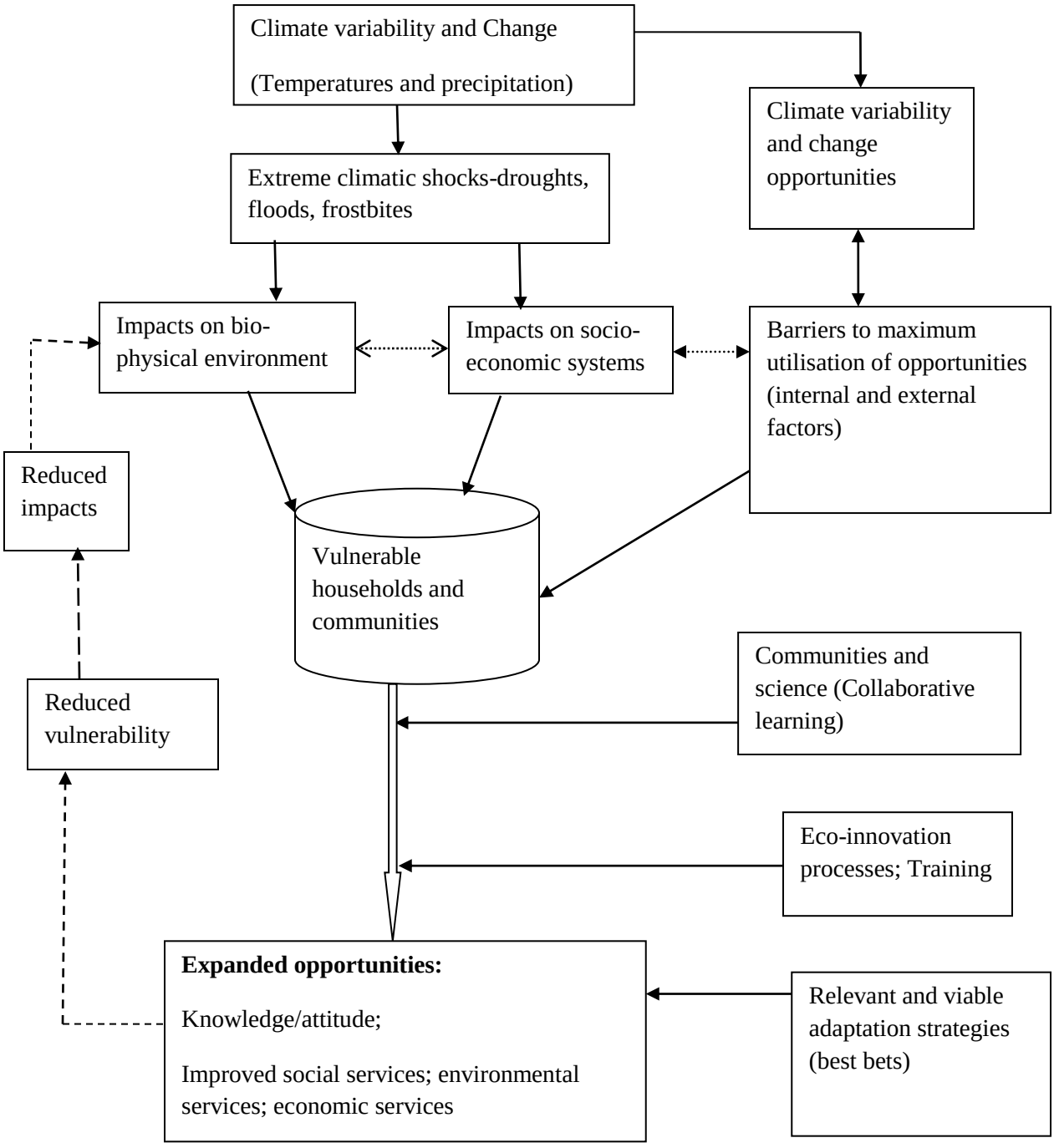

Figure 3.2: Conceptual framework

3.5 Methods

The section below presents the various methods that were used to achieve the objectives of this study.

3.5.1 Objective 1: To examine the temporal characteristics of rainfall and temperature indices and perceived impacts on the livelihood resources of the agropastoral communities in Kieni Sub-county

To achieve this objective, analysis of twenty seven (27) climate extreme indices was conducted using the guideline given by the World Meteorological Organization- Commission of Climatology and the Climate Variability and Predictability (WMO-CCI/CLIVAR) working group (WMO,2009)-see table 3.2 for description of the indices. Daily temperature and precipitation data observed since 1991 -2015 and 1985-2015 was analysed for temperature and rainfall respectively. This was done to give insight on specific trend on different indices such as maximum and minimum temperature, consecutive wet days and so on. This information is very important in informing the agropastoral community in Kieni on specific behaviour and trend for each climatic indices. The aspects studies were the degree of seasonal and inter-annual variation of rainfall and temperature providing evidence of climate variability and change in Kieni. Household surveys, Focus Group Discussions (FGDs) were also used to triangulate the scientific data and to give the community's perception and opinion on the climate variability and change impacts on crops, livestock, natural resources and communities' social aspects were. CRiSTAL tool was used to qualitatively analyse the community's opinion and perception on impact of climate variability and change on livelihood resources. The participants from the community were asked to list the impacts that the hazards they identified caused to the livelihood resources. Each hazard i.e. drought, frost bites and invasive pests and diseases were listed with their associated effects to livelihood resources.

Table 3.2: Definition of indices

Index	Description	Unit
CWD	Consecutive wet days	Days
DTR	Daily temperature range	^{o}C
GSL	Growing season length	Days
ID	Icing days(number of days where TX<0 ^{O}c	Days
PRCPTOT	Annual total precipitation in wet days	Mm
R10mm	Heavy precipitation days	Mm
R20mm	Very heavy precipitation days	Mm
R95p	very wet days	Mm
R99p	Extremely wet days	Mm
RX1day	Monthly maximum 1-day precipitation	Mm
RX5day	Monthly maximum consecutive 5-day precipitation	Mm
SDII	Simple daily precipitation intensity index	Mm/day
SU	Number of summer days; when TX>25Oc	Days
TMAX mean	Annual mean maximum temperature	^{o}C
TMIN mean	Annual mean minimum temperature	^{o}C
TN10p	Number of days when TN<10th percentile	%
TN90p	Number of days where TN>90th percentile	%
TNn	Monthly minimum value of daily minimum temperature	^{o}C
TNx	Monthly maximum value of daily minimum temperature	^{o}C
TR	Number of tropical nights	Days
TX10p	Count of days when TX<10th percentile	Days
TX90p	Number of days when TX>90th percentile	Days
TXn	Monthly minimum value of daily maximum temperature	^{o}C
TXx	Monthly maximum value of daily maximum temperature	^{o}C
WSDI	Warm spell duration index	Days
CDD	Maximum length of dry spell; maximum number of consecutive days with RR<1mm	Days
CSDI	Cold spell duration index; annual count of days with at least 6 consecutive days when TN<10th percentile	Days

3.5.2 Objective 2: To establish the coping strategies available to agropastoral communities in Kieni

The study addressed this objective by use of household survey, FGDs and key informant interviews. These tools were used to collect information regarding demographic characteristics, socioeconomic status, current productive investments, technology access and use, markets, coping responses to climatic shocks, adaptation strategies currently being undertaken and perceived opportunities brought by climate change.

CRiSTAL tool was used to analyse the qualitative data regarding importance of each livelihood resource identified on their local coping strategies. Through the group consultations, the each of the impact on livelihood resource identified earlier in the CRiSTAL steps, the participants were asked to list their coping mechanism.

3.5.3 Objective 3: To determine the social and environmental opportunities brought by climate variability and change for agropastoral communities in Kieni Sub-county

To address this objective, household survey and key informant interviews were used. Techniques such as Focus Group Discussions (FGD) and diagrams were applied. Emphasis was put on group data and building up of a knowledge base that reflects the whole community. PRA protocol was first established to guide the discussions based on peer reviewed data and advice from experts. Participants were asked to free list on variety of perceived or already identified opportunities brought by climate change and its variability. They were also asked to list any kind of barrier or constraint that they perceived as impediment to their maximum utilisation of opportunities brought by climate change.

3.5.4 Objective 4: To evaluate the climate adaptation policies, bylaws and ordinances that facilitate improved uptake of social and environmental opportunities and enhance adaptive capacity for the agropastoral communities in Kieni Sub-county

This objective was met through systematic analysis and evaluation of the existing county, sub-county policies, bylaws, development plans and programes that are being implemented in Kieni to enhance adaption to climate variability and change.

Such documents included the County Intergrated Development Plan, Forest Act of 2005(revised in 2012), Water Act of 2002, Crop Production and Livestock (Seed and Ware Potato production and marketing standards) Rule of 2005, Nyeri County Agriculture Development Act of 2016, programme documents such as the Fish Farming Enterprise Productivity Programme (FFEPP) of the Economic Stimulus Programme (ESP) and Economic Recovery, Poverty Alleviation and Regional Development Programme (ERPARDP).

3.6 Data collection process, tools and techniques

The sections below present the specific data collection tools and techniques that were used to collect both primary and secondary data for the study.

3.6.1 Reconnaissance field visit

Initial field reconnaissance visit to the study site was conducted to help the researcher appreciate and familiarise with the area, meet the relevant stakeholders and actors and to introduce the research objectives and get relevant feedback from the stakeholders on appropriateness, design and the process of the study. The researcher met with various key stakeholders including the local community, government officials from (the National Drought Management Authority (NDMA), agricultural sector, Nyeri County, Kenya Wildlife Service (KWS), Kenya Forest Service (KFS); local administration (chairs to the "*nyumba kumi initiative",* chiefs and ward administrators. This initial field visit helped the researcher to build trust with the community and identify field assistants.

3.6.2 Training of local field assistants

Two local field assistants were identified who assisted throughout the data collection process. This was meant to enhance trust and participation of the locals in the study which improved ownership and willingness of the community to constructively participate in the study. The field assistants were recruited based on their past experience in similar studies and their qualifications. They were also fluent in Kikuyu language which is the major language used by the community in the study area.

The assistants were trained for two days and a pilot survey conducted to ensure that the objectives of the study were clear and data gathered was relevant. The pilot survey was conducted in ten households in Mwichuiri area of Narumoru. All the weakness and mistake identified after the pilot survey was corrected before the commencement of the actual study period.

3.6.3 Household surveys

The selected locations -Narumoru and Mweiga have got a total of 11,880 people (GoK, 2009c). Cochran's sampling formula was used to get the number of households to be engaged in each location (Cochran, 1963). A total of 383 households were engaged in the study area which represented 56% from Narumoru and 44% from Mweiga. The surveys were done early mornings and in the evenings because during the day the agropastoral community members were busy taking care of their farms and animals. In most cases the Kikuyu and Kiswahili language was used by the enumerators to communicate and get response for the survey questions.

3.6.4 Focus group discussions (FGDs)

A total of four FGDs were conducted within the selected locations with facilitation by a trained leader. Gender parity was considered during the constitution of the groups. Village leaders were used to advice on the selected participants' priority given to their gender and amount of years lived in the area. FGDs were very useful in getting insights regarding the community's opinions and needs in relation to climate variability and change in the area. Special care was taken to note non-verbal communication and group interactions which were observed and noted.

3.6.5 Field observation

Field observation was part and parcel of the study. It was used to give the researcher a personal opinion on what is going on in the study area. Observation sheet was used to record observations made on the physical environment, land use and land management, community behaviours and actions that relate to climate change adaptation and people's social relations. Field observation sheet used is in appendix 5.

3.6.6 Key Informant interviews

Key Informant Interviews were conducted between June 2015 and June 2016; this was informed by the nature of work and schedules of the targeted informants. A total of 20 individuals from community based organisations, non-governmental organisations; community leaders, ward administrators, area agricultural officers, NDMA officers, KMD officers, farmers, youth's representatives and opinion leaders were engaged. These interviews were meant to get information on the knowledge, impacts and climate change opportunities in the study area.

CHAPTER FOUR: CHARACTERISTICS OF EXTREME CLIMATE EVENTS IN KIENI SUBCOUNTY

4.0 Introduction

This chapter presents findings on climate extremes in Kieni Sub-county. Information on the methodology and data used is also highlighted. Trend analysis of temperature and precipitation in the area is also presented.

4.1 Changes in temperature extremes

The decadal trends in temperature extremes were analysed for the year 1990-2015 in two weather stations in the area (Munyaka Met station and Narumoru Park Gate).Table 4.1, shows the year/decadal trends of the extreme indices of temperature in Kieni. The indices were obtained using the RClimDex software. The values in bold represent values significant level set i.e. ($P \leq 0.05$).This report dwells on the trends that are within the significant level. The maximum and minimum temperature in both stations shows positive trend portraying an overall increase in daily maximum and minimum temperature.

Table 4.1: Weather stations trends in temperature indices

Indices	Munyaka	Narumoru Park Gate	Units
TMAXmean	0.12	**0.046**	^{o}C
TMINmean	0.847	**0.034**	^{o}C
SU25	0.412	0.109	D
GSL	0.596	0.514	D
TXx	**0.006**	0.051	^{o}C
TXn	0.119	0.059	^{o}C
TNx	**0.014**	**0.0065**	^{o}C
TNn	**0.004**	**0.042**	^{o}C
TX10p	0.065	**0.033**	%
TX90p	0.708	0.513	%
TN10p	0.819	**0.006**	%
TN90p	0.057	0.888	%
WSDI	0.582	0.139	%
CSDI	0.65	0.118	D
DTR	0.544	0.574	^{o}C

The monthly maximum value of daily maximum temperature (TXx) have decreased over the period 1991-2015 as shown in figures 4.1(a) and 4.1(b).Figures 4.1(c) and 4.1(d) shows that the monthly maximum value of daily minimum temperature (TNx) have decreased over the period 1991-2015 in the area. This brings an opportunity for the farming community adjust the variety of crops that they are growing.

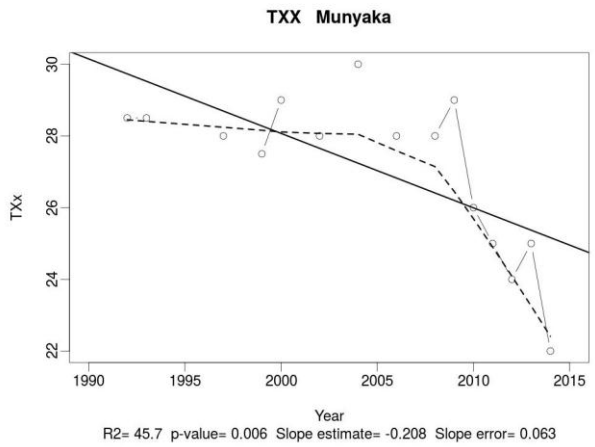

Figure 4.1(a) Monthly maximum value of daily maximum temperature (TXx) in Munyaka

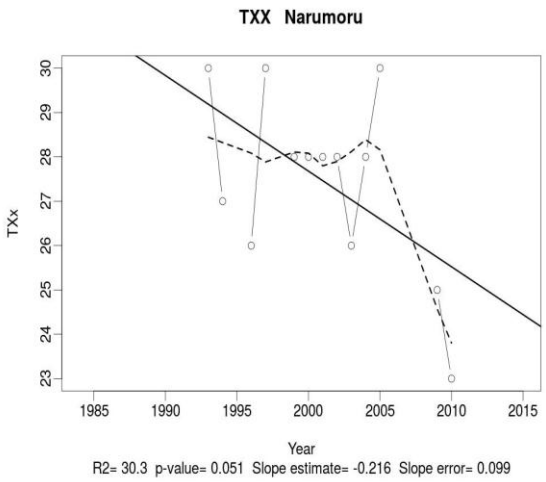

Figure 4.1(b) Monthly maximum value of daily maximum temperature (TXx) in Narumoru

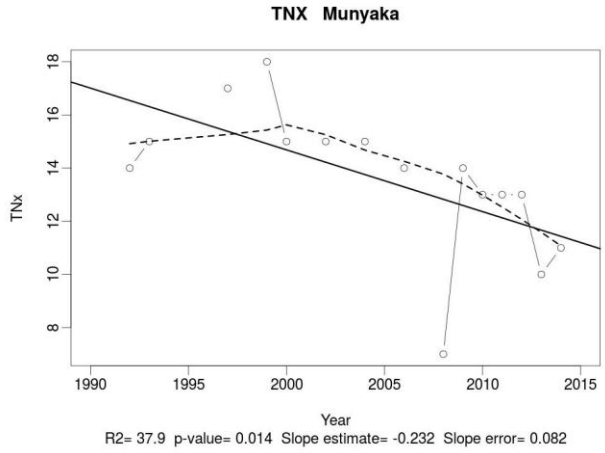

Figure 4.1(c) Monthly maximum value of daily minimum temperature (TNx) in Munyaka

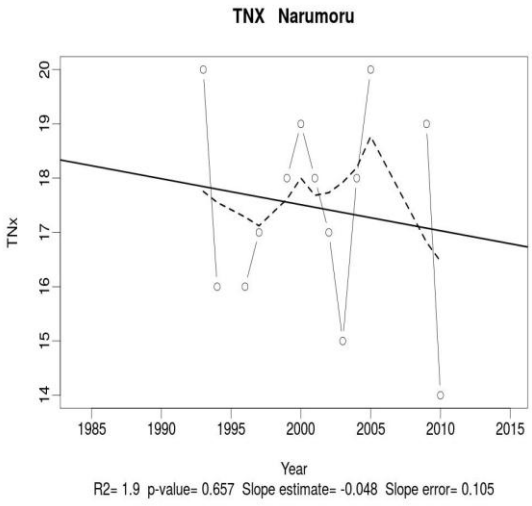

Figure 4.1(d) Monthly maximum value of daily minimu temperature(TNx) in Narumoru

The monthly minimum value of daily temperature has increased in Munyaka as shown in figure 4.2.

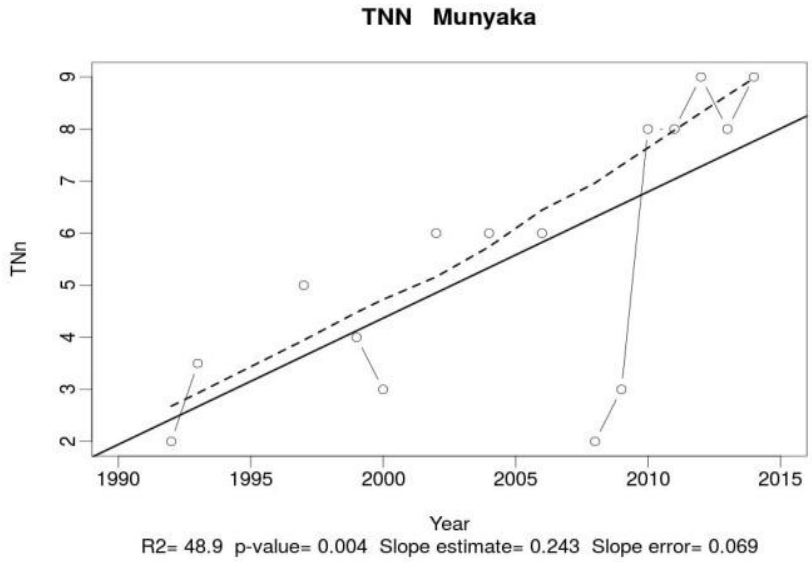

Figure 4.2 Monthly minimum value of daily mimimum temperature(TNn) in Munyaka

The number of days when TN<10thpercentile (cool nights) and number of days when TX<10thpercentile (cool days) have increased in Narumoru Gate Park met station as depicted in figure 4.3(a) and 4.3(b).

