BORAN PASTORAL INNOVATIONS IN RESPONSE TO CLIMATE CHANGE: A CASE OF MERTI DIVISION, ISIOLO COUNTY, KENYA

BY

OMAR BORU JILLO AGA (B. Env.Sci.)

N50/CE/14196/2009

DEPARTMENT OF ENVIRONMENTAL EDUCATION

A Research Project Report Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of Master of Environmental Studies (Climate Change and Sustainability) in the School of Environmental Studies of Kenyatta University

JUNE 2013

DECLARATION

Declaration by Candidate

This research project report is my original work and has not been presented for a degree in any other university.

Omar Boru Jillo Aga (B. Env.Sci.)

N50/CE/14196/2009

Signature…… Date 04/12/2013

Declaration by Supervisors

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

Dr. James Koske

Signature …….. Date ……

Department of Environmental Education

Dr. John Muriuki

Signature…….. Date……..

Department of Environmental Education

DEDICATION

I dedicate this work to God for his grace during my studies. I also dedicate it to my parents and my wife for their support.

ACKNOWLEDGEMENT

I wish to thank almighty God who gave me energy through the whole process from proposal development to the project write up.

I wish to express my sincere gratitude to Dr. James Koske and Dr. John Muriuki who are my supervisors for their guidance and support during my work.

I thank all the Boran herders from Merti Division who participated in this study for their patience and sincere responses. In addition I thank all the key informants who participated in the interview.

I also express my sincere gratitude to my parents, my wife and friends, Guyo Malicha, Abarufa Jillo, Kimani Samuel, Samoei Kipkosgei, Halkano Jillo and Mohammed Fugicha for their moral support as I did my work.

I also thank my Boss Mr. Jamleck Njeru for his continued support during my studies. Finally I appreciate the assistance offered to me by the staff of Department of Environmental Education, Kenyatta University.

ABSTRACT

Pastoralism is the main source of livelihood for Boran community inhabiting Northern Kenya. Over time, they have developed coping strategies aimed at minimising losses from aridity. Although the strategies may have served the community well in the past, they are presently perceived as inadequate in the light of climate change. This study investigated necessary adjustments in the strategies and innovations among the Boran in Merti Division of Isiolo County. Specific objectives were to investigate innovations by Boran pastoralist' in response to climate change, to find out the main drivers of innovation practices and to establish the relationships between herders' innovation practices, climate change and livelihood strategies Qualitative and quantitative approaches were applied. The target population was 400 from which a random sample of 80 herders was drawn. All the 6 local chiefs and 6 community leaders in the area were also interviewed. Data was collected using semi structured questionnaires and key Informant interviews. The resulting data was coded and statistically analyzed using the statistical package for a social scientist (SPSS). Then the results were analysed, discussed and presented in graphs, pie charts and tables. The results showed that there were main drivers of innovations among Boran pastoralists in Merti Division. They include prolonged droughts, conflicts and invasive species which are linked to climatic changes. There were also response strategies which were found to be improvement in their usual drought coping strategies while others are newly emerging strategies. The innovation practices include agreement between herders and ranchers, livelihood diversification, inter-community negotiations, change in mobility, among others. The study established that 53% of the pastoralists were aged over 40 years while 47% were aged below 40 years though there was no significant difference between the two groups ($p=0.0921$). On the period the respondents had worked as pastoralist, the results showed that majority (52%) had worked for more than 9 years while the rest had worked for less than 9 years as pastoralists. Further, the results of the study established that climate change was a key driver of herders led innovation practices. The study established that a unit deterioration of the climate change would lead to an increase in the herders led innovation practices by 4.5 units with this being significant at 5% level of significance ($p=0.000$). On the other hand, livelihood strategies were also to be significantly associated with herder led innovation with a p-value of 0.000. The study concluded that climate change has had an impact on Boran pastoralists' forcing them to improve their existing drought coping mechanisms and adopt newly emerging strategies. Some of the key recommendations are increasing participation of pastoralist in development of pastoral policies, reducing obstacles that hinder pastoral mobility and strengthening of security and peaceful existence in Northern Kenya in order to enhance adaptation to climate change.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OFABBREVIATIONS AND ACRONYMS