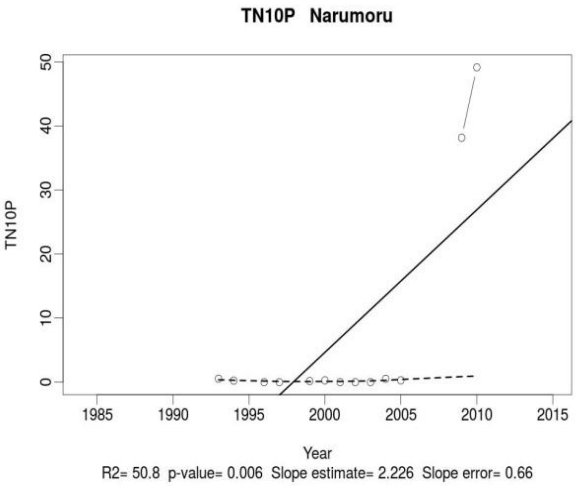

Figure 4.3(a): Number of days when TN<10thpercentile

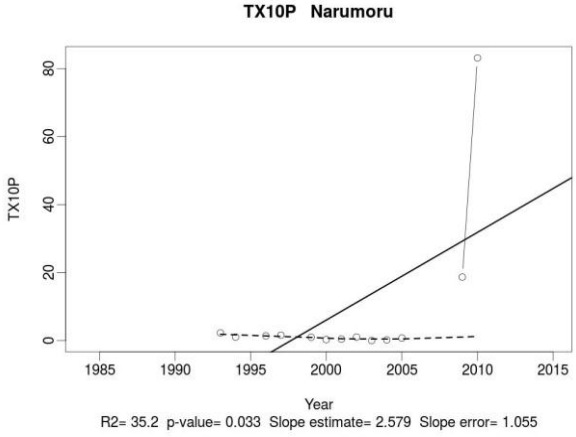

Figure 4.3(b): Number of days when TX<10thpercentile

4.2 Rainfall indices trends

Observed rainfall data from three weather stations is used to calculate the extreme indices for Kieni Sub-county. As shown in Table 4.2, the bold values represent significant level at 5%. Unlike the temperature trends, the numbers of indices that are significant are much lower in precipitation. The monthly maximum 1-day precipitation (Rx1day), only one station showed significant trend. Simple Daily Intensity Index (SDII) which shows days with precipitation amount on wet days with rainfall amount greater or equals to 1mm showed general increase in all the three stations with Munyaka weather station presenting significant trend. The Consecutive Wet Days (CWD) with rainfall greater than or equal to 1mm have generally decreased in all the locations with Munyaka showing statistically significant trend as shown in table 4.2 and figure 4.4.

Table 4.2: Decadal trends of the extreme indices of rainfall in Kieni

Station	**rx1day**	**rx5day**	**Sdii**	**r10mm**	**r20mm**	**R25mm**	**Cdd**	**cwd**	**r95p**	**r99p**	**Prcptot**
Sasini	**0.06**	0.337	0.711	0.785	0.433	0.94	0.156	0.687	0.871	0.516	0.865
Narumoru	0.564	0.482	0.13	0.52	0.301	0.397	0.554	0.227	0.105	0.619	0.745
Munyaka	0.134	0.271	**0.027**	0.824	0.344	0.263	0.757	**0.001**	0.168	**0.059**	0.302

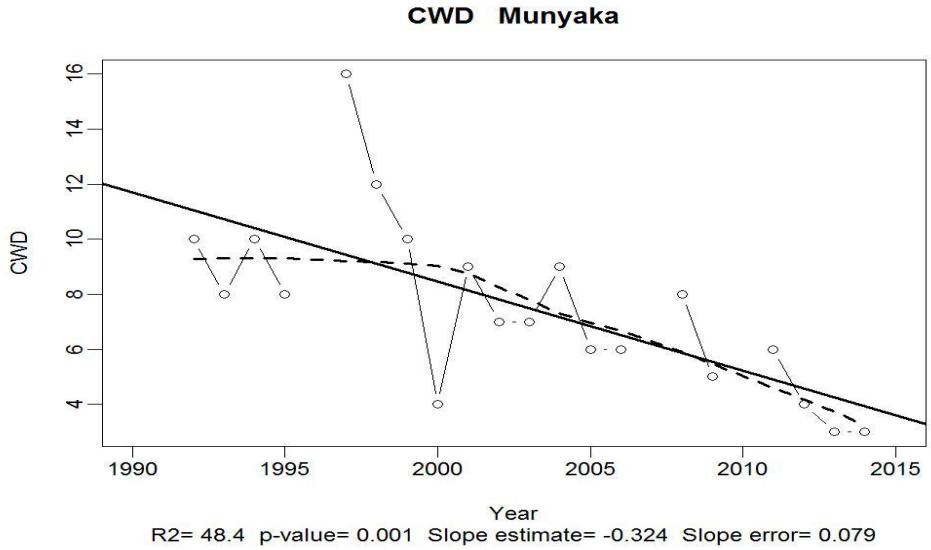

Figure 4.4: Contribution of consecutive wet days in Munyaka station

4.3 Analysis of rainfall and temperature variability

It is indisputable today that climate variability and change has occurred and is still occurring all over the world; the difference being the magnitude of its impacts on ecosystems. Studies conducted in the latest past shows that the mean temperature has risen with evidence showing that Africa will particularly warming with up to 2^{o}C (Seneviratne *et al*.,2012). Studies also show that the Eastern African region has been experiencing rise in seasonal mean temperature and at the same time there is high confidence that the extreme temperatures will increase (Funk and Barbara, 2012; Anyah and Qui, 2011; Moyo *et al*., 2012; Wagesho *et al*., 2013; Opiyo *et al*., 2014).

A study conducted by FEWSNET in 2010 revealed that many parts of Kenya will experience more dry seasons and decline of more than 100milimiter in rainfall by the year 2025. The report also showed that the experienced decline in rainfall is matched with increases in air temperature. Overall, the study revealed that the frequency of dry seasons will increase in Kenya. Other studies have also revealed significant warming in East Africa (Christensen *et al*., 2007; Nyong and Niang-Diop, 2006; Williams and Funk, 2010).

Central Kenya which is one of the country's food baskets has been experiencing significant changes in temperature and precipitation trends. The region's minimum temperature has been increasing since 1960 with a magnitude of 0.8-2.0^{o}C while the trend of maximum temperature has been increasing with a magnitude of 0.1-0.7^{o}C (GoK, 2010b). Research shows that rainfall has been dropping every 3-4 years in Nyeri County (Karienye *et al*., 2012).

This study was undertaken to assess and determine rainfall and temperature trends in Kieni Sub-county for year 1985-2015. This analysis can be used as a base for long term prediction of climate pattern especially forecast on droughts which always have serious implications for rural livelihoods. Analysis of climate trends and being able to predict incidences of extreme weather events is of particular importance especially in planning for adaptation.

4.3.1 Trend of rainfall

In this section, annual, monthly and seasonal rainfall trend in the study area is analysed and presented.

4.3.1.1 Annual rainfall over Kieni Sub County

In table 4.3, the study findings showed that long-term mean annual rainfall estimated during 1985-2015 was 870.29 mm for Sasini Farm (Mweiga); 644.56 mm for Munyaka and 1664mm Narumoru Park gate weather station in Narumoru.

Table 4.3: Long-term mean annual rainfall

Site	Weather Station	Average	SD	CV
Mweiga	Sasini Farm	870.29	182.67	0.21
Narumoru	Munyaka	644.56	188.76	0.293
Narumoru	Narumoru Park Gate	1664.31	397.27	0.239

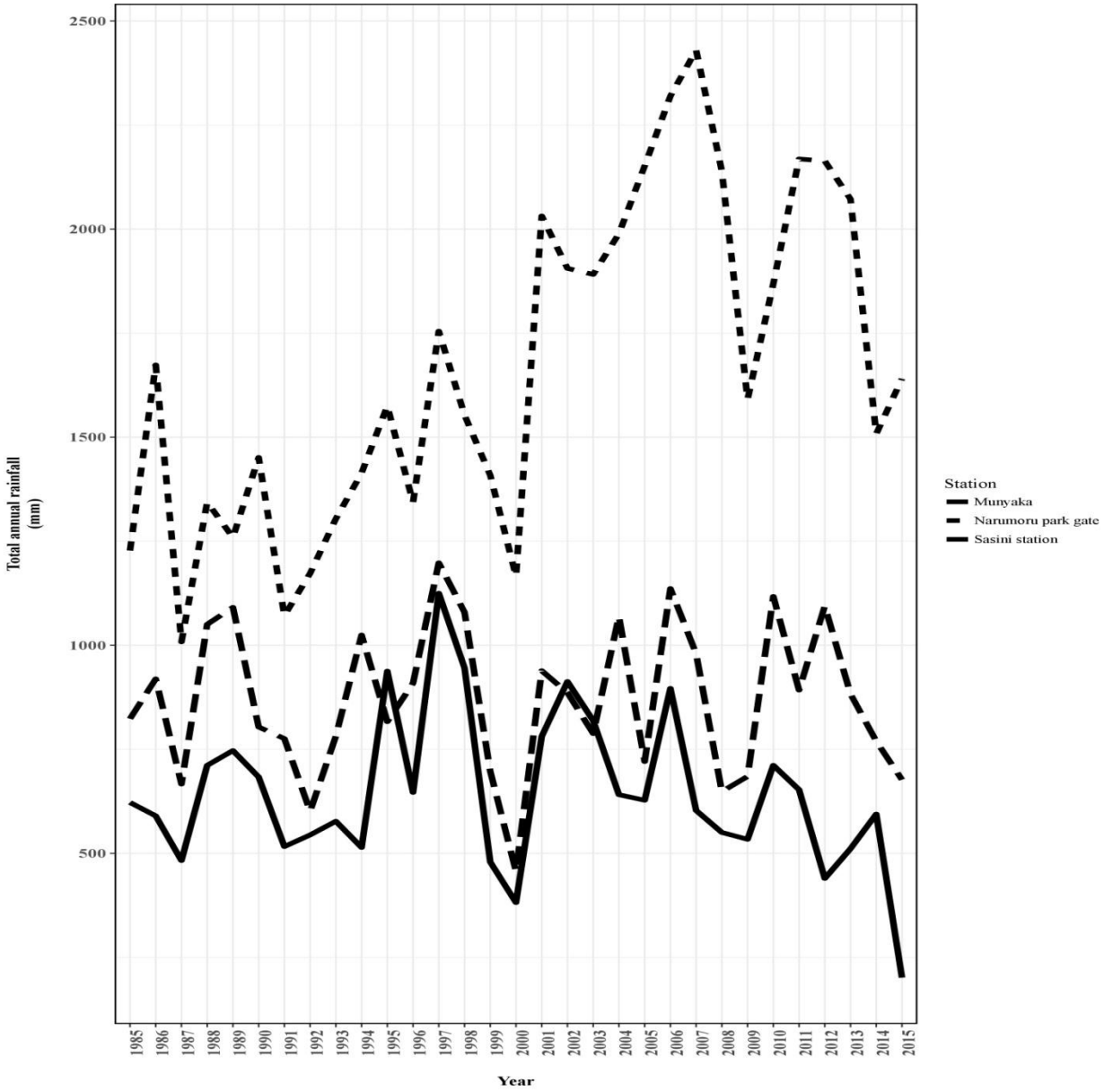

Figure 4.5: Inter-annual rainfall variation by weather station

Figure 4.5 shows the total-annual rainfall variation for the three weather stations which represents the study sites. The study shows rainfall variations between the weather stations. The Narumoru Park Gate receives much rainfall as compared to Sasini and Munyaka weather stations. Various reasons could contribute to this on being that the location of the weather station is close to Mt. Kenya National Park which is forested and mountainous. As shown in figure. 4.5, the rainfall pattern and variation for the three stations was similar up to around year 2000 when Narumoru Park Gate started receiving more rainfall.

This can also be attributed to the efforts made in the 1980s and 1990s to conserve the major water towers in Kenya. In response to heavy commercial exploitation of Mt. Kenya Forest Reserve and other major water catchment areas in Kenya, the government revised the Forest Act back in 1982 and 1992 respectively (Emerton, 1999). This saw coming into force of a number of prohibitions and bans against the use and exploitation of forest resources in Kenya. The reintroduction of *Shamba* System in forest management in 1990s has contributed to community forest conservation that has helped the local communities to plant trees and conserve the forest hence modifying the microclimate of the area (Emerton, 1999). Studies done show that planting of trees and reduction of deforestation by 50% by year 2050 has a potential of avoiding emissions equivalent to 50pg C (Bala *et al*., 2007; Johnson and Coburn, 2010).

Information on figure 4.5 also reflects that there was a sharp increase in the amount of rainfall received between 1997 and 1998; this finding corroborates with the information obtained through FGD where participants reported enhanced rainfall during the same period. This observation agreed with other reports which reported that between 1997 and 1998, Kenya as a country received El-Niño rains (Karienye *et al*., 2012; UNEP 2008). These rains are highly influenced by the El Niño- Southern Oscillation (ENSO).

The El Niño is normally associated with rainfall above normal which is normally followed by prolonged dry period known as La Niña (World Bank, 2012).A study conducted in 2012 confirms that in Nyeri county droughts tend to take a decadal cycle though in the recent past it has become more frequent (Karienye *et al.*, 2012). Other studies done shows the decadal cycle of droughts in the East Africa which bring negative socio-economic impacts (Funk *et al*., 2005; Huho *et al*., 2011; Hillbruner and Moloney, 2012; Verdin *et al*., 2005;Williams and Funk, 2011; Lyon and DeWitt 2012; Yang *et al*., 2014). Major droughts that have been encountered in the country include the 1974, 1942-44, 1947, 1951-1955, 1957-1958, and 1984-1985 and the 1999-2000 (UNDP-WMO-GOK-IGAD- DNCN, 2002).From the analysis done for Kieni, the dry spell of 2000 is also clearly visible in all the three weather stations as it is among the years with the lowest amount of rainfall. The 1983-1984 and 1999-2000 droughts are termed as the most severe in Kenyan history because it brought death to both human and animals and forced the government to spend much on response and rehabilitation (Ojwang' *et al*., 2010).

4.3.1.2: Monthly and seasonal rainfall trend results

Rainfall in the three weather stations follows the same trend with high amounts of rainfall reported during the months of March – May and between October and December (see figure 4.6).

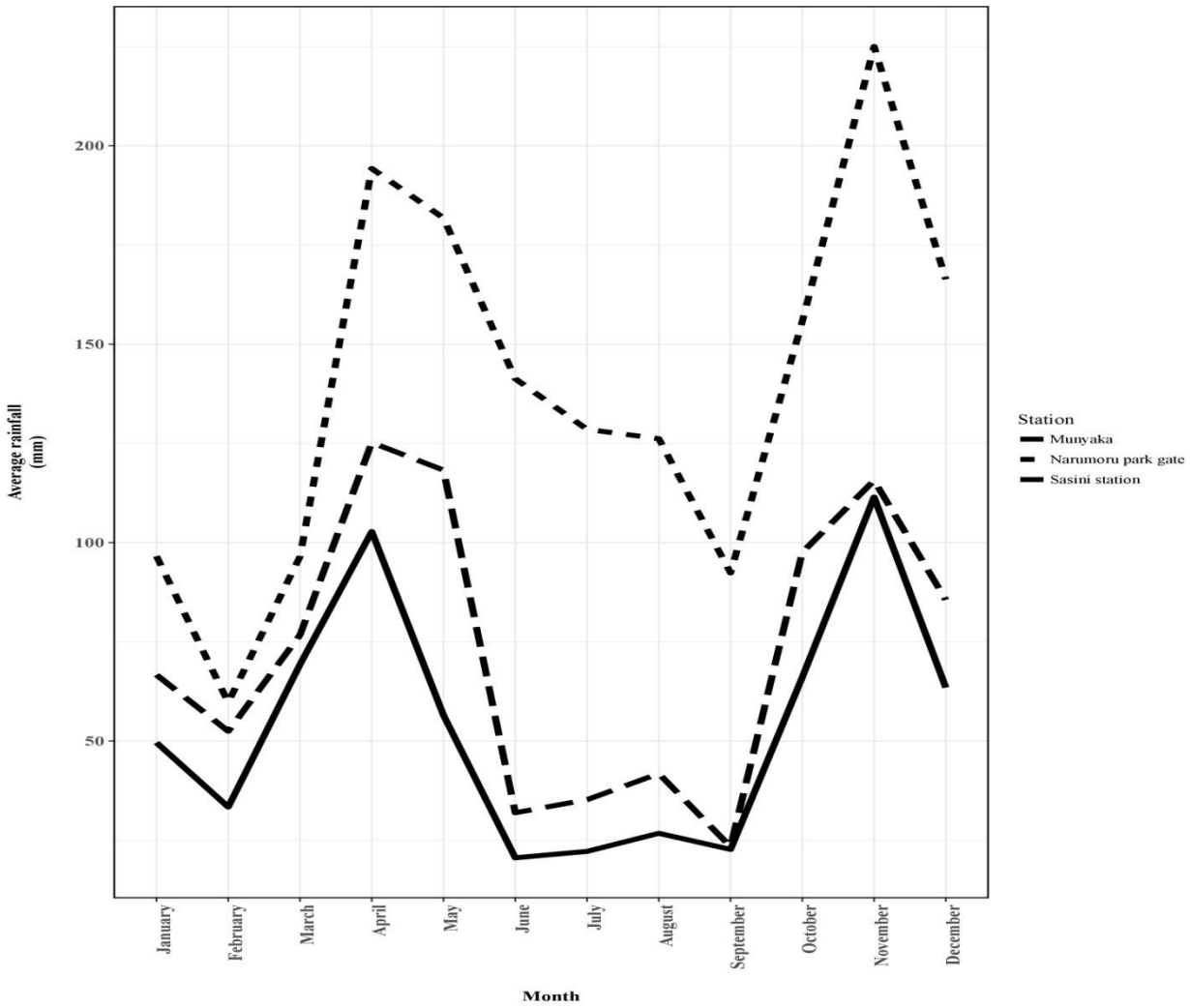

Figure 4.6: Monthly rainfall variability

During the two seasons, April and November reported the highest amount of rainfall respectively. February and September reported the lowest average monthly rainfall amounts in the two sites. Figure 4.6 show that from June – September, Narumoru Park Gate reported higher amounts of rain on average as compared to other sub-sites. In comparison, Sasini in Mweiga reported higher amount of rain on average compared to Munyaka in Narumoru.

This could be because of the fact that Mweiga is colder than Narumoru and it is usually a dry spell in the latter during this time of the year. During the years under study, Narumoru reported higher average monthly rainfall throughout the year compared to Mweiga a factor that is highly influenced by the high rainfall received at Narumoru Park Gate.

The average amount of rainfall during the long rains-March-April-May (MAM) was 106.7 mm for Sasini, 76.2 mm for Munyaka and 157.5mm for Narumoru Park Gate respectively as shown in table 4.4. On average, Narumoru Park Gate reported higher amount of rain during the short rains season-October-November-December (OND) compared to the long rains season.

Table 4.4: Seasonal variability results

	Munyaka		**Narumoru Park gate**		**Sasini farm**	
	Long rains	Short rains	Long rains	Short rains	Long rains	Short rains
Average	76.2	80.3	157.5	182.4	106.7	99.6
SD	47.5	49.6	83.2	70.5	59.9	56.3
CV	0.623	0.618	0.528	0.383	0.561	0.565

In table 4.4, the study shows that more successful short rains seasons were observed in Narumoru compared to the long rains season. Research done in East Africa region predict that there will be an increase in rainfall over the region and particularly the short rains (OND) which is greatly influenced by El Nino like walker circulation response to global warming (Tierney *et al*., 2015; Tierney *et al*., 2013). Other studies shows that the precipitation pattern over East Africa will be enhanced with the warming climate implying that the long rains too will increase (Boko *et al*.,, 2007; Taylor *et al*, 2012; Held and Soden, 2006; Seager *et al*., 2010; Laine *et al*., 2014). The coefficient of variation was used to study the variation in rainfall between seasons (see table 6). During the short rains, Munyaka reported a C.V of 0.618%; Narumoru Park Gate reported 38.7% while Sasini reported 56.5%. In Munyaka, a higher variation was reported during long rains and short rains as compared to Narumoru Park Gate despite having the two sites located in same geographical area.

The differences in the degree of variation between long rains and short rains seasons in Narumoru are a possible explanation for higher average rain reported during the short rains for the years under study. Seasonal rainfall trend depicts the bimodal rainfall season which is common in all parts of Kenya. Figure 4.7 shows that in all the sites the year 1997-1998, received concentrated rainfall which was a similar event experienced throughout the country due to the El Niño rainfall.

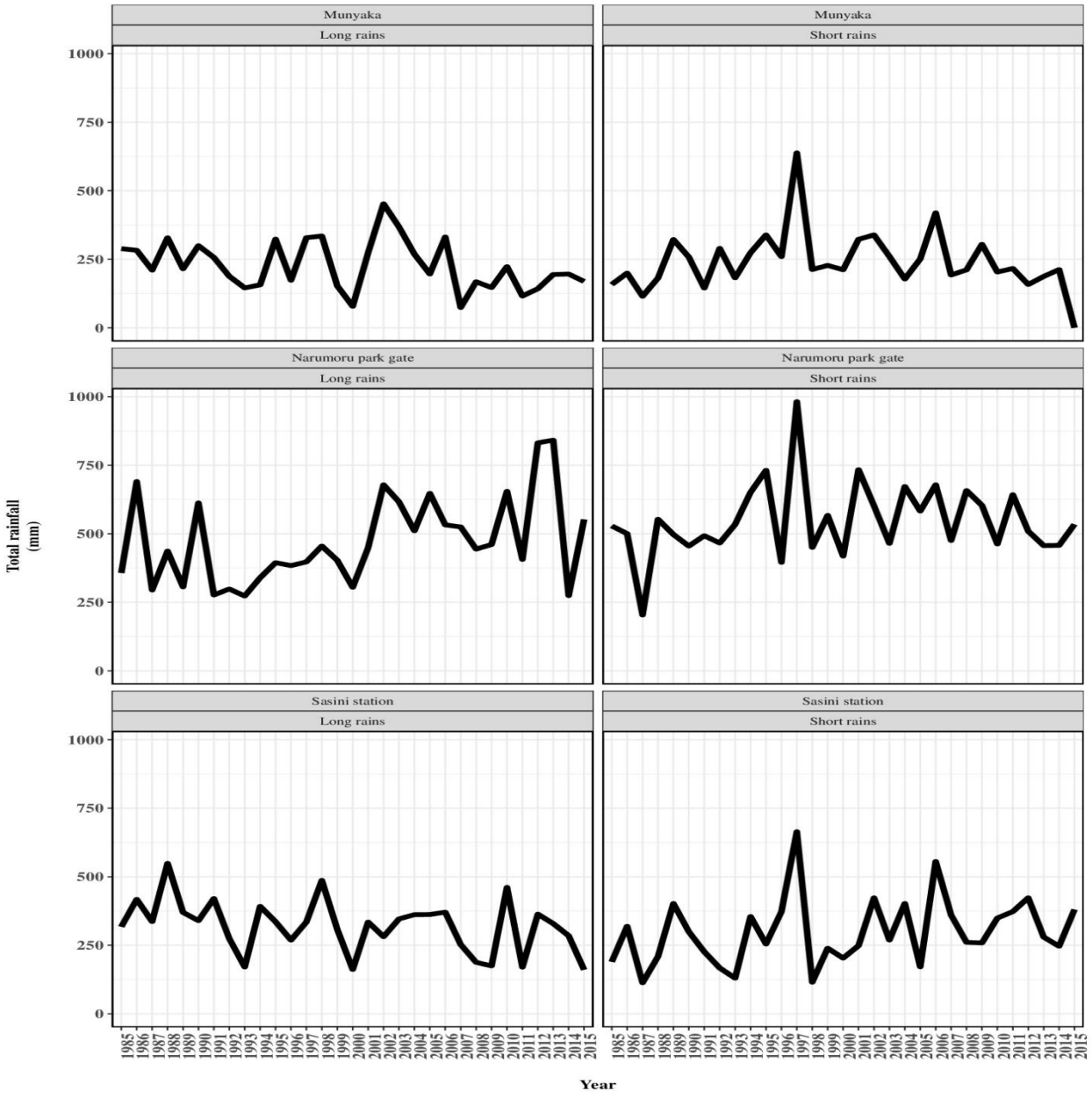

Figure 4.7: Seasonal rainfall trends

4.3.1.3: Mann-Kendall test results

Table 4.4 reveals that for Sasini Farm and Munyaka, the months of March, April, May, June and July depicted a negative trend in rainfall while the months of August, September, October and November revealed a positive increasing trend. Narumoru Park Gate however showed positive trend for the months of January to October and negative trend of -0.097 for November and -0.138 for December. This test showed a movement towards more successful short rains in the study area and declining long rains. These results collaborates with the information shared during the FGDs and Key Informant interviews where it was reported that the short rains season has become more reliable for the communities in that area and the farmers are highly utilising this season as opposed to long rains seasons. Discussants in the FGDs reported that they were utilising the short rains by planting fast maturing crops such as cabbages, spinach and kales which they also sell and earn some income.

Table 4.5: Mann-Kendall test results

	Station		
Month	**Sasini Farm**	**Munyaka**	**Narumoru park gate**
Jan	-0.11	-0.017	0.069
Feb	0.118	-0.022	0.385
Mar	-0.084	0.024	0.424
Apr	-0.17	-0.215	0.166
May	-0.116	-0.194	0.265
Jun	-0.058	-0.179	0.441
Jul	-0.071	-0.11	0.501
Aug	0.191	0.093	0.574
Sep	0.127	0.123	0.336
Oct	0.273	0.062	0.394
Nov	0.135	0.013	-0.097
Dec	-0.045	-0.168	-0.138
Ave. monthly rainfall	-0.015	-0.131	0.501
Period	1985 – 2015	1985 – 2015	1985 – 2015

4.3.2: Trend analysis of temperature

This subsection presents findings on the observed monthly and annual temperature trend analysis.

4.3.2.1: Monthly and annual temperature trend results

Monthly and annual temperature series for 1991-2015 were investigated. The time series was guided by the availability of observed data from the weather stations. In figure 4.8 the results showed a similar trend for both sub-sites though Narumoru Park Gate was a little warmer than Munyaka. March and October were the warmest months in Narumoru Park Gate at 17.6^{o}C and 17.5^{o}C respectively. In Munyaka, the warmest months are February at 16^{o}C, April at 16.4^{o}C, May at 16.3^{o}C and September at 16^{o}C. The study also observed that July is the coldest month on both sub sites with Munyaka experiencing average monthly temperature of 15.2^{o}C and Narumoru Park gate an average of 16.5^{o}C.

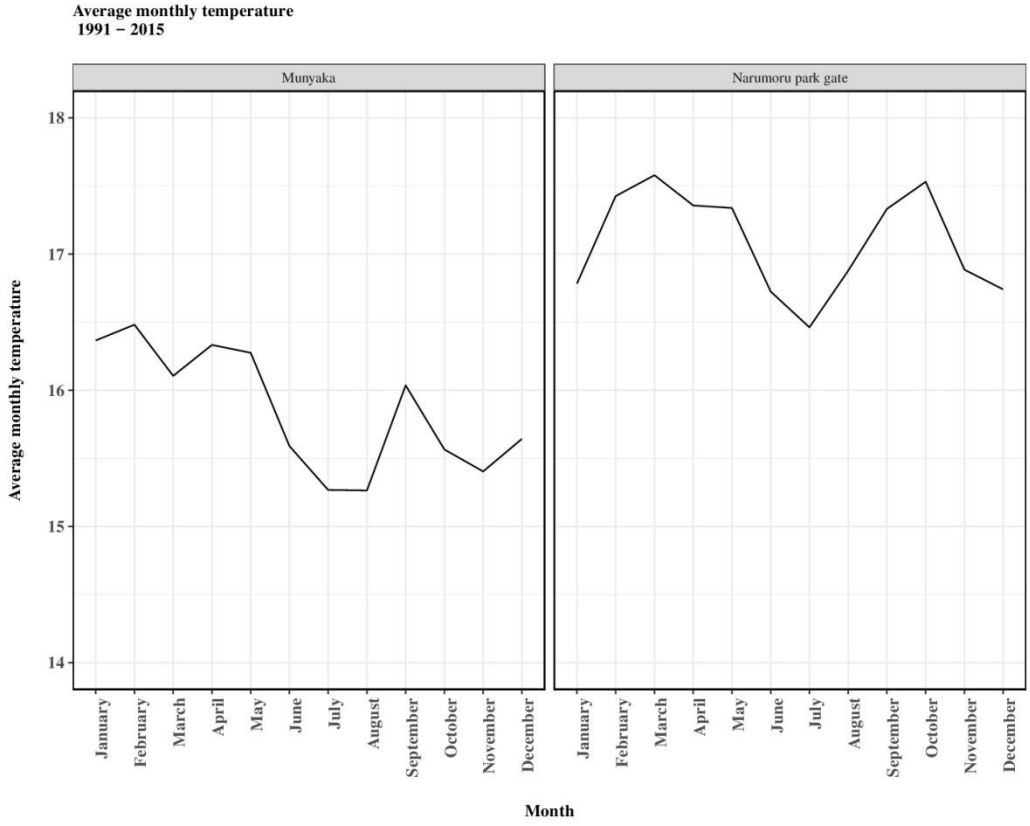

Figure 4.8: Average monthly temperature

The study revealed a decreasing trend for minimum and maximum temperature in both sub-sites from 1991 way up to post 2012. The Mann-Kendall test results revealed a significant trend on average minimum temperature for Munyaka and average maximum temperature for both sites (see table 4.6).

Table 4.6: Temperature Mann-Kendall test results

Station	Average minimum	Average maximum	Average
Munyaka	-0.192	-0.215	-0.290
Narumoru Park gate	0.085	-0.196	-0.101

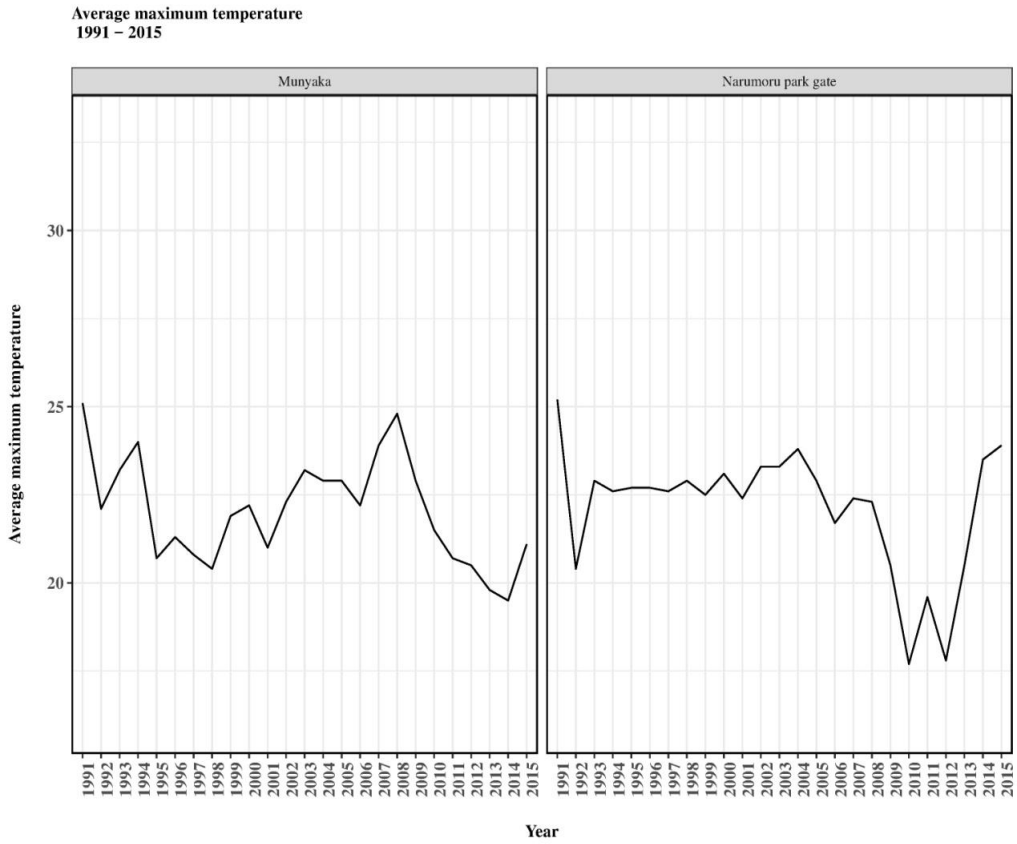

Figure 4.9: Average maximum temperature

The average maximum temperature in the area shows a decreasing as reflected in figure 4.9. The trend shows that in 1991, the average maximum temperature was 25^{o}C but decreased in a similar trend until 2012, when both sites started to show an increasing trend. The average minimum temperature trend reflects a slight difference between the two weather stations with Munyaka cooler that Narumoru Gate Met Station as shown in figure 4.10.

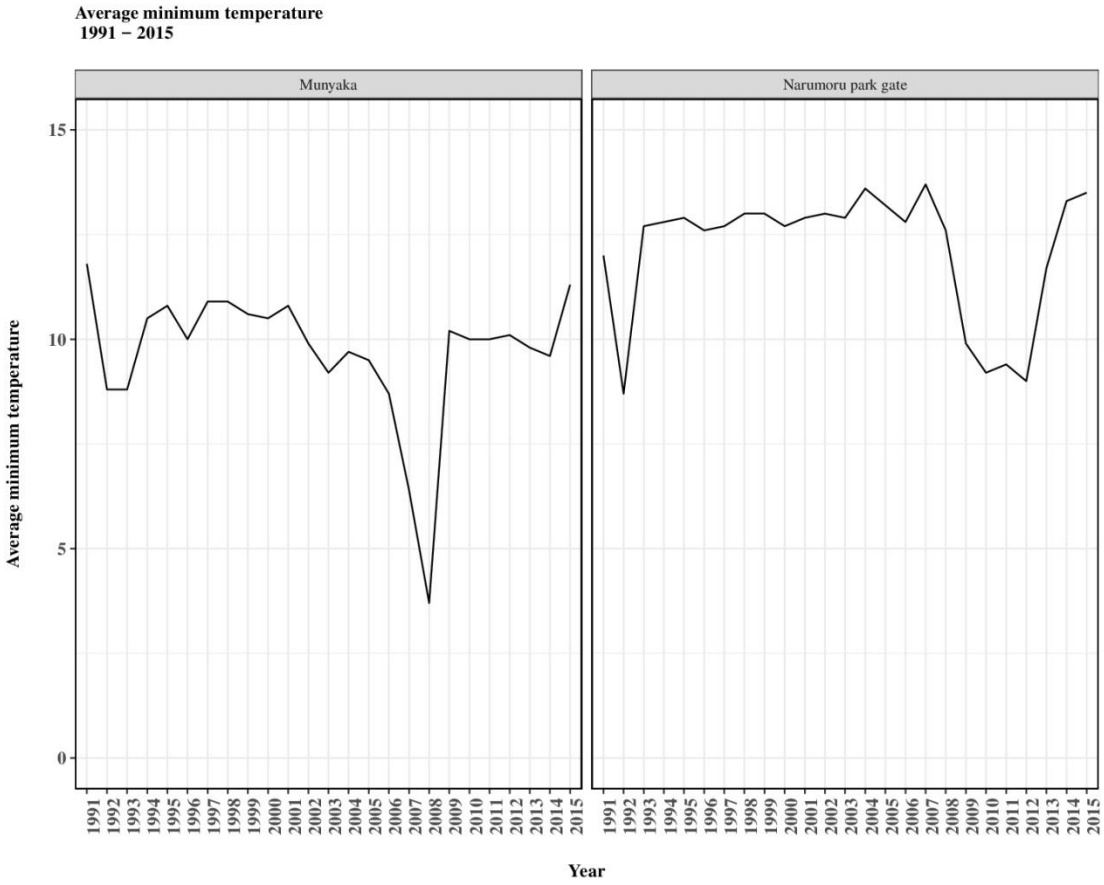

Figure 4.10: Average minimum temperature

CHAPTER FIVE: LOCAL COPING STRATEGIES FOR AGROPASTORAL COMMUNITIES IN KIENI

5.0 Introduction

This chapter presents findings on local coping mechanisms in Kieni Sub-county. Information on the household characteristics, community knowledge and awareness of climate variability and change, severity of change and perception of impacts of climate variability and change on local livelihood resources is also presented.

5.1 Household characteristics

Most of the surveyed households were headed by males (242), while 141 of the households were headed by females as reflected in table 5.1. The average age of the heads of the households was 49years. On average, every respondent has lived for 29 years in the study area.

Table 5.1: Household headships in the study area

Household heads	Percentage of Sample n =383
Male headed	63
Female headed	37

5.2 Community knowledge and awareness of climate variability and change

Out of the 383 agropastoral households surveyed, 97% reported to have seen changes in the rainfall pattern and as well change in temperatures. It was reported that the rainfall is no longer reliable and its highly unpredictable nature frustrates the community members who depend on it for agricultural and livestock keeping. The survey also revealed that there had been delays in the onset of the long rains (MAM). These rains were also reported to have shrunk – starting end of March and ending in early May. Short rains (OND) were perceived to have become heavier and of late extending way into January. From the FGDs, it was reported that in the past, the rainfall seasons were clear and distinct but today it has become highly variable and unpredictable.

One of the crop farmer- Jane Mbogo lamented that "*..when I got married here close to thirty years ago, the rainfall would come at the beginning of March and end at the end of May, nowadays, the rainfall delays and sets in the second week of March and ends abruptly by first week of May or it does not rain at all..*" The increased occurrence of frostbites and reduced agricultural production was associated with the variable weather (rainfall and temperature).

In Narumoru, of much concern was the increase in strength and speed of wind which was associated with increase in invasive pests and diseases for both crops and livestock. The community's perception of variable and changed rainfall was based on the amount received and duration while the temperature change was based on the intensity of hot and cold days which many reported to also gauge with their bodies. The short rains were reported to be more reliable season and many of the agropastoral community members reported that they were capitalising on it to grow crops that matured faster. This corroborates well with the observed rainfall pattern that revealed that short rains are more successful in the area as earlier discussed.

Table 5.2: Community perception on changes in climate (From CRiSTAL assessment)

Observed Climate Change	**Non-Climate Hazards**
- Temperature has increased - Evenings and nights area extremely cold - Long rains have become erratic with delayed onset and abrupt cessation Short rains are extending from October to January - Increase in frostbite events	Environmental degradation due to cutting down of trees/ clearing of forests lack of credit facilities and poor access to market and Land fragmentation Human Wildlife conflict Low technological skills and lack of innovation Counterfeit and low standard agricultural inputs Poor policy and institutional coordination

Table 5.2 outlines the observed climate change and what the community perceived as drivers of vulnerability in the area. The results indicate that other than climate variability and change, the agropastoral community in Kieni are exposed to a combination of socioeconomic and environmental factors that render them highly vulnerable. These drivers are:-

5.2.1 Land fragmentation

The community reported that the land in the area has been highly fragmented due to population increase. According to the traditions of these communities, land has a cultural value and therefore every son has a right to inherit land from the father. This means that no matter the size of the land and the number of sons, the land has to be subdivided. Land fragmentation has been associated with decline in agricultural production leaving communities vulnerable to malnutrition and acute food insecurity, this finding is consistent with other studies carried by Omosa (1998), Mwavali (2009), Flintan (2011), Musambayi (2013) and Obonyo *et al.* (2016) who further looked at the attitudes of the farmers on land fragmentation and revealed that majority of the farmers oppose land fragmentation practice.

5.2.2 Environmental degradation

The community reported that massive cutting of trees in the area has exposed them to even drier climate and strong winds. The discussants in the FGDs noted that by the time they settled in Kieni 40years ago, the climate was 'good' because the trees and the forests were intact. Slowly the community cleared the forests to give way for settlement and agricultural activities an act that has rendered the area vulnerable to climate variability and change. This finding is supported by other research done in the area and neighbouring county for especially Macharia *et al.* (2009), Huho and Kosonei (2013) and Ojwang' *et al.* (2010) who however noted that the massive expansion of agriculture into the arid and semi-arid land and use of unsustainable farming practices often accelerate environmental degradation.

5.2.3 Human wildlife conflict

In Kieni, there is increasing cases of human wildlife conflict especially in Kieni west where baboons and monkeys destroy crops as well as harass women and children. The agropastoral community reported that these animals raid their farms throughout the year. From the FGDs, it was reported that the baboons and monkeys invade in troops of over thirty and eat everything leaving families vulnerable with lack of food and income. The community reported that although they report the incidences to the Kenya Wildlife Services (KWS), no substantial steps have been taken to protect them from these animals. They recommended a compensation strategy for crops and human life destroyed by the wild animals.

5.2.4 Low technological skill and lack of innovation

The agropastoral community in Kieni Sub-county reported that they are vulnerable because they lack in technological knowhow. The areas that were of particular concern were in seasonal and inter-annual climate prediction that would give the farmers a heads up in their farm activities. It was reported that farmers did not get any information regarding climate prediction for the area and therefore they could not plan for their farming activities based on clear scientific information. The community also lack in machinery, knowledge and skills such as the use of drip and sprinkler irrigation, soil testing services and agricultural extension services.

5.2.5 Lack of credit facilities

Any form of business requires financial support either from banking systems, insurance or government financial corporations. The agropastoral communities in Kieni Sub-county reported that it is extremely hard for them to access financial support to boost their livelihood activities. From the key informants interviews and FGDs, the agropastoral community intimated that formal credit lenders such as banks shy away from lending for crop and livestock keeping because it is seen as high risk business. The few who had accessed the formal financing however complained of the high interest rates of 18%-24% being charged by the banks.

5.2.6 Counterfeit and low standard agricultural inputs

From the house hold survey conducted, 95% reported to that they suffer losses because of using substandard or counterfeit inputs. The discussants in the FGDs and the key informants reported that there are middle men in the area who sell substandard fertilisers, chemicals and animal drugs that are of low quality risking their produce. The seeds were also reported to be of poor quality which affect the amount and quality of harvest.

5.3 Severity of the change

The study shows that the agropastoral community do understand that climate has changed. In table 5.3, the community has outlined the climate hazards they experienced. The three major hazards in the area are drought, invasive pests and diseases and frost bites.