ASALS- Arid and Semi- Arid lands

DFID- Department for International Development

GDP- Gross Domestic Product

GHG-Green house gases

SSA-Sub Saharan Africa

UNEP- United Nations Environment Programme

UNDP- United Nations Development Programme

WISP- World Initiative for Sustainable Pastoralism

DEFINITION OF TERMS

Innovation- Refers to discovering new and better ways of doing things or modifying an existing way of doing things. It encompasses both radical and increamental changes in thinking, products, processes and or organisation (Scoones and Adwera, 2009).

Local innovations- The new ways of doing things (in terms of technology or socio-economic organisation or institutional configuration) that result from the innovation process (Scoones and Adwera, 2009).

Livelihoods- Comprises the capabilities, and material and social assets necessary for a means of living, includes the idea of coping with and recovery from external stresses, (Scoones, 1998), and the sustainability of the resource base on which livelihoods depend (Ashley and Carney 1999, Norton and Foster, 2001).

Livelihood strategies- Refers to the range and combination of activities and choices that people make in order to achieve their livelihood goals. Livelihood strategies include: how people combine their income generating activities, the way in which they use their assets, which assets they chose to invest in, and how they manage to preserve existing assests and income (DFID, 2001).

Resilience- The amount of change a system can undergo and still retain the same function and structure while retaining options to develop in desired directions (Berkes *et al.* 2003, Holling ,1973).

Vulnerability- The susceptibility of a system to disturbance and loss, determined by the exposure to perturbations, sensitivity to perturbations, and the capacity to adapt (Smith and Wandel, 2006).

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Pastoralism is a livestock production system that is based on extensive land use and often some form of herd mobility, which has been practiced in many regions of the world for centuries (WISP 2007). Currently, extensive pastoralism occurs on about 25% of the earth's land area, mostly in the developing world, from the drylands of Africa and the Arabian Peninsula, to the highlands of Asia and Latin America where intensive crop cultivation is physically not possible (FAO 2001). In addition, cattle and sheep ranchers in Western North America, Australia, New Zealand, and a few other regions of the world presently practice a modern form of pastoralism. Worldwide, pastoralism supports about 200 million households and herds of nearly a billion head of animals including camel, cattle, and smaller livestock that account for about 10% of the world's meat production (FAO 2001). Pastoralism is globally important for the human populations it supports, the food and ecological services it provides, the economic contributions it makes to some of the world's poorest regions, and the long-standing civilizations it helps to maintain (Nori and Davies 2007). Unfortunately, threats and pressures associated with human population growth, economic development, land use changes, and climate change are challenging professionals and practitioners to sustain and protect these invaluable social, cultural, economic, and ecological assets worldwide (Nori and Davies 2007).

The climate of Africa is warmer than it was 100 years ago and model-based predictions of future green house gases (GHG) induced climate change for the continent clearly suggest that this warming will continue and, in most scenarios, accelerate (Hulme *et al*,2001). Observational records show that during the 20th century the continent of Africa has been warming at a rate of about 0.05°C per decade with slightly larger warming in the June–November seasons than in December–May (Hulme *et al*., 2001). By 2000, the five warmest years in Africa had all occurred since 1988, with 1988 and 1995 being the

two warmest years (IPCC, 2007). This rate of warming is not dissimilar to that experienced globally, and the periods of most rapid warming the 1910s to 1930s and the post 1970s occur simultaneously in Africa and the rest of the world (IPCC, 2007).