The community was also asked to give the indicators they use to gauge the hazards by way of indicating what they used as early warning signs for climate hazards. These indicators included: Extremely high and low temperatures, presence of frost, reduced and erratic rainfall, changed rainfall patterns and increased velocity and strength of wind. The increase in velocity and strength of wind was observed by how much the wind rips off housing roofs and fallen crops and trees after the wind event.

Table 5.3: Community's early warning signs of climate hazards and coping strategies (from CRiSTAL assessment)

Climatic events/hazard	Signs	Coping strategies
Droughts	Presence of eagles, butterflies, locusts and dragon flies Movement of birds Strong winds blowing from the North East Abrupt end of rainfall High levels of frostbites Extreme low temperature Extreme high temperature	-Buying of food for consumption and fodder for livestock -Reduce farmed land and irrigate small kitchen gardens for vegetables -Migrate in search of casual labour in flower farms and urban centres -Depend on remittances from family members who work in the urban areas
Frostbites	Extreme high temperatures during the day Extreme low temperature during the night Rare amount of dew on the grass or iron sheets Extended very cold mornings Misty weather Increase in aphids attack	Buying of food and fodder for animals -Go to hospital and take medication -Depend on remittances from family members working in urban areas -Search for casual waged labour in flower farms and urban areas
Invasive pests, diseases and plants	Presence of rust Increase in aphids Presence of white flies	-Use of herbicides, fungicides and pesticides -Crop rotation -Intercropping -Buying food Search for casual waged labour In flower farms and urban areas - Depend on '*chamas'/* community social welfare groups for support

The study investigated how households and the community perceived the severity of the impacts of climate variability and change.

In this, the agropastoral community members were asked to rank droughts, invasive pests and diseases (IPDP) and frostbites in terms of frequency of occurrence; intensity and how difficult it is to cope with. Analysis of ranking data tool was used (Abeyaseker, 2001; Coe, 2002). Figure 5.1 show that drought was most intense and most difficult to cope with as compared to other hazards. In terms of frequency, frostbites and droughts occur more frequent.

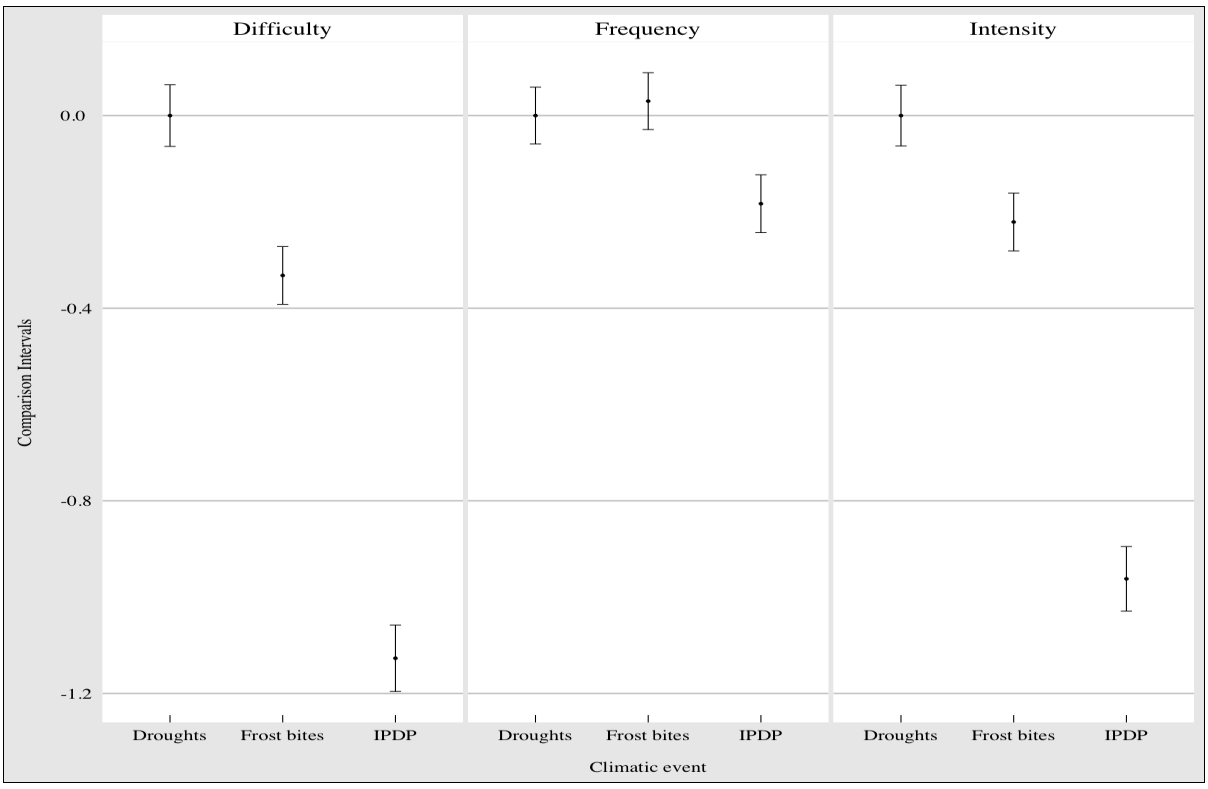

Figure 5.1: Comparison intervals of hazards

5.4 Perception of impacts of climate variability and change on livelihood resources

After identifying the climate related hazards in the area, the participants were asked to outline the context of livelihood in the area. As indicated in table 5.4, the agropastoral community in Kieni identified livelihood resources that they deemed important. The most common form of livelihood system in Kieni is crop cultivation and livestock keeping (NDMA, 2014). This means that the communities interact with the natural resources on daily basis.

The surveyed community members, reported that due to the increased climatic events such as droughts, frostbites, invasive crops and pests, and unreliable weather patterns, the agropastoral community has experienced increase in crop failure and loss of livestock due to lack of fodder and strained water resources. This is because this community depends on the traditional free range grazing system which is highly susceptible to climate variability and highly affected by the current land fragmentation in the area. The study shows that agriculture is one of the significantly impacted sectors by climate variability and change. This finding supports research findings for instance Sacramento *et al.* (2010), Mary and Majule (2009), Njenga *et al.* (2014) and Ogalleh *et al.* (2012).

Table 5.4: Important resources in the area (From CRiSTAL assessment)

LIVELIHOOD RESOURCES	
Resource	*Resource Type*
Land; water; forests (for wood fuel and medicinal services); pasture	Natural
Market access; Credit facilities and Bank deposits; crops; livestock	Financial
Social relationships and community cooperation(mostly in "*chamas"/community banking system);*agricultural commercial villages; Government social services-payment to elderly people	Social
Technological skills and innovation; Climate information services	Human
Roads; Standard and subsidised agricultural inputs; irrigation systems	Physical

5.4.1 Influence of climate hazard on livelihood resources

The participants were asked to determine the impact of the each perceived hazards on their livelihood resources. This would help in analyzing the existing and possible coping strategies and opportunities in the area. The extent of the influence of these hazards was indicated using numbers between 0 and 5 with 0 depicting no influence while 5 depicted very strong influence. Table 5.5 shows importance of climate hazards on the various livelihood resources as identified by the agropastoral community in Kieni vulnerability assessments.

Table 5.5: Livelihood context- influence of hazards on livelihood resources

Hazard	Drought						Frost bites						Invasive pests and diseases					
Resource	0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
Natural																		
Land						X	X									X		
Water						X	X						X					
Forests-trees						X						X				X		
Pasture						X						X				X		
Financial																		
Market access				X						X						X		
Credit facilities				X			X									X		
Bank deposit				X						X						X		
Crops						X						X						X
Livestock						X						X						X
Social																		
"Chamas"/community banking system				X						X			X					
Agricultural commercial villages						X						X						X
Government social services-payment to the elderly	X						X						X					
Human																		
Technological skills and innovation	X									X						X		
Climate information services						X				X						X		
Physical																		
Roads	X						X						X					
Standard and subsidised agricultural inputs	X									X								X

As shown in table 5.5, drought has a high impact on natural resources, some financial resources as well as some social resources like the agriculture commercial groups because the livelihood activities to utilise these resources often depend on the quantity, quality and general output of water (rainfall), land, trees, crops and livestock. This is also depicted with frostbite and invasive pests and diseases to some extent. Crops and livestock are depicted as highly impacted on by all the three hazards. This study therefore is consistent with research done by IPCC (2012) which shows that climate has a direct influence on crop growth and yields through its impact on the various physiological processes which in turn affects communities' livelihoods. Temperature and rainfall in particular are the most important climate elements that affect the farmer planting time, germination and maturity of the crops as well as the amount of yields to be harvested.

This means that when the patterns of rainfall and temperature levels increase or reduce, they affect the growth of crops as well as their characteristics. This finding is consistent with findings by Herrero *et al.* (2010) and Jensen *et al.* (1993).

In the FGDs, the community reported that the frequency of drought occurrence has increased from every 10years in 1984 to every 3-5 years ten years ago to every other year in 2015.To support their argument, the discussants in Rekeka CBO focus group discussion reported that in the past six years (2009-2015), they had not harvested maize from their land. This was also supported by the NDMA County Information officer and the Agricultural Officers for Kieni West and Kieni East who associated the community's vulnerability to lack of adequate water for irrigation and domestic use. The looming food insecurity, increase in food prices, migration, incidences of school drop outs and separation in marriage were reported to have a direct relation to climate variability and change.

The community reported high incidences of invasive diseases and pests for both crops and livestock. These diseases and pests cause harm, destruction and even death to livestock. Through the FGDs, it was reported that the strong and speedy winds that blow from the Northeast (direction of Laikipia County) of the area always carry with it invasive diseases and pests. The migration of the Maasai pastoralists from the neighbouring Laikipia County in search of greener pastures during dry seasons was also associated with the increase of these diseases and pests especially for animals. The discussants noted the most common livestock diseases in the area are; East Coast Fever (ECF), anaplasmosis (*ndigana),* nagana, mastitis, pneumonia especially for calves, goats and sheep and *mucoid enteritis* a bacteria disease affecting rabbits. These diseases are severe and often cause death of livestock. Livestock pests that were noted include; ticks, tse tse flies and intestinal worms.

In crops, several invasive diseases were also noted such like; Maize Lethal Necrosis Disease (MLND). MLND is a disease that first invaded southern part of the rift valley in year 2011 before spreading to other parts of the country (Wangai *et al.,* 2012). This disease is caused by two viruses-the sugarcane mosaic virus transmitted by aphids and maize chlorotic mottle virus transmitted by thrips (Wangai *et al.,* 2012). The irish potato farmers in Kigama commercial villages reported presence of potato cyst nematode (*Globodera rostochiensis)* and bacterial wilt or '*gatombo*' as famously known by the local community.

The discussants reported that in 2016, there was invasion of a disease they called '*kathuri'* which affects irish potatoes in a similar manner like the bacterial wilt but it is more lethal. However, they expressed concern that the agricultural officers have not discovered what it was and therefore there was no cure at that moment (reported *at FGD in Kigama commercial village, in Mwichuiri on 2nd June, 2016*). One of a farmer Mr. Gitonga expressed frustration by saying "*I left maize farming to venture into fast maturing and high value crops only to find the same problems in potato growing".* Other severe crop diseases are blight and leaf rust. The major invasive pests reported in Kieni include millipedes, earthworms, cutworms, redspider mites, destructive birds and aphids. Of particular significance is the millipede which the discussants in the FGDs reported to have given up hope on their eradication. It was reported that the millipedes invade and destroy every type of crop. Most affected crops include irish potatoes, cabbage, kales and spinach. Plate 1 shows how millipedes are infesting irish potatoes in the area resulting in reduced yields.

Plate 1: Photo showing millipede infestation on irish potatoes in the area.

Frost and cold bites were also reported as impacts of climate variability and change in Kieni. From the house hold survey, 100% reported to have suffered from frost damages. A frost is defined as the occurrence of a cold air of below 2^{o}C especially during clear, cold and still nights (Kalma, 1983; Kalma *et al.,* 1992; Blennow, 1997; FAO, 2005).

Through information shared by the key informants, frost was reported to damage crops at any development stage with severe damages occurring during flowering/ fruit development stage, this is in congruent with a study conducted by Kotikot and Onywere (2015) who also noted that the damage is aggrevated by lack of adequate information on frost. The FGDs established that frost damage all types of plants including napier grass, rhodes grass, maize, beans, trees, cabbage and irish potatoes. This finding is well supported by other research done within Kenya and globally for instance FAO (2005), Barlow *et al.* (2015) and Morshrik *et al.* (2011) who argued that the world will continue experiencing frost waves despite the fact that the earth is warming. In this study, the key informants from the agricultural sector reported that frost affect the health of plants by damaging their leaves, fruits and flowers and eventually causing death of plants. The findings on frost damage supports the research done across the Abardare and Mt. Kenya region that revealed that 38.4% of the area is at risk of being hit by frost and that the month of April, May, October and November show high occurrence rate of frostbites Kotikot and Onywere (2015). This paints a grim picture for farmers because these months are the most critical for crop production in the area.

Globally, frost is said to be the leading weather hazard that substantially reduces production of vegetables, pasture, fruits and even forest cover (FAO, 2005a.). For example, in the United States of America, major economic losses are caused by failed harvests owing to the freezing of crops. In Kenya, the Kenya Tea Development Authority (KTDA) posted a 1billion loss in 2012 due to frost damage on tea plantations in central Kenya and in the Rift Valley in January 2012 (FAO, 2015; Bore*et al.*, 2013; Kotikot and Onywere, 2015).On livestock frost was reported to cause severe shortage of pasture and fodder. This is because frost is known to damage all kind of plants including grass.

5.4.2 Importance of livelihood resource on local coping strategies

For each of the livelihood resource identified earlier in the CRiSTAL steps, an analysis of their influence and importance on local coping mechanisms was done. The importance was indicated by entering a number between zero (0) and five; where 0 represented not important and five represented very important.

Table 5.6: Importance of livelihood resources on coping strategies: Drought

Current hazard : Drought	Destruction of crops and fodder						Reduced/ strained flow of water						Loss of income					
Current coping strategies	-Purchase of food for human consumption and fodder for livestock -plant drought resistant crops						-Reduce farmed land to irrigated kitchen gardens -Walk distances to fetch water for animals and domestic use						-Migrate in search of casual labour -Depend on remittances from family members working in towns					
Resource	0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
Natural																		
Land						X						X						X
Water-community dams						X						X						X
Forests						X						X						X
Pasture						X				X								X
Financial																		
Market access					X					X								X
Credit facilities and insurance for animals and crops						X			X									X
Bank deposit						X						X						X
Crops						X						X						X
Livestock						X						X						X
Social																		
"Chamas"/community banking system						X						X						X
Agricultural commercial villages						X					X							X
Government social services-payment to the elderly						X						X						X
Human																		
Technological skills and innovation						X						X						
Climate information services						X						X						X
Physical																		
Murrum and bitumen roads	X						X						X					
Standard and subsidised agricultural inputs						X	X										X	

The information on table 5.6 shows that natural, social, and financial resources are highly valued as important requirements for the successful uptake of the existing coping strategies for drought events in the area. Purchase of food and fodder for animals was said to have low sustainability because there is little or no money in the community and households to buy the often overpriced food and fodder during the drought season.

The participants were quick to offer an alternative coping strategy which doubled up as an opportunity in making of hay and silage during bumper harvest and storing it for use during the dry season. The discussion revealed that this hay and silage can be sold and bring income to the community and households. The participants pointed that there is need for an evolution in how they conducted their livelihood activities and suggested growing of drought resistant crops and fodder and investment on post-harvest management strategies as a way of fighting the effects of drought. Investment on agribusiness technologies such like greenhouse farming and insurance for crops and livestock were as huge opportunities for the community to adapt better Migration in search of casual labour was also said to have low sustainability because the population of those seeking labour has increased tremendously.

Table 5.7: Importance of livelihood resources on coping strategies: Invasive pests and diseases

Current hazard : Invasive pests and diseases	Destruction of crops and fodder						Loss of income						Sickness and eventual death of both crops and livestock					
Current coping strategies	-crop rotation and intercropping -use of herbicides, pesticides and accarides						-work as casual labourers in flower farms -depend on *chamas* and social welfare groups						Buying food					
Resource	0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
Natural																		
Land						X						X						X
Water-community dams						X						X						X
Forests						X						X						X
Pasture						X						X						X
Financial																		
Market access				X						X								X
Credit facilities and insurance for animals and crops						X						X						X
Bank deposit						X						X						X
Crops						X						X						X
Livestock						X						X						X
Social																		
*"Chamas"/*community banking system						X						X						X
Agricultural commercial villages						X						X						X
Government social services-payment to the elderly						X						X						X
Human																		
Technological skills and innovation						X						X						
Climate information services						X						X						X
Physical																		
Murrum and bitumen roads	X						X						X					
Standard and subsidised agricultural inputs						X	X										X	

Information on table 5.7 shows that the agropastoral community in Kieni perceived natural and financial resources as important enablers for coping with invasive pests and diseases. Technological skills and access to quality and standardised agricultural inputs were also ranked highly as important resource for community and household adaptation.

The participants reported that they had been using strategies like spraying of herbicides, accarides and pesticides which was not effective. As reported by the participants, there is a huge challenge in the use of pesticides and herbicides due to the presence of counterfeit products in the market. The sustainability of this strategy was said to be low because they were too expensive for the farmers and herders. Crop rotation and intercropping were identified as coping mechanisms to fight the effects of pests and diseases by the crop growing farmers. The participants identified use of integrated pests and disease control methods and provision of certified and subsidised agricultural inputs as a required evolution in the area to enhance their adaptive capacity. Greenhouse farming was also identified as an opportunity that the community can exploit to their advantage.

Table 5.8: Importance of livelihood resources on coping strategies: Frostbites

Current hazard : Frostbites	Destruction of crops and fodder						Sickness in people						Loss of income					
Current coping strategies	-Buying of food for consumption and fodder for livestock						-- go to hospitals and take medication -depend on remittances from family members working in towns						- work as casual labourers in flower farms and nearby urban areas					
Resource	0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
Natural																		
Land						X						X						X
Water-community dams						X						X						X
Forests						X						X						X
Pasture						X						X						X
Financial																		
Market access				X						X						X		
Credit facilities and insurance for animals and crops						X						X						X
Bank deposit						X						X						X
Crops						X						X						X
Livestock						X						X						X
Social																		
"Chamas"/community banking system						X						X						X
Agricultural commercial villages						X						X						X
Government social services-payment to the elderly						X						X						X
Human																		
Technological skills and innovation						X						X						
Climate information services						X						X						X
Physical																		
Murrum and bitumen roads	X						X						X					
Standard and subsidised agricultural inputs						X	X										X	

Information in table 5.8 outlines the importance of livelihood in coping with frostbites. It shows that land, financial and social resources are deemed important in improving adaptive capacity. The participants noted that investing in low cost livelihood sources such as poultry farming especially the *"kienyeji"* breed and dairy goat farming would go a long way in helping the community adapt better. Research on how to fight frost was also recommended.

CHAPTER SIX: SOCIAL AND ENVIRONMENTAL OPPORTUNITIES BROUGHT BY CLIMATE VARIABILITY AND CHANGE

6.0 Introduction

This chapter presents findings on the various available and perceived opportunities and options brought by climate variability and change for agropastoral community in Kieni Sub-county. The uptake of these opportunities by the community and barriers to their utilisation is also examined in detail.

6.1 Awareness and perception of opportunities associated with climate variability and change

For Kieni agropastoral communities, a range of opportunities exist that the communities are already exploiting. There is much more that they are yet to take up to enable them adapt better. In this study, both the ancillary benefits and adaptation opportunities are investigated and discussed. As shown in figure 6.1 out of the 383 surveyed households, 91% reported to have awareness about climate variability and change opportunities. Only 9% of the households surveyed reported that they were not aware of any opportunities which come with climate change.

From the FGDs, it was reported that those who did not perceive opportunities in climate variability and change saw it as a negative situation and hence all the events associated with it were seen to be devastating. They felt helpless in the face of climate variability and change and termed it as God's way of punishing humanity for all their misdeeds. This has also been noted by a research done in Zimbabwe by Moyo *et.al.* (2012) where the community indicated that the effects of climate variability and change were an act of God and cannot be influenced meaning cultural and religious factors contributed to climate change.

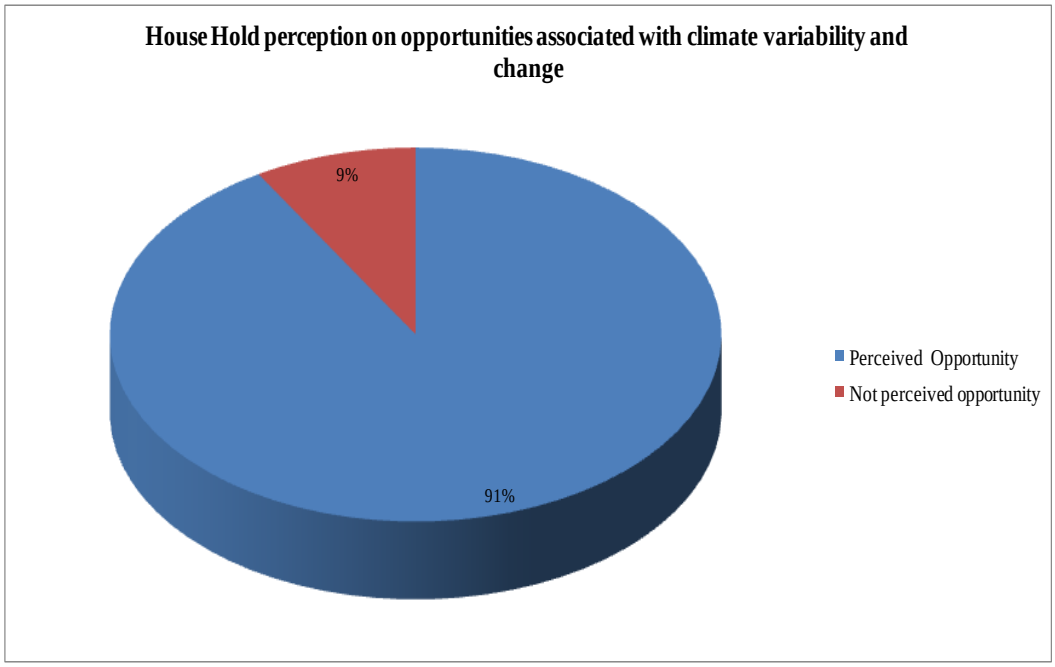

Figure 6.1: Household awareness and perception

Figure 6.2 represents the results that are discussed under seven thematic groups: local livelihoods diversification; technological innovations and development; land use and land management; farm production practices; financial and market services; employment and education. The approach for analysing and categorising the adaptation options was borrowed from a typology done in Canada on classifying and characterisation of agricultural adaptation strategies to climate change (Smit and Skinner, 2002).The livelihood diversification looked at other livelihood activities that the community is engaging in or perceived as an opportunity and that is not their traditional or usual means of livelihoods. This means other novel activity other than traditional crop farming and traditional livestock keeping in free range and pastoralism. Research shows that, livelihood diversification varies for different individuals and communities but are often linked with a whole range of possible activities and have positive and negative outcomes (Adams and Mortimore, 1997; Ellis, 1996; Hussein and Nelson,1998).

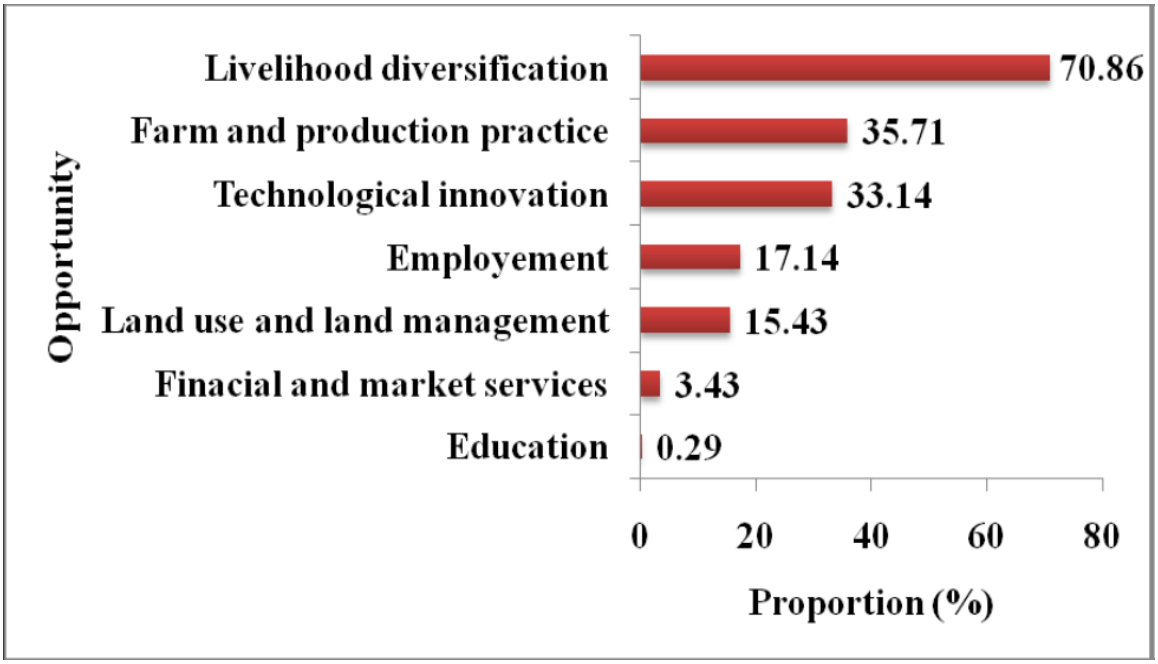

Figure 6.2: Perceived opportunities

The communities reported that diversification of livelihoods was used as an opportunity brought by climate change and it offered an avenue for adaptive response to the reducing income from their mainstream livelihood activities due effects of climate change. It was also termed as a very important opportunity that helped them spread risk and cope with crisis such as loss of crop or animals due to climate change. Seventy percent of the three hundred and fifty (350) households that had perceived an opportunity in livelihood diversification engaged in alternative livelihood activities, details of the specific alternative livelihood opportunities are discussed in section 6.2. Another classification was based on opportunities in technological innovation and development. This includes opportunities developed through research funded by government, private sector and non-government organisations. For Kieni communities, opportunities under this typology was seen in aquaculture farming, greenhouse farming technology, access to climate information (i.e. provision of weather forecasts in timely and contextualised manner) and water harvesting technology. The full discussion on each opportunity is done in section 6.3.

Land use and land management was also a classification used to highlight the opportunities available indecisions taken at farm level to increase the options of farm productivity under climate variability and change. These included irrigation and tree planting which are discussed in detail under section 6.4.

Farm production practices classification was used to give a deeper focus on activities that present an opportunity to increase adaptive capacity of the agropastoral communities. The communities saw opportunities in diversification of crop and livestock types and varieties as discussed in section 6.5. Another classification used was the financial and market services which offer opportunity using income strategies; may it be from government in terms of subsidies, funds such as Uwezo, women and youth enterprise funds, extension services and credit, access to market. The study revealed that government support programs have great influence on decision to financial management by individual and communities for example decision to take up crop and livestock insurance and household income generating activities. This finding is supported by research done by Smit and Skinner (2002) in Canada. Section 6.6 discusses this in detail. Employment and education were also used as classification in sections 6.7 and 6.8 respectively.

6.2 Opportunities in local livelihoods diversification

This section discusses the perceived livelihoods diversification opportunities in poultry farming, dairy cow farming, dairy goat farming, and social and environmental enterprises**.**

6.2.1 Poultry farming

The communities in Kieni Sub-county reported that they were aware and had perceived a potential in rearing of poultry. Out of the 350 households that reported to have seen any opportunity in climate variability and change, 23.43% reported an opportunity existed in the rearing of both indigenous chicken commonly known as "*kuku wa kienyeji"* and the exotic type majorly for eggs and meat. Some community members were already taking advantage of the fact that poultry keeping does not involve a lot of capital and does not depend heavily on rainfall patterns which had become erratic over time. It was reported that the market for poultry products was expanding and that the farmers were taking advantage of it to diversify their livelihoods and to increase their incomes.

The increased income had supported various households in food, health, education and development. However, the key informant interviews revealed that there were a number of bottlenecks associated with income generated by the farmers. For instance, the local NDMA Information Officer and the chairlady for Rekaka– a community based organisation in Narumoru said that there was need to train the community on financial management, how to save, entrepreneurship and investments to help the agropastoral community maximize on the returns that they make from their novel climate smart innovations.

With the increased uptake of poultry keeping, there exists a major opportunity for farmers to cross breed the local chicken with improved breeds such as Kenbro to improve the weight and egg production of the hatched chicks. Report by Arid Lands and Resource Management Project (ALRMP) in 2011 indicates that kenbro breed of chicken is a dual purpose breed suited for both meat and egg production and is best suited for the semi -arid areas because it can withstand difficult environmental conditions ALRMP (2011). This breed of chicken grows faster than the indigenous ones maturing at 10 to 14 weeks for meat and egg-laying at 25 to 27 weeks. Through the FGDs, it was reported that Kenbro chicken and their eggs fetch higher prices in the market. For example, it was reported that Kenbro eggs go for US$ 0.15 a piece while a hen or cock can fetch as much as US$ 5-10, this finding is supported by a report by ALRMP (2011).

6.2.2 Dairy cow farming

The study revealed that of the households reporting an awareness of the livelihoods opportunities availed by climate change and variability, 22.29% perceived dairy farming as an opportunity that can be exploited to help them cope better with climate variability and change. This was also triangulated during the focus group discussions held with Kigama commercial village and Rekaka CBO on 2ndJune, 2016 where discussants confirmed to have found dairy cow farming more profitable. This is further supported by a research done by Ngigi in 2003 which showed that small-scale dairy farming was very profitable. When probed further, the discussants revealed that due to climate variability and change, reduced land resources and increased population, dairy farming is showing great potential for the communities in the semiarid regions.

Many perceived dairy farming as a potential employer. Other studies done corroborate these findings for example Staal *et al.* (2008), USAID (2010), Mawa *et al.* (2014), IFAD (2006) and Karanja (2003) who reported that improved and increased production of dairy products help farmers enhance on-farm incomes, improve diet and nutrition, ultimately contribute to poverty reduction as well as supply surplus dairy products to the ballooning peri-urban and urban populations.

The study revealed that the greatest potential is perceived to be in the intensive dairy farming system as opposed to the traditional grazing system. However, most of the community members who are already utilizing this opportunity preferred to stock one to three cows. This is a decision that was influenced by the increased fragmentation of land, diminishing pasture due to climate change, high cost of stocking, rearing and maintaining dairy cows.

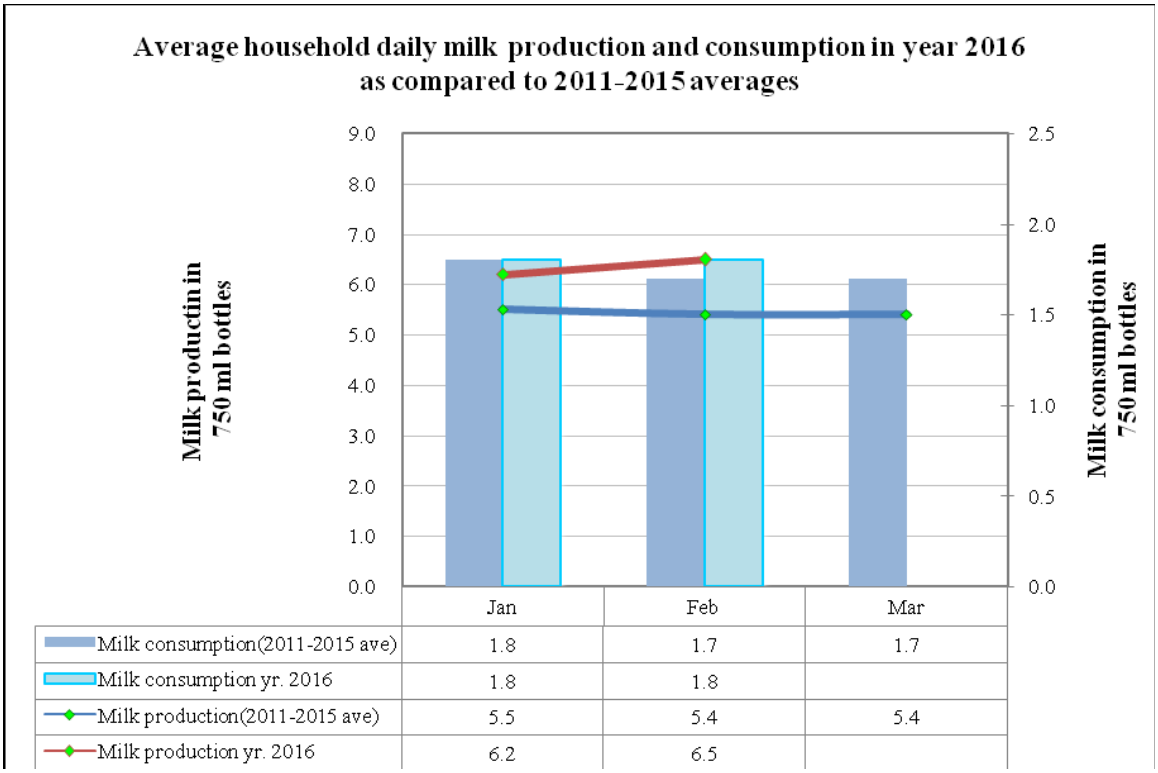

Figure 6.3: Presentation of average milk production and consumption for the region in Kieni

Source: NDMA (2016). Nyeri County Drought Early Warning Bulletin for February 2016

Research shows that production and consumption of milk has increased since 2011 (see figure 6.3). This means that the communities are taking up the opportunity they observed in dairy cow farming.

6.2.3 Dairy goat farming

Out of the 383 surveyed households, 5% perceived an opportunity in dairy goat farming. They attributed this to the growing demand for goat milk due to its nutritional value. The discussants in Kiambogo and Rekeka FGDs triangulated this information by revealing that goat milk is highly recommended by doctors for people suffering from HIV/AIDS, diabetes and those allergic to cow milk. These findings are consistent with the findings of research conducted recently by Mburu *et al.* (2014), Shivairo *et al.* (2013) and Kipserem *et al.* (2011).The study revealed that the Alpine breed of goats has high potential in the production of milk.

In the FGDs and through the key informant interviews and observations made, the study revealed that the alpine breed produced an average of 2.6 litres of milk per day a finding that is consistent with findings from a research conducted by Mburu *et al.* (2014) and revealed that a pedigree alpine breed starts to produce milk at the age of 2 years. The study also revealed that the price of goat milk was relatively higher compared to cow milk. The farm gate price was between USD 1-1.5 per litre. The discussants further revealed that goat rearing require little resources and hence was very popular among women in the area.

6.2.4 Social and environmental entrepreneurship

Out of the 350 households who reported to have seen livelihood opportunities in climate variability and change, 13% reported social and environmental enterprises as a great opportunity. When probed further, the community revealed that on farm innovations and diversification summed up for the foreseen business opportunities. These forms of social and environmental enterprises were in agribusiness. Agribusiness can be seen as carrying out agricultural activities with a business perspective. The agribusiness should be designed and intended to earn revenues for the farmer as well as make profit. The communities in Kieni have taken up different forms of agribusiness including; farming itself, value addition such as processing canola seeds into packed cooking oil and energy production and marketing of the farm produce.

This study is supported by work of Bairwa *et al.* (2014*)* and Baruah, (2004) who terms agribusiness as not just the practice of tilling land, planting seeds, harvesting crops or milking cows but a more holistic practice that encompasses value addition, marketing and including people and entrepreneurs who supply farm inputs as well as policy makers. In Kenya, the government through the National Agribusiness Strategy of 2012 has cited agribusiness as a key strategy in realisation of the country's Vision 2030 and for achieving the national food security goal. The Nyeri County Government with the help of the World Bank has set aside a total of 295 acres of land to be used as an agribusiness park in Kieni. Agribusiness has massive potential in unlocking youth unemployment in Kenya.

The study revealed that there is huge potential for growth in agribusiness in Kieni because of increased demand for raw and processed food due to rapid urbanisation due to devolution, high population growth and for export markets. However, the country still has a challenge in incentivising young people to take up farming as a form of gainful employment.

6.3 Opportunities in technological innovation and development

This section presents the various subsectors as cited by the agropastoral community in Kieni. They include opportunities in fish farming, greenhouse farming, access to weather and climate information and water conservation.

6.3.1Aquaculture

The agropastoral communities in Kieni reported that fish farming offered a great opportunity for vulnerable communities to respond to climate variability and change. The subsector was also recognised as one that can help many rural families combat food insecurity. In the FGDs held with farmers group in Ndiriti, in December 2015, and Rekeka CBO in June 2016, the discussants termed fish as one of the cheapest way of accessing protein for their families. These findings are consistent with reports by FAO (2014) and World Bank (2010) who revealed that worldwide, fish and other aquatic sources of food provide important nutrition and minerals to 4 billion people and forms more than 50% of the animal protein for poor people. The aquaculture subsector of the economy is currently recognised as one that has much potential especially in the fight against food insecurity (ACP and EU, 2011). The Government of Kenya, through the Economic Stimulus Program (ESP) of 2009 under the *'Fish Farming Enterprise and Productivity Program*" has invested heavily in fish production.

This programme has seen tremendous growth in the quantities of fish produced. For example, the study revealed that in the year 2000 only 1,000 metric tonne of fish was produced in Nyeri County as compared to 12,154 in 2010 (Economic Stimulus Program (ESP) Report, 2010). In 2013, Nyeri County was ranked the best fish producer from ponds in the entire country with 21,800 metric tonnes in 2012.This means that there is great potential for fish farming. In the country, a positive trend is registered in adoption of aquaculture with the number of ponds increasing from 7477 fishponds in 2007 to 28,000 in 2010 (ESP, 2010). The government initiative in stimulating fish production offers an opportunity for promoting rural enterprise that can help agropastoral communities respond to climate variability and change.

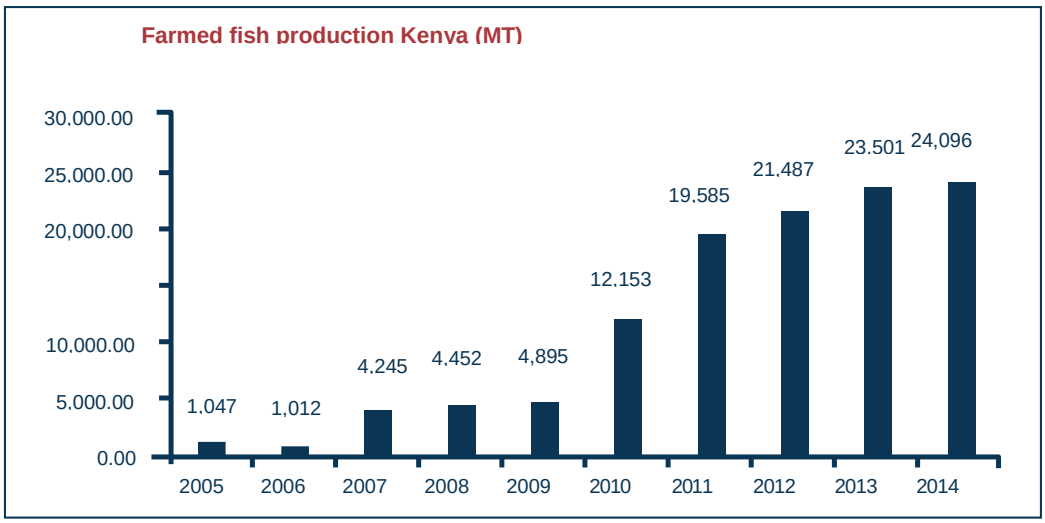

Figure 6.4: Aquaculture (farmed fish) production since 2005 in Kenya
Source: State Department Bulletin (2014).

6.3.2 Greenhouse farming technology

Greenhouse farming technology was reported as an opportunity brought by climate variability and change by 22% of the total households who reported to be aware of perceived livelihood opportunities.

Despite the high start-up costs, greenhouse farming was highly favoured because the farmers felt that they can control the microclimate, pests and diseases. Greenhouse farming takes up a very small portion of the land but has higher yields than open field farming. The farmers reported that high value crops such as tomatoes, capsicums, strawberries and eggplants were preferred. "*These crops mature faster and have got high demand in the market*", said one of the FGD participants.

During the FGDs, it emerged that greenhouse farming was particularly very popular with the unemployed youth and women who have recognized the financial opportunities in greenhouse technology. The advantages given in favour of greenhouse farming are: i) a farmer can be assured of all year round production of quality agricultural produce ii) the technology produces up to six times more per unit area iii) it is environmental friendly and makes organic production of food possible iv) one is able to manage pests and diseases with ease v) has little or no pesticide residuals.

6.3.3 Access to weather and climate information

The community in Kieni reported that there is an opportunity in the provision of climate information services. When asked whether and how they receive climate information, 98% said through the weather forecasts on radio or televisions for the few households which own one. They also cited that the information shared was not focussed to their specific area but to the region and at best to the county level. Therefore, Kieni farmers felt that they can never prepare adequately with such unfocussed climate information. The community lamented that there was a huge gap in climate information sharing, understanding and application. This finding is supported by a research done in East African Countries by Kadi *et al.* (2011) which revealed that there was a missing link in technical advisory services that is given by scientists to enhance proper understanding and hence applications of climate products such as seasonal weather forecast, monthly weather forecast and agro-climatological services. This means that, although the Kenya Meteorological Department (KMD) compiles climate information and then releases them to different Dekadal Crop and Weather Bulletins, the agropastoral communities in Kieni are still struggling to get adequate climate information services. The agropastoral community in the study area expressed a very keen interest in collaborating with climate information service providers to ensure that local climate information is disseminated using the right form and channels and hence benefit them.

6.3.4 Water conservation and rain harvesting

The community in the study area reported to have perceived water conservation as a great opportunity brought by climate variability and change. In the FGDs, the discussants revealed that the reason the community was highly vulnerable was due to lack of adequate clean water for domestic and agricultural use.

The discussants noted that during the rainy seasons there were huge runoffs which could be collected and stored in dams for use during the dry season. There were various methods which could be used to harvest rain water right from the homesteads such as gutters placed on the roof of the houses which then directed the water to storage tanks. Runoff water could be collected using constructed water pans and diversions of road side culverts. On the farms, ponds could be dug to store the water.

6.4 Opportunities in land use and land management

6.4.1 Irrigation

Out of the households surveyed reporting an awareness of the perceived livelihood opportunities, 15% reported irrigation as a potential adaptation option in Kieni. Both low-cost technologies and the public irrigation schemes were seen as areas that can be exploited to help agropastoral communities secure their livelihoods. The National Irrigation Board has established irrigation projects in the area such as Ndiriti-Aguthi irrigation project, Githiru, Narumoru dam and Karemeno dam. The community however faulted the system and said that it was not reliable especially because the water levels were too low.

Moreover, during the dry seasons when water is needed the most it is highly rationed or the supply is stopped altogether. The low cost irrigation which can be adapted by farmers on their small plots has a high potential to transform the subsistence farmers in the area into intensive producers of food. The Agropastoral communities in Kieni Sub-county reported that the greatest disservice by the National Irrigation Board (NIB) was the lack of water conservation and rain harvesting technologies. At the country level, the Kenyan government has taken food insecurity as a priority area and has rolled out several projects to enhance food security in the country. A good example is the Galana irrigation scheme in Tana River County. The total irrigated area in Kenya is about 80,000 hectares and both the public and small-scale irrigation is still short of the 300,000 hectares maximum potential (Purcell, 1997).It is also important to note that enhancing irrigated agriculture would go a long way into building women's capacity and increase their earning power as they are the majority participants in subsistence farming.

6.4.2 Tree planting

Tree planting was reported as an opportunity for the farmers. Through the household surveys and FGDs, the communities reported that trees benefit them in various ways including source of fodder for animals, as a source of edible fruits, and as an alternative source of food in times of scarcity as well as a source of income. This finding is supported by the work of Oke and Odebiyi (2007) who noted that trees provide shade, modify microclimate of an area, and offer other environmental services such as medicine and marketable products. Matocha *et al.* (2012) also supports this finding and further argues that planting of trees offers a synergy between climate change mitigation and adaption where trees offers carbon sequestration services while those trees can be used to benefit communities as sources of food, income sources as well as protect fragile lands from harsh climate conditions such as landslides.

6.5 Opportunities in farm production practices

6.5.1 Diversification of crop type and varieties

The agropastoral community in Kieni identified crop diversification as a potential opportunity brought by climate variability and change. Crop diversification was reported in the addition of novel crops or a cropping system such as crop rotation, intercropping, agro forestry and introduction of new crops such as drought resistant varieties of sorghum, millet and cassava. The communities through the FGDs revealed that these new ways of crop farming have given them better and added value compared to the traditional way of crop production such as mono-cropping and depending on maize as a food crop. This finding is consistent with a study done by Bradshaw *et al.* (2011) and Akinnagbe and Irohibe (2014) who reported that most farmers use drought resistant varieties of crops, change planting time, afforestation and soil conservation measures as agricultural based adaptation strategies. Akinnagbe and Irohibe (2014) further observed that capacity building of farmers through training, education and extension services would go a long way to support climate change adaptation.

On individual farm level crop diversification, the farmers reported having multiple production locations and sites where they introduced new varieties of crops and increased the number of cultivated species and value addition processes.

The farmers in the FGDs observed that novel and improved crop varieties increase the plants' resistance to environmental stressors such as water and heat stress and invasive pests and diseases. Key informants reported that crops have also been improved in terms of nutritional value in order to benefit both humans' and animals' health. These findings supports the work of Brenda, (2011); Orindi and Eriksen (2005); Wandel and Smit (2000).

In Kieni, specific crop diversification potential lay in fruit farming. About 7% of the households surveyed reported that farming of fruits such as macadamia; tomato fruits; pumpkins and improved variety of passion fruits have the highest potential. Macadamia nuts were termed the '*new cash crop*' of the region especially in Mweiga. Planting of drought resistant crops such as sorghum and cassava was also highlighted as an opportunity in the face of climate variability and change.

6.5.2 Diversification of livestock types and varieties

Diversification in livestock production was also identified as an opportunity to enhance community resilience in Kieni. Bee keeping, rabbit farming and pig farming were seen to have the greatest potential.

6.6 Opportunities in financial and market services

6.6.1 Access to agriculture subsidy, extension services and credit

The household survey revealed that access to agricultural inputs and services at a subsidized price was seen as an opportunity to enhance resilience. Availability of fertilisers and other agronomic essentials at an affordable price was seen as the most important incentive in unlocking the agricultural potential in the area. Coupled with agricultural extension services, subsidised inputs help farmers implement and benefit from various agricultural practices they engage in. This finding is consistent with a study done by Dorward (2009) who reported that in put subsidies have a great potential (though not exclusive) to unlock the perennial problem of shortage of grain. He further observed that offering of agricultural input subsidies should be a well planned long term investment to achieve a wider and sustainable agricultural value chain.

Access to credit facilities was also cited as an opportunity that can help farmers adapt better. However, the communities in Kieni reported that access to finance for agribusiness development is normally limiting. The key informant from agricultural sector and the NDMA reported that this challenge is more pronounced in Kieni due to high environmental uncertainties related to the fact that the area falls under arid and semi arid zone.

In Kieni the agropastoral community members have formed small societies in the form of *'community table banking'* where groups of likeminded people come together, contribute, save and loan money to one another. Table banking groups comprise of 15-30 individuals who contribute their modest income on a weekly or monthly basis depending with a group. These groups have a membership, leadership and governance structures that guides their operations. Through the FGDs with farmer groups in Kiambogo, Kigama, Ndiriti and Aguthi, it was revealed that many of the farmers groups in the study area were exploiting the opportunities in government policies such as the Youth Fund, Women Enterprise Fund and the Uwezo Fund to access credit to advance their agribusinesses. One of the CBOs in the area reported to have accessed 70,000 KES from Uwezo Fund which they used to start up a poultry farming business. However, a number of other farmers groups are yet to access the funds despite sending numerous applications to the relevant bodies.

6.6.2 Access to market

The agropastoral community in Kieni Sub-county reported to have perceived an opportunity in marketing their agricultural products (crops and animals). They cited the formation of cooperative societies as a major step towards consolidating farmers' bargaining power and hence better prices for their produce. The Government's role in the regulation of agricultural market was seen as the most important to protect farmers especially from middlemen. Extensive research results reveal that there is a direct and indirect relationship between access to market and agricultural productivity.

This finding is consistent with the findings of Ijaimi (1994), Von Oppen *et al.* (1997), Kamara and Von Oppen (1999), Freeman and Salim, (2002) and Kamara, (2004) who slightly differed from the rest by adding that although the cumulative agricultural productivity physically increases with general improvement in market access, there is a huge disparity in how the market-generated benefits are distributed between smallholder and large scale farmers as well as between those with better infrastructural services such as roads and those without.

6.7 Opportunities in employment

Employment was seen as an opportunity to enhance resilience of the agropastoral communities in Kieni. From the 350 households who were aware of the opportunities, 17% of them view that employment in various sectors of the economy could help the communities adapt better. Such employment would work by way of creating a fall-back option during the dry seasons. The study revealed that though the community did not have the expert terms for green jobs or adaptation jobs, the opportunities they mentioned actually fall right within these categories. Examples of the jobs mentioned were in; development of canola and biogas energy (renewable energy), green house farming, fish farming, organic farming and conservation agriculture. The government of Kenya through the Vision 2030 and the County Integrated Development Plans aim to achieve an annual growth rate of 10% per annum. This can only be achieved through transition to green economy as advocated for by the *Future we want* (UNCSD, 2012). Creation of green jobs is paramount for Kenya. In line with this the government has developed a green economy strategy that will support efforts aimed at addressing poverty and unemployment for many Kenyans GoK (2015).

6.8 Opportunities in education

Education not only helps people improve their perceptions, knowledge and understanding of climate related risks but also enhances their socioeconomic status (Lutz *et al.,* 2014). As important as this is, a small percentage (0.29%) of the agropastoral community in Kieni viewed education as key to climate adaptation and building of resilience in the area. Communities need to be aware of the risks that surround them in order to prepare and respond appropriately.

Recent research conducted in El Salvador and Brazil, revealed that people who had low education levels were more likely to see their surrounding environment as risk free compared to those who had high education who were more aware of the environment risks (Wamsler, 2012). Formal education is seen to have a positive impact on the community's perception and understanding of the risks which exist; access to information related to risks and risk avoidance; coping mechanisms and knowledge and access to potential and available institutional support (Wamsler, 2012).

6.9 Utilisation of opportunities brought by climate variability and change

Out of the 350 households who reported to have spotted opportunities brought by climate variability and change, 67% had taken up one or more of the perceived opportunities. A sizeable number, 33% of the households were not utilizing any of the opportunities that they perceived.

Table 6.1: Uptake of opportunities brought by climate variability and change per gender

			Gender	
		Taken advantage	Female	Male
Perceived opportunities	No	No	57.6	42.4
	Yes	No	55.6	44.4
		Yes	48.0	52.0

Table 6.1 shows that despite being the majority who perceived opportunities brought by climate variability and change; female headed households had a lower uptake level (48%) as compared to male headed households (52%).

6.10 Barriers to uptake of opportunities brought by climate variability and change

The research revealed a range of barriers that limit the agropastoral communities to pursue perceived opportunities brought by climate variability and change.

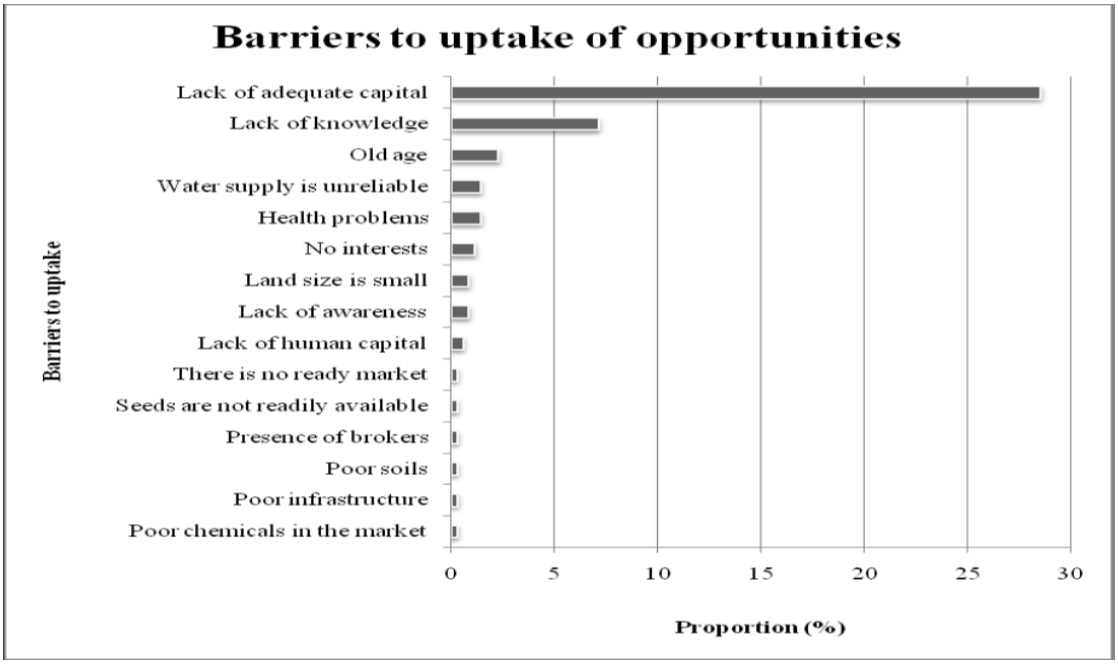

Figure 6.5: Barriers to uptake of opportunities

Figure 6.5 shows that access to financial assets and services is considered a huge impediment in uptake of social and environmental opportunities associated with climate variability and change. Lack of knowledge and awareness on opportunities brought by climate variability and change was also a huge barrier in uptake. Poor market and lack of credit facilities were also cited as a barrier. In the focus group discussions, the discussants vigorously lamented the presence of middlemen who they blamed for '*messing with the produce prices'.*

The community expressed their disappointment with the government for issuing empty promises on streamlining the market. Apart from the middlemen, the weights and measures of some farm produce, particularly potatoes, cropped up. The discussants in the FGDs reported that the government had issued a warning in 2014/2015 that the weight of potato bag should not exceed 50kg but the enforcement was poor. This made many farmers lose out because those who did not fill the ninety kilogram bag could not access the market.

Old age and health problems were also cited as barriers to uptake of climate variability and change opportunities. Further probing of those who cited ill health, a majority complained of cold related diseases such as frostbite, pneumonia, respiratory tract infection and arthritis (which scientifically is not caused by cold weather per se but may be attributed to the extreme weather conditions in the early evening through nights to morning hours).

Subjective perceptions and views also came out as a factor that limit uptake of the opportunities brought by climate variability and change. About 2% of those who spotted opportunities said they did not have interest in utilising them. This means that different people have different perceptions that influence choices of adaptation.

CHAPTER SEVEN: CURRENT CLIMATE CHANGE AND AGROPASTORAL SECTOR RELATED POLICY AND SUPPORTING PROGRAMMES EVALUATION IN KIENI

7.0 Introduction

This chapter presents analysis of climate change and agriculture related policies, ordinances and bylaws in Kieni. Policy gaps in agriculture sector and climate change adaptation are also highlighted and recommendations given.

7.1 Background

Government climate change policies at local level are disseminated in form of ordinances and bylaws that are outlined by the local communities and county government. These ordinances and bylaws are very important agropastoral sector because they aid in decision making and subsequent actions taken in relation to climate variability and change adaptation as well as impacts on resources (Ministry of Agriculture Livestock and Fisheries (MALF), 2016).This study sort to evaluate the relevant county and sub-county bylaws and ordinances and community regulations that are being implemented in Kieni to support climate change adaptation for the agropastoral communities.

7.2 Nyeri county integrated development plan (CIDP)

The Nyeri County Intergrated Development Plan (CIDP) 2013-2017 outlines the key priority areas for development in support of the Kenya Vision 2030. A good number of the projects lined up for implementation in Kieni are in water supply to the communities e.g. water projects in AguthiNdiriti, SimbaraBondeni, HukuGakawa, TheguThungari, Njeg'u water project in Mweiga and Mwea borehole water project in Narumoru. These projects are aimed at expanding water coverage in Kieni. The CIDP has also outlined projects of which are currently ongoing in rehabilitation of degraded land in former quarries in Maragima, Mweiga, Chaka, Mureru and Mwichuiri in Narumoru. Other projects in the CIDP include improve breeding stock which in Kieni it is specifically being targeted for rabbit keeping where procurement of rabbits breeding centres and upgrading of local rabbit breeds has been successful although the rabbit farmers reported that there is no market for these rabbits.

The CIDP also outline the food security project and the county government of Nyeri has procured and distributed certified seeds to farmers in parts of Kieni for the 2016 planting season. However, the community participants indicated that not all farmers were able to get the seeds.

The community reported that county government's decision to centralise the seeds and farm inputs depot for the whole county at Kiganjo was seen as an impediment to climate adaptation efforts because the depot is located too far from their farms adding a cost implication to the poor agropastoral communities. More need to be done to ensure that those seeds reach each and every farmer in the area.

The CIDP offers an opportunity by itself for climate variability and change adaptation. The projects outlined and the ones being implemented do offer social and environmental opportunities for the agropastoral communities in Kieni. The CIDP plans to harness runoff water experienced during rainy seasons by excavating of water pans, dams construction and abstracting from water ways and conserving it for use in dry seasons. The county government has invested huge amount of money in irrigation schemes in Kieni through the dams such as NdathiMbiriri, Karemeno and AguthiNdiriti dams which are aimed at increasing water for irrigation in the area. This is one of the opportunities that the community had perceived. Another sector that the CIDP focusses on is poultry farming which offers an opportunity in keeping of indigenous chicken and the upgraded breeds such as sasso, kenbro, kroiller and rainbow rooster. This is an opportunity that many women in the FGDs had perceived and reported to engage in since it does not require much capital to start and manage.

7.3 Ordinances and bylaws related to environment sector in Kieni

In environment, the Nyeri County CIDP specifically targets increasing forest cover by encouraging agroforestry throughout the county. This is implemented with other policies e.g. the Forest Act of 2005(GoK, 2005), the communities in Kieni have formed community forest associations (CFAs) which are located next to Mt. Kenya and the Aberdare forests. Through these associations the communities are able to farm and graze in the forest in a sustainable way. These CFAs have members who possess indigenous knowledge of trees since they have interacted with the forest for a long time and often advice on tree species in respect to their uses, availability and abundance and diversity (Koech *et al.,* 2009). This has contributed immensely to the forest conservation efforts and especially of the indigenous and medicinal tree species in Kieni.

In Narumoru for instance, Kieni Local Rights Programme (LRP), is a community based organization that was formed in 2002 and later came to form Mount Kenya Conservation Action Group that brought together 54 tree growing groups in the group has worked in collaboration with Kenya Forest Service (KFS) to rehabilitate Mount Kenya forest. The network also encourages the locals to plant trees on their land. This network has become an advocate of the environment and climate and has already trained pupils in 26 primary and students 3 secondary Schools on tree planting and management. The network also gives out tree seedlings for free to be planted. Some of the trees planted are *Grevillea robusta* (*mukima),* bamboos to be planted in riparian areas, and fruit trees such as macadamia, mango grafted avocado, grapes, tree tomatoes and oranges. A whole range of opportunities are being realized through tree planting including of nutritional benefits.

The evaluation revealed that the county government and other actors including Non-governmental organisations (NGOs), Faith Based Organisations(FBOs), donors and the local community are already implementing programmes that support the Environmental Management and Coordination Act (EMCA) of 1999 And the Climate Change Act of 2016 by way of mainstreaming it in the agricultural sector for both crop and livestock activities. The Climate Change Act policy gives guidelines to the county departments including environment and agriculture ministry to make climate change adaptation and mitigation considerations in all their planned interventions. Fastenopfer a catholic organization in Switzerland and Caritas Nyeri have a climate change adaptation project that aims at reducing carbon dioxide emissions through promotion of energy-efficient and affordable cooking stoves. Energy saving stoves have helped the rural women in Kieni to use few charcoal for cooking hence reducing their trips into the Mt. Kenya and the Aberdare forests to cut trees for wood fuel.

7.4 Ordinances and bylaws related to water sector in Kieni

The Water Act of 2002 provides for the management and conservation of water resources in Kenya. In 2007, the government setup a water management rules to fill in the gaps in the Act which gave rise to the Water Resource Management Authority (WRMA). This authority is mandated to ensure proper use and management of the water resource.

In Kieni, the community has developed Water Users Associations (WRUAS) which are avenues through which they relate with WRMA in water issues. In the 2007 Water Rules, WRUA is defined as "an association of water users, riparian land owners, or other stakeholders who have formally and voluntarily associated for the purposes of co-operatively sharing, managing and conserving a common water resource". These WRUAS are community led and they have water committees which organize and talk on behalf of the community. Members are encouraged to own the associations and their aim is to conserve the water resource. The study noted that there are no specific guidelines on how the WRUAS are formed apart from saying that for the WRUA to be recognized by the government it should be registered and have a constitution. The government has left them free from interference from its bodies.

In support of climate change adaptation and mitigation, there are a number of WRUAs in Kieni e.g. Kigathi water Community Based Organisation, Narumoru water scheme, AguthiNdiriti scheme, Kabura-ini and Gitwe scheme that engage in various activities. These WRUAs, promote responsible and sustainable water abstraction form the rivers, boreholes and dams; they promote soil and water conservation practices within their catchment areas and also ensure that there is peaceful coexistence between the community and wildlife through proper water sharing-allowing proper flow of water to support life downstream. The water users associations are also core in dealing with water resource conflicts in the sub-county, they also act as the link between the government and the community in matters related to water availability and policy. Caritas Nyeri which is a Faith Based Organisation has also supported climate change adaptation efforts by promoting human development through various projects such as the rural water programme that has helped to improve access to quality water for domestic and livestock use in Kieni. The programme was started in 2012 and ended in 2014, and had over 4,500 beneficiaries with great impact seen in the reduction of water-borne diseases and consistent access to clean water for the community.

7.5 Ordinances and bylaws related to crop and livestock production sector in Kieni

The county has also developed the Nyeri County Agriculture Development Act of 2016 (County Government of Nyeri, 2016) that seeks to establish an efficient legal and institutional framework for development in agriculture including; crop development, Livestock development (domesticated animals and emerging livestock), fisheries, value chain development, farm inputs, pests and disease control and conservation among others. The study revealed that the benefits of this policy is yet to be felt by the agropastoral communities in Kieni who reported to have experienced challenges in the marketing of their produce and in the value chains especially in rabbits and fish. The evaluation done on the CIDP revealed that despite Kieni being a leader in livestock keeping in the county, it does not have a livestock market. Further, the evaluation of the current CIDP,2018-2022 revealed that the sub-county has go 16 cattle dips,140 disease control pens,110 agrovets shops, zero poultry hatcheries, 1 artificial insemination bull station,30 slaughterhouses,23 hide and skin bandas.

The other policy evaluated is the Crop Production and Livestock (Seed and Ware Potato production and marketing standards) Rule of 2005 that has been adopted by ten counties through Legal number 113 of 2008 capping the total potato weight to 50kg per sack. The study revealed that this directly affected the potato farmers in Kieni who lamented the lack of policy coordination in implementation of the rule vis a viz reality (in this case lack of storage mechanisms for such farm produce). The farmers reported that they preferred extending the potato sack to 150kg to dispose the produce before it goes bad. However, if the rule and the subsequent Potato Production and Marketing Bill of 2014(GoK, 2014) is well implemented, it would go far in enabling the farmers to maximize on returns for their potato production.

To curb overexploitation of potato farmers in Kieni, the study revealed that NGOs in collaboration with local communities and international development partners are helping farmers put up storage facilities for their produce. With support from development partners, Kieni plans to construct a Sh6 million store as it seeks to cushion potato and onion farmers against post-harvest losses. The stores acts as an information centres and proper storage areas which is meant to prolong the shelf life of the harvest by four to six months while ensuring that quality is maintained.

An example on the ground is the A 2SCALE initiative which is co-funded by the Irish embassy has helped the Kianjogu-Kiambogo farmer group to build low-cost stores, allowing farmers to store their produce until the prices become favourable rather than disposing them immediately after harvesting. The farmer groups reported that they store their produce to sell later which has helped them fetch better income because prices usually increase even by 150% of the harvest price. The study established that the storage initiatives have helped farmers to source for better markets, an example being the Kianjogu-Kiambogo farmer group in in Kieni West which signed a contract to supply potatoes to a cannery. This was possible because they are able to store and accumulate produce for bulk supply.

Other national government programmes supporting climate change adaptation being implemented directly on the ground include, the Fish Farming Enterprise Productivity Programme (FFEPP) of the Economic Stimulus Programme (ESP) and Economic Recovery, Poverty Alleviation and Regional Development Programme (ERPARDP). These programmes are assisting Kieni community by providing extension services, provision of agricultural inputs such as feeds for fish and the fingerlings. The programmes are also helping the beneficiaries build fishponds to enhance uptake of aquaculture as an opportunity for self-development in terms of income and a way of fighting food insecurity.

Kieni Sub-county also implements the National Animal Disease Act CAP.364 of 1989 which was revised in 2012(National Council for Law Reporting, 1989). The statute, which is implemented by the County Veterinary Department, imposes quarantines for disease control during outbreaks.

In conclusion, the study revealed that Kieni communities are already implementing climate change and agriculture policies, bylaws and ordinances at the local level. The national policies like the Climate Change Act and the Kenya Vision 2030 are being cascaded down through plans, programmes rules and bylaws such as the Nyeri County Intergrated Development Plan, County Agriculture Development Act of 2016, community forest and water associations and the many programmes being implemented by NGOs, FBOs, government and development partners to enhance climate change adaptation.

The evaluation shows that climate change and agricultural related policies present opportunities for communities to enhance the uptake of social and environmental opportunities brought by climate variability and change. For example the plans outlined in the CIDP, in tree planting, irrigation, up scaling of fish farming, improving of breed in poultry and rabbits and promotion of green economy presents opportunities that the communities in Kieni can exploit for their own benefit. The evaluation has revealed that communities are capable of designing their own course of action and champion climate change adaptation and best practices. As seen with the community based forest association, if given a chance, the communities are very knowledgeable about their ecosystem and they are capable of finding solutions for a better future.

CHAPTER EIGHT: SYNTHESIS AND DISCUSSION

8.0 Introduction

This chapter puts together findings of the study to showing their relationship to the main topic.

8.1 Characteristics of extreme events in Kieni Sub County

This chapter answered the first objective "To examine the temporal characteristics of extreme rainfall and temperature indices and perceived impacts on the livelihood resources of the agropastoral communities in Kieni Sub-county". The objective was achieved by analysis of twenty seven (27) climate extreme indices using the guideline given by the World Meteorological Organization- Commission of Climatology and the Climate Variability and Predictability (WMO-CCI/CLIVAR) working group (WMO, 2009). Observed daily temperature and precipitation data from 1991 -2015 and 1985-2015 was analysed for temperature and rainfall respectively. The aim was to gain an understanding of the rainfall and temperature trend in the area. Analysis of extreme indices is important to the community and policy makers because the behaviour of individual indices is analysed and its changes noted helping in adjustment of adaptation strategies. The aspects studies were the degree of seasonal and inter-annual variation of rainfall and temperature providing evidence of climate variability and change in Kieni. To triangulate the scientific evidence of climate variability and change, the study applied household surveys, key informant interviews and Focus Group Discussions (FGDs) to give the community's perception and opinion on the climate variability and change impacts on crops, livestock, natural resources and communities' social aspects were.

CRiSTAL tool was used to qualitatively analyse the community's opinion and perception on impact of climate variability and change on livelihood resources. This tool helped the study to gain insight on the climate and livelihood context of the area where the community was able to outline the changes they have noted with the climate and specific hazards experienced, highlight the livelihood resources available for them, explain how the identified hazards impact on their livelihood sources and their local coping strategies.

The tool advocates for community participation and therefore, to ensure that the participants were available for the discussions, the consultations were done in the afternoon from around 4pm when the community members were sure of attending after their days work in their farms and tending to their livestock. The study involved a group of 20 agropastoral community members with a representation of nine men and eleven women.

From the analysis of extreme indices, the maximum and minimum temperature in Kieni shows positive trend portraying an overall increase in daily maximum and minimum temperature. However, the monthly maximum value of daily maximum temperature (TXx) and monthly maximum value of daily minimum temperature (TNx have decreased over the period 1991-2015. The number of days when TN<10^{th}percentile (cool nights) and number of days when TX<10^{th}percentile (cool days) have increased in Narumoru Gate Park met. This means that the area is cooling offering an opportunity to exploit growing of crops that do well in cold areas and keeping livestock that can adapt to colder climate.

The monthly and annual temperature trend analysis results showed a similar trend for Munyaka and Narumoru though Narumoru Park Gate was a little warmer than Munyaka. March and October were the warmest months in Narumoru Park Gate at 17.6^{o}C and 17.5^{o}C respectively. In Munyaka, the warmest months are February at 16^{o}C, April at 16.4^{o}C, May at 16.3^{o}C and September at 16^{o}C. The study also observed that July is the coldest month on both sub sites with Munyaka experiencing average monthly temperature of 15.2^{o}C and Narumoru Park gate an average of 16.5^{o}C.

In rainfall, the observed monthly maximum 1-day precipitation (Rx1day), showed significant trend in Sasini weather station. Simple Daily Intensity Index (SDII) which shows days with precipitation amount on wet days with rainfall amount greater or equals to 1mm showed general increase in all the three stations with Munyaka weather station presenting significant trend. The Consecutive Wet Days (CWD) with rainfall greater than or equal to 1mm has generally decreased in all the locations with Munyaka showing statistically significant trend. Analysis of annual rainfall over Kieni showed that long-term mean annual rainfall estimated during 1985-2015 was 870.29 mm for Sasini Farm (Mweiga); 644.56 mm for Munyaka and 1664mm Narumoru Park gate weather station in Narumoru. This reflected variability among the three stations.

The analysis also reflects that there was a sharp increase in the amount of rainfall received between 1997 and 1998; this finding corroborates with the information obtained through FGD where participants reported enhanced rainfall during the same period. This observation agreed with other reports which reported that between 1997 and 1998, Kenya as a country received El-Niño rains (Karienye *et al*., 2012; UNEP 2008). The study also showed that the area is receiving more successful short rains seasons.

This was triangulated in the FGDs where participants indicated that the short rains are proving to be more reliable and the community is utilising it to plant fast maturing crops such cabbages, spinach and kales which they consume in their homes and also sell for an income.

On perception of climate change in the area, out of the 383 agropastoral households surveyed, 97% reported to have seen changes in the rainfall pattern and as well change in temperatures. The survey revealed that there had been delays in the onset of the long rains (MAM). These rains were also reported to have shrunk – starting end of March and ending in early May. Short rains (OND) were perceived to have become heavier and of late extending way into January.

From the FGDs, it was reported that in the past, the rainfall seasons were clear and distinct but today it has become highly variable and unpredictable. Non-climate hazards that were seen to aggravate the already grave situation were also highlight. These includes: environmental degradation due to cutting down of trees/ clearing of forests; lack of credit facilities and poor access to market and land fragmentation; human wildlife conflict; low technological skills and lack of innovation; presence of counterfeit and low standard agricultural inputs and poor policy and institutional coordination. The study investigated how households and the community perceived the severity of the impacts of climate variability and change. In this, the agropastoral community members were asked to rank droughts, invasive pests and diseases (IPDP) and frostbites in terms of frequency of occurrence; intensity and how difficult it is to cope with. Analysis of ranking data tool was used (Abeyaseker, 2001; Coe, 2002).Results showed that drought was most intense and most difficult to cope with as compared. On impacts of climate variability and change, the surveyed community members, reported that due to the increased climatic events such as droughts, frostbites, invasive crops and pests, and unreliable weather patterns, the agropastoral community has experienced increase in crop failure and loss of livestock due to lack of fodder and strained water resources.

8.2 Local coping strategies for agropastoral communities in Kieni

This chapter covered the second objective on *"to establish the coping strategies available to agropastoral communities in Kieni Sub-county".* This was majorly covered through the second module of CRiSTAL tool where the livelihood context is set highlighting important resources and how they help in coping with identified hazards.

Under this step the community highlighted the livelihood resources available in the area based on the five categories of resources as follows under natural resources: Land; water; forests (for wood fuel and medicinal services); pasture were identified; in Financial services Market access: Credit facilities and Bank deposits; crops; livestock for social-political resources; Social relationships and community cooperation(mostly in "*chamas"/community banking system);*agricultural commercial villages; Government social services-payment to elderly people, for human resources; Technological skills and innovation; Climate information services and physical resources; Roads; Standard and subsidised agricultural inputs and irrigation systems were identified.

When asked to determine the impact of the each perceived hazards on their livelihood resources, drought was identified as having the highest impact on natural resources followed by financial resources as well as some social resources like the agriculture commercial groups because the livelihood activities to utilise these resources often depend on the quantity, quality and general output of water (rainfall), land, trees, crops and livestock. The participants were also asked to determine the importance of livelihood resource on local coping strategies. The importance was indicated by entering a number between zero (0) and five; where 0 represented not important and five represented very important. Results showed that natural, social, and financial resources are highly valued as important requirements for the successful uptake of the existing coping strategies for drought, frost bites and invasive pests and diseases events in the area.

The participants noted that investing in low cost livelihood sources such as poultry farming especially the *"kienyeji"* breed and dairy goat farming would go a long way in helping the community adapt better. The community highlighted some coping strategies as opportunities; these were in greenhouse farming, investment on post-harvest management strategies, aquaculture and agroforestry practices.

8.3 Social and environmental opportunities brought by climate variability and change

Out of the 383 surveyed households, 91% reported that they had perceived an opportunity associated with climate variability and change. Nine percent of the households surveyed reported that they were not aware of any opportunities which come with climate variability and change.

The approach for analysing and categorising the adaptation options was borrowed from a typology done in Canada on classifying and characterisation of agricultural adaptation strategies to climate change (Smit and Skinner, 2002). These categories include i) diversification of livelihoods which was seen as an opportunity brought by climate change and it offered an avenue for adaptive response to the reducing income from their mainstream livelihood activities due effects of climate change. Seventy percent of the three hundred and fifty (350) households that had perceived an opportunity in livelihood diversification engaged in alternative livelihood activities, these opportunities were in poultry farming; dairy cow farming; dairy goat farming; social and environmental entrepreneurship; ii)Opportunities in technology was perceived by 33.14 % households that perceived opportunities in climate variability and change. These opportunities were seen in aqualculture, greenhouse farming, access to weather and climate information water conservation and rain harvesting; iii) opportunities in land use and land management was perceived by 15.43% of the households, specific opportunities were seen in irrigation and tree planting; iv) Thirty five point seven percent of the surveyed households reported of opportunities in farm production practices which included diversification of types and varieties of crops and livestock v)Opportunity in financial and market services, this was reported by 3.43% of the surveyed households who reported to have seen an opportunity associated with climate variability and change.

Opportunities were seen in access to agriculture subsidy, extension services and credit facilities and access to market for the various produce in the area vi) Out of the 350 households who reported to have perceived opportunities associated with climate variability and change, 17.14% reported that employment as an opportunity. Examples of jobs mentioned included development of canola and biogas energy, greenhouse farming, fish farming, organic farming and conservation agriculture vii)Only 0.29% of the households who reported to have seen opportunities brought by climate change reported that education as an opportunity. This is despite the fact that education helps people to improve their perceptions, knowledge and understanding related risks as well as enhances their socioeconomic status (Lutz *et al.*, 2014).

8.4 Policy evaluation

The study evaluated the relevant county and sub-county policies; bylaws; ordinances; community regulations and programmes that are being implemented to support climate change adaptation for the agropastoral communities in Kieni. The study revealed that Kieni Sub-county is implementing the Nyeri County Intergrated Development Plan (CIDP) on the ground through programmes and projects that enhance climate adaptation for the agropastoral community. A number of projects in water sector that are meant to enhance water access, availability and sustainable use have been implemented including irrigation dams. These projects are in AguthiNdiriti, SimbaraBondeni, HukuGakawa, TheguThungari, Njeg'u, and Mwea locations. The sub-county is also working on projects in rehabilitation of degraded land e.g. the rehabilitation of quarries in Maragima, Mweiga, Chaka, Mureru and Mwichuiri in Narumoru. Kieni has also invested on improving breeding stock of the farmers and livestock keepers for instance there is an extensive support for rabbit keeping where procurement of rabbits breeding centres and upgrading of local rabbit breeds has been successful although the rabbit farmers reported that there is no market for these rabbits. The distribution of certified seeds and inputs to improve on food security is also ongoing in the sub-county. However, the farmers observed that there is need to decentralise the input depot to make it easy for them to access the inputs in time.

The CIDP offers an opportunity by itself for the agropastoral community to exploit through the projects outlined and the ones being implemented. For instance the extensive investment in water conservation and provision through construction of dams such as NdathiMbiriri, Karemeno and AguthiNdiriti dams, drilling of boreholes, water pans has improved water availability for domestic and irrigation purposes. This means that the community can now use the water to irrigate their farms to boost produce for their families and income generation. Another opportunity that the CIDP presents is in the diversification of varieties, types and breeds of crops and livestock for example the focus on upgraded poultry breeds such as sasso, kenbro, kroiller and rainbow rooster. This is an opportunity that many women in the FGDs had perceived and reported to engage in since it does not require much capital to start and manage.

In support of the Forest Act of 2005(GoK, 2005), the CIDP targets increasing forest cover by encouraging agroforestry throughout the county. In Kieni the communities have formed community forest associations (CFAs).Through these associations the communities are able to farm and graze in the forest in a sustainable way. The communities have also planted tree which they could exploit by engaging in the carbon trading market. Other trees planted are of nutritional value e.g. the mango grafted avocado, oranges and macadamia while others are used to feed livestock e.g. the commonly grown *calliandra calothyrsus* is fast maturing and drought resistant (Franze *et al.*, 2013).

The evaluation of the Water Act of 2002 revealed that the community has developed Water Users Associations (WRUAS) which are avenues through which they relate with WRMA in water issues. Members in these associations act as the custodians of the water resources in the area. Although there are no specific guidelines on how the WRUAS are formed or interference from the government, the WRUAs are working in harmony with the locals and the Water Resource Regulatory Authority. An example of the WRUAs in the study area are the Kigathi water Community Based Organisation, Narumoru water scheme, AguthiNdiriti scheme, Kabura-ini and Gitwe scheme that engage in various activities.

Through the developed Nyeri County Agriculture Development Act of 2016 the county seeks to establish an efficient legal and institutional framework for development in agriculture including; crop development, Livestock development (domesticated animals and emerging livestock), fisheries, value chain development, farm inputs, pests and disease control and conservation among others. The study revealed that the benefits of this policy is yet to be felt by the agropastoral communities in Kieni who reported to have experienced challenges in the marketing of their produce and in the value chains especially in rabbits and fish. This study revealed that despite being a livestock keeping leader in the county, Kieni sub-county does not have a livestock market and it has only one artificial insemination bull station and has no poultry hatcheries.

Evaluation on the Crop Production and Livestock (Seed and Ware Potato production and marketing standards) Rule of 2005 revealed that Kieni potato farmers are getting assistance for investment in low cost storage facilities for their produce-an example being the Kianjogu-Kiambogo commercial village that has benefited from the A 2SCALE initiative which is co-funded by the Irish embassy. The stores allow farmers to store their produce until the prices become favourable rather than disposing them immediately after harvesting. The study established that the storage initiatives have helped farmers to source for better markets and have increased their bargain power.

Other national government programmes supporting climate change adaptation being implemented directly on the ground include, the Fish Farming Enterprise Productivity Programme (FFEPP) of the Economic Stimulus Programme (ESP) and Economic Recovery, Poverty Alleviation and Regional Development Programme (ERPARDP). These programmes are assisting Kieni community by providing extension services, construction of fish ponds and provision of agricultural inputs such as feeds for fish and the fingerlings. The National Animal Disease Act CAP.364 of 1989 which was revised in 2012(National Council for Law Reporting, 1989) is also being implemented through the County Veterinary Department to carry out surveillance and impose quarantines for disease control during outbreaks.

The study also revealed that different actors are working on the ground to support climate adaptation efforts. NGOs like Caritas Nyeri is working with the community to improve on the cooking stove to make it more efficient hence helping the women access affordable cooking stove that use little charcoal of firewood for cooking hence saving the trees. The NGO is also working on rural water provision helping Kieni community access quality water which has impacted on the community sanitation and hygiene and overall wellbeing. The chapter has concluded that the communities in Kieni are implementing climate change and agriculture related policies that are helping them adapt better. It has also concluded that there are social and environmental opportunities that are being derived from the policies, ordinance, bylaws and regulations that are being implemented by the county and sub-county administrations as well as the community itself. The community is also seen as a key partner in policy implementation as reflected by the community based water and forest associations. These communities once they buy-in into the programmes, they are able to take it fur and get solutions to their own adaptation barriers.

CHAPTER NINE: CONCLUSION AND RECOMMENDATIONS

9.0 Introduction

This chapter presents a summary and general conclusion of the main findings with regard to the research objectives. Recommendations for further study into opportunities brought by climate variability and change and barrier to uptake of these opportunities are also highlighted.

9.1 Summary of the key findings

The analysis of extreme climate indices revealed that the maximum and minimum temperature in Kieni portray an overall increase in daily maximum and minimum temperature. The analysis also revealed that, the monthly maximum value of daily maximum temperature (TXx) and monthly maximum value of daily minimum temperature (TNx have decreased over the period 1991-2015. The number of days when TN<10^{th}percentile (cool nights) and number of days when TX<10^{th}percentile (cool days) have increased in Narumoru Gate Park met offering an opportunity to exploit on diversification of crop and livestock types and varieties.

Rainfall analysis showed that the observed monthly maximum 1-day precipitation (Rx1day), showed significant trend in Sasini weather station, meaning that the rainfall distribution in the area has changed. Simple Daily Intensity Index (SDII) which shows days with precipitation amount on wet days with rainfall amount greater or equals to 1mm showed general increase in all the three stations with Munyaka weather station presenting significant trend. The Consecutive Wet Days (CWD) with rainfall greater than or equal to 1mm have generally decreased in all the locations with Munyaka showing statistically significant trend. The short rains (OND) are becoming more successful in the area offering an opportunity to the community to change on crop variety and types.

The study revealed that the community in Kieni are aware of climate variability and change with 97% of the 383 agropastoral households surveyed reporting to have seen changes in the rainfall pattern and as well change in temperatures. The community perceived short rains (OND) as having become heavier and of late extending way into January. This collaborated with the scientific evidence of a successful OND in the area.

The study also revealed that the agropastoral community in Kieni has a good idea of opportunities associated with climate variability and change with 91% of the 383 households surveyed reporting to have perceived an opportunity. Opportunities are in awareness of climate variability and change, livelihood diversification, farm and production practice, technological innovations, employment, land use and land management, financial and market services and education.

Policy evaluation revealed that there are opportunities associated with implementation policy, bylaws and ordinances that are in existence. In Kieni, the implementation of these policies through various programmes is helping the communities adapt better. Prioritisation and implementation of the County Intergrated Development Plan, Forest Act of 2005, Water Act of 2002 and other national government programmes the Fish Farming Enterprise Productivity Programme (FFEPP) of the Economic Stimulus Programme (ESP) and Economic Recovery, Poverty Alleviation and Regional Development Programme (ERPARDP) is supporting community climate change adaptation in Kieni.

9.2 Conclusions

The importance of studying climate variability and change at local level cannot be overstated. The study looked at the extreme climatic indices which are important at giving specific day to day changes in weather over a long period. Results revealed that different weather stations in the same study area gave varying results. For example, the long-term mean annual rainfall reported for 1985-2015 was 870.29 mm for Sasini Farm; 644.56 mm for Munyaka and 1664mm Narumoru Park gate. However the study did not investigate the factors behind the difference in climate at micro level such as land use change and conservation measures being undertaken. From the Mann-Kendall test, the study revealed that the area is receiving concentrated and more successful short rains.

This is a very important finding that could help policy makers and the county government when planning for adaptation measures. This study also did not establish what is causing the increase in short rains in the area and would recommend further research on that.

The local coping strategies were also examined. This study revealed that the agropastoral communities in Kieni are utilising local mechanisms to adapt to climate variability and change. These strategies include buying of food and fodder during drought; looking for casual labour in flower farms and in the urban areas; depending on remittances from family members who work in the cities; depend on social networks (*chamas*) where they loan monies for use as well as depend on the government cash transfer of the elderly; reducing farmed area during drought and practising small scale irrigation (for kitchen gardens). Other strategies included engagement in local enterprise and diversification of livelihoods which include agribusiness, aquaculture, rearing of chicken, dairy goats and rabbits.

This study also examined how the agropastoral community in Kieni perceive opportunities brought by climate variability and change and their uptake. The study revealed that 91% of the surveyed community members are aware and perceive there are opportunities associated with climate change. Despite the plenty of opportunities available for uptake, it is clear that a good number of these community members have not taken initiative to utilise the opportunities available to them to help them adapt better. This means that in the absence of crucial assets such as natural and human capital, social networks, institutional and good governance, technology and general good health, communities may not be able to adapt to the changing and variable climate.

It is therefore paramount that adaptation enablers such as education and awareness creation, capacity building, shared learning and promotion of local climate change innovations be enhanced to help rural communities make informed decisions on climate adaptation.

The study revealed that the county government of Nyeri is implementing the CIDP which has prioritised important areas such as water and irrigation, rehabilitation of degraded land, planting of trees, diversification of crop and animal types and varieties which were identified by the community as opportunities associated with climate variability and change.

The evaluation also revealed that a number of projects are ongoing at the local level in Kieni which are helping the vulnerable community to cope with effects of climate variability and change. The actors in these projects are the communities, NGOs, CBOs, FBOs and the government who are working together in adaptation projects such as use of energy saving stoves, connection of water to the communities, construction of dams and drilling of boreholes in the area.

9.3 Recommendations

The study has shown that although the agropastoral community in Kieni are highly impacted by climate variability and change, they are also aware of the social and environmental opportunities available.

This research revealed that a number of household and community level response strategies are being utilised. Most of these response strategies are what the community reported as opportunities brought by climate variability and change.

The study therefore recommends further research to understand the factors behind the difference in climate in different sites of the same study area as well as establish the causes of increased short rains in the area.

The study also recommends improvement on market access, pricing of produce and policy enforcement from government especially on marketing of farm produce. For example, the law on the weight of a potato sack which was cut from 110kg to 50kg as stipulated by the International Labour Organisation (ILO) as maximum packaging weight for agricultural produce should be upheld and enforced across the country. This will protect poor farmers against exploitation by the middlemen. At the same time, storage mechanisms and post-harvest management of agricultural produce and products must be put in place to help the agropastoral communities maximise on their production when market prices are more favourable.

The study revealed that old age was seen as a barrier to utilisation of opportunities brought by climate variability and change in Kieni. Therefore, there is also need to create a strategy that would incentivise the youth to take up farming as a form of employment. Training and awareness creation on rain harvesting and water conservation technologies should also be enhanced. This would help the community members to retain substantial amount of water even after the rains for their subsistence irrigation and domestic use.

The study also recommends training in financial management, a saving culture and access to credit facilities for the agropastoral community in Kieni Sub-county. This will help the communities to gain knowledge on how to invest the monies they receive from their various social and environmental enterprises hence building their resilience.

The study also recommends further research on the relationship between climate change and health especially on cold related diseases in Kieni Sub-county. This would give insights on what majority of the agropastoral community in the area believes to be health problems brought by changing climate.

On policy, local policy approach carbon trading initiatives. This would help the farmers who are undertaking agroforestry and intensive tree planting benefit from the carbon markets. There is need to train the agropastoral communities on what trees to plant especially those that can be intercropped with other crops to boost food security. The legal obligations and implications of tree planting initiatives under foreign funding programmes should also be made clear to farmers. Above all relevant policy improvement is needed in carbon trading sector to ensure that the agropastoral communities who commit to such activities do not end up giving up their entire land rights without proper compensation.

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APPENDICES

APPENDIX 1: HOUSEHOLD QUESTIONNAIRE

Thank you for taking time to participate in this survey. These questions are designed with the intension of assessing social and environmental opportunities offered by climate variability and change to agropastoral communities in Kieni of Nyeri County. The main objectives of this research are:

1. To explore the characteristics of extreme climate indices and their impact on livelihood systems in Kieni
2. To establish the adaptation strategies available to agropastoral communities in Kieni
3. To determine the communities' uptake of opportunities brought by climate variability and change
4. To propose policy recommendation on possible future adaptation responses for agropastoral communities in Kieni

Please answer each question to the best of your ability.

PART A: GENERAL INFORMATION

1. Gender(Tick appropriately)

   Male: ☐ Female: ☐
2. Age:……..…..
3. Are you the household head? Yes: ☐ No: ☐
4. If no, what is your relationship to the household head?

   ……What is your role in your family?

   ……
5. Education level (tick where applicable)

   Informal ☐ Primary ☐ Secondary ☐ College ☐

   University graduate ☐ Post graduate ☐
6. How long have you lived in this area?

PART B: INDICATORS OF CLIMATE VARIABILITY AND CHANGE ON LOCAL LIVELIHOOD SYSTEMS

1. What does climate change mean to you?

……

……

……

2. Have you noted any change in climate in this area so far? Yes ☐ No ☐
    a. If yes in the above question, what changes have noted?

……

……..

    b. Do you think it is permanent or temporary change? Yes ☐ No ☐
3. What are the signs of climate change and variability with regard to the following climatic disasters?

Climatic events	Signs of climate change and variability
Droughts	
Frostbites	
Invasive pests, diseases and plants	

4. What are the impacts of the following disasters to your crop production?

Climatic events	Impacts of climate change and variability
Droughts	
Frostbites	
Invasive pests, diseases and plants	

5. What are the impacts of the following disasters to your livestock production?

Climatic events	Impacts of climate change and variability
Droughts	
Frostbites	
Invasive pests, diseases and plants	

6. How do you respond to the following climatic events?

Climatic events	Response to climate change and variability impacts
Droughts	
Frostbites	
Invasive pests, diseases and plants	

7. What would you suggest as the appropriate solutions for better managing the following climatic events?

Climatic events	Solutions to climate change and variability (current and future)
Droughts	
Frostbites	
Invasive pests, diseases and plants	

PART C: VULBNERABILITY ASSESSMENT

1. What risks or threats would you associate with climate variability and change?
   a) How often do they occur?
   b) How intense is the risk?
   c) How difficult is it to cope with the risk?

Risk	Frequency 1-Always 2-Often 3-Sometimes 4-Seldom 5-Never	Intensity 1-Very serious 2-Serious 3-Less serious 4-Not serious	Difficulty 1-Very difficult 2-Difficult 3-Neutral 4-Easy 5-Very easy
Droughts			
Frostbites			
Invasive pests, diseases and plants			

Frequency: always - every year, often - 2-3 years, sometimes - 3-5 years, seldom – 5-7 years.

2. Can something be done to remove vulnerability? Yes No

Explain your answer?

……

……

……..

PART D: ADAPTATION /COPING STRATEGIES, BARRIERS AND OPPORTUNITIES

1. What is your source of income? (you can tick more than one)

Source of income	How important is the source of income? 1. Not important 2. Slightly important 3. Very important 4. Extremely important	Estimated income from different activities 1. 0 – 25000 2. 25001 – 50000 3. 50001 – 75000 4. 75001 – 100000 5. Above 100000
Agriculture		
Livestock keeping Poultry farming		
Fishing		
Enterprise/business		
Horticulture		
Other (please explain)		

2. What would you term as your priority capital in terms of human capital, skills, technology, social resources, financial resources, physical and natural resources? Please rank in terms of importance (1 High-5 Low).

Priority capital	Rank of importance
Human capital	
Skills	
Technology	
Social resources	
Financial resources	
Physical resources	
Natural resources	
Others (specify)	

3. Which of these strategies have you used to reduce the effects of climate change

- ☐ Change of crop variety
- ☐ Change of animal breed
- ☐ Aquaculture
- ☐ Greenhouse farming
- ☐ Agro-foresting
- ☐ Intercropping
- ☐ Irrigation
- ☐ Water harvesting
- ☐ Other (Please specify)

4. What determines your choice of adaptation strategy?

……

……

……

5. What obstacles have you individually experienced while adapting to climate change?

……

……

……

6. What would you want to do/to be done to adapt better?

What to be done?	Appropriate person/organization to do?

7. What do you think are the opportunities that come with climate change?

……

……

……..

8. Have you taken an advantage of any of those opportunities? Yes ☐ No ☐

9. If yes which ones?

……

……

……

10. If no, what would you attribute as major personal barrier to effective utilization of those opportunities emanating from climate variability and change?

……

……

……

11. What would you suggest as ways for improvement to your uptake of these opportunities?

……

……

……

APPENDIX 2: KEY INFORMANT INTERVIEW QUESTIONS

INDICATORS OF CLIMATE VARIABILITY AND CHANGE ON LOCAL LIVELIHOOD SYSTEMS

1. What does climate change mean to you?
2. What changes have you noted in this area and do you think it is permanent or temporally?
3. How do these climatic events affect the following communities' source of livelihood and life activities in general?

Activity/source of livelihood	Droughts	Invasive pests,diseases and crops	Frostbites
Crop yield			
Animals production			
Source of clean water			
Food security			
Food prices			
Source of Agricultural manual labour			
Migration			
Property and infrastructure			
Human-wildlife conflict			
Education			
Human health and nutrition			
Others specify			

VULBNERABILITY ASSESSMENT

1. How many households in this area are vulnerable or impacted by the following climate related risks?

Risk	No. of households affected
Droughts	
Frostbites	
Invasive pests ,diseases and plants	

2. Which groups are most vulnerable?
3. Why do you think that they are vulnerable?
4. What do you think can be done to reduce the vulnerability?

ADAPTATION /COPING STRATEGIES, BARRIERS AND OPPORTUNITIES

1. Do you think the communities are doing something towards adapting to climate change?

   If yes what strategies are they using?

2. What challenges do you see or envision for community adaptation?
3. What do you think can be done to overcome the challenges?
4. Do you know of any government institutions or civil society organizations that promote/ support change adaptation initiatives? If yes, which ones and in which ways do they support?
5. What are the national and local factors that limit you to achieve full potential in climate change adaptation?
6. In your opinion, what opportunities do you see in climate change adaptation?
7. How can the communities' take advantage of these opportunities?

APPENDIX 3: PRA PROTOCAL

1. Introduction (15minutes)
   - Greetings
   - Introduction of the transdisciplinary team members and the study
   - Explanation of the purpose of the programme and activities to participants
   - Group formation

INDICATORS OF CLIMATE VARIABILITY AND CHANGE ON LOCAL LIVELIHOOD SYSTEMS; ADAPTATION /COPING STRATEGIES, BARRIERS AND OPPORTUNITIES (60minutes)

Tool #1: Focus Group Discussion

Sign of climate change	Impact	Livelihood system impacted	Coping strategy	Barriers/ constrains	Opportunities	Challenges to utilisation of the opportunities	Solutions to those challenges

Activities

- Participants brainstorm and free list on the board on what climate change mean to them, the changes they have seen with climate and impacts on their livelihood systems
- Participants are asked list coping strategies for each climate change impact, barriers to adapting to climate change and opportunities

Questions

- What does climate change mean to you?
- Have you noted any change in climate in this area so far?
- If yes in the above question, what changes have noted?
- Do you think it is permanent or temporary change?
- How does the change affect and influence your modes of production/livelihood sources?
- What can be done to adapt to these changes?
- Which ways do you use to respond to the impacts of climate change?
- What challenges to do you experience while adapting to climate change?
- Do you think something good can come out of climate change? If yes, in what ways can climate change be good or be an opportunity?
- What could be preventing you from exploiting these opportunities for maximum adaptation?
- What would you suggest as a solution to those challenges?

Tool#2: Resource mapping

Activities

- Participants are asked to draw a map of the division showing all natural resources
- Ask participants to also show institutions, buildings and places that offer important social services

Questions

- What resources are abundant in this division?
- Which resources are scarce in the area?
- How do you use the available resources?
- How accessible is land resource?
- Do women, youth and men have equal access to land other important resources?
- Who makes decision on how land and other resources are allocated?

Tool #3: Seasonal calendar

Activities

- In a spacious area, participants draw calendar on the ground
- Participants draw a matrix showing each month along one axis
- Symbols to be chosen for different topics(rainfall, temperatures, water availability, fodder, income for men and women, expenditure for men and women, food availability
- Participants put stones/seeds under each month to indicate amount of precipitation received in each month(many stones/seeds indicating more precipitation)

Questions

- How is the rainfall pattern over the year? How does it vary?
- Which are the hottest months of the year?
- How is the water availability for livestock and human consumption over the year?
- How does livestock fodder availability vary over the year?
- What months are the busiest for farm work?
- What time of the year do you have food shortage?
- How is the income pattern for men and women over the year?
- How is the expenditure pattern for men and women over the year?
- Which is the most appropriate season for additional activities for men and women?
- What time constraints do you experience and what is the reason for that?

VULBNERABILITY ASSESSMENT (30minutes)

Tool #1: Risk ranking and scoring

Risks	No. of Votes	How often do they occur			How intense/severe is it			How difficult is it to cope with risk		
		Not often	often	Very often	Not much	Much	Very much	Not difficult	difficult	Very difficult

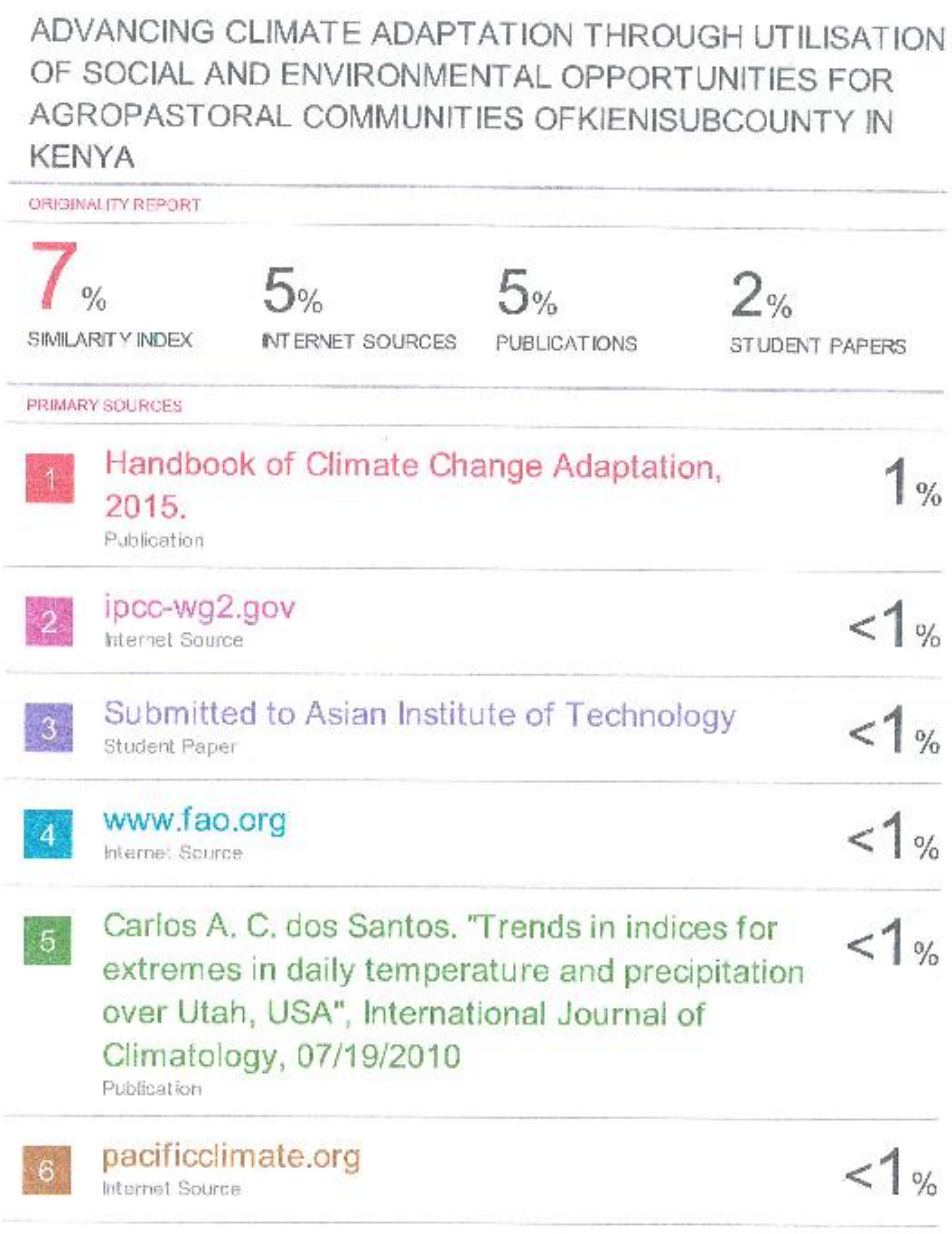
Activities

- Group participants to brainstorm and list freely
- Participants write different risks on a card and paste them on the flip chart.
- The facilitator asks participants to vote by show of hand how much they think the risk is of huge concern to them
- Threats are ranked and listed on the flip chart according to the number of votes

Questions

- What climate related risks do you face in your area?
- Which ones are you most concerned about?
- How intense are they?
- What do you think can be done to manage them?

APPENDIX 4: PLAGIARISM CHECKER RESULT CERTIFICATE



ADVANCING CLIMATE ADAPTATION THROUGH UTILISATION OF SOCIAL AND ENVIRONMENTAL OPPORTUNITIES FOR AGROPASTORAL COMMUNITIES OFKIENISUBCOUNTY IN KENYA

ORIGINALITY REPORT

7%	5%	5%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Handbook of Climate Change Adaptation, 2015. Publication	1%
2	ipcc-wg2.gov Internet Source	<1%
3	Submitted to Asian Institute of Technology Student Paper	<1%
4	www.fao.org Internet Source	<1%
5	Carlos A. C. dos Santos. "Trends in indices for extremes in daily temperature and precipitation over Utah, USA", International Journal of Climatology, 07/19/2010 Publication	<1%
6	pacificclimate.org Internet Source	<1%

APPENDIX 5: FIELD OBSERVATION SHEET

Field Walk Observation Sheet	
Date:	
I will be observing: land, environment, community(children, women, men, youth), shelter structures	
Location	**Observation**