Livestock production depends on natural resources, which in much of Africa primarily means pasture and water. Climate change therefore affects livestock production in a myriad ways, both directly through impacts on livestock performance, and indirectly through impacts on environment, society and economy. Impacts will be experienced on forage yields, livestock productivity, ecological processes and farm level profitability, possibly leading to modification of regional and national food production and incomes (WISP, 2010). The impact of climate change on livestock production in Africa is also greatly influenced by the vulnerability of African livestock keepers (WISP, 2010). Past studies reveal that farmers in developing countries are highly vulnerable to climate change (Rosenzweig and Parry, 1994; Mendelsohn et al., 2001; Kurukulasuriya *et al.*, 2006; Seo and Mendelsohn, 2008). Unlike the farmers in the rest of the world, they are vulnerable because they are already located in a hot climate zone and have limited capacity to cope with climate risk (Mendelsohn *et al.*, 2006)

In Kenya, over 60% of the national herd is held by pastoralists and it produces about 10 % of the Gross domestic product (GDP) and 50% of agricultural GDP (Huho *et al.*, 2011). In the Arid and Semi Arid lands (ASALS) of Kenya, pastoral economy accounts for 90% of employment opportunities and 95% of family incomes and livelihood security (Huho, *et al.*, 2009, USAID, 2010). In Northern Kenya, pastoralism is largely practised by the Boran, the Turkana, the Maasai, the Rendille, the Samburu, the Gabra, the Orma and the Pokot. Pastoralism in this region is nomadic in nature, where herders adapt to spatial-temporal variability in pasture and water availability through herd migration. Drought is by far the greatest cause of livestock mortality. Pastoralists in Northern Kenya keep different types of livestock which include cattle, goats, donkeys and camels. However the dominant stock varies from one ethnic community to the other depending

on cultural values attached to specific livestock types and also due to climatic conditions (Huho *et al*, 2010).

Pastoralism is the main source of livelihood for communities in Northern Kenya. Pastoralists constitute 13.2 % of Kenya's estimated 39 million people (GoK, 2009), with livestock as their major source of livelihood and food security. The pastoralists contribute a significant share (approximately 70%) of the total marketed livestock in the country (Galvin *et al*., 2004). Pastoralists herd their livestock in the ASALS of the country where several extreme climatic events have occurred (Olukoye *et al*., 2004). Pastoralism is a dynamic system comprising of people, livestock, and natural resources such as vegetation, soil, water, temperature, wind, traditional system, and economic attributes such as markets. However, pastoralists' support system is prone to adverse effects of climatic variability and change. The notable droughts in the past three decades that impacted negatively in Northern Kenya include those in the years 1971,1975,1977,1980, 1983-1984, 1995-1996,1999-2000 and 2004-2006. The extreme climatic events often result in a number of adverse impacts include loss of livestock, a major source of livelihood and food security especially among pastoralist communities in the region.

In the recent years, 2005/2006, Northern Kenya experienced loss of livestock and human lives to Rift valley fever epidemic. The outbreak of the disease was due to floods caused by mild El nino phenomenon that is attributed to climate change.

The increasing vulnerability of pastoralists' livelihoods to climate change is a pressing problem in Kenya's ASALs and ecosystem resulting from the interaction of ecological, socio-economic and socio-political factors. Northern Kenya represents a typical semi arid region within East Africa and adverse effects of climate change are likely to impact negatively on the livelihood support base as well as ecosystem structure and function. Innovations, which are new practices introduced by pastoralists themselves in response to climate change provide new ideas and practical experience to learn from. Alongside formal scientific and technological advancements, pastoralists are developing and testing new knowledge and practices to manage longstanding challenges and more recent pressures resulting from climatic changes.

1.2 Statement of the Problem

Pastoral productivity in Kenya is severely constrained by climate variabilty and attendant vegetation change (invasive species, demise of indigenous grass species and total landscape change) and other physical limitations, partly accentuated by inappropriate production systems (clearing of land, land use change). Innovations are an important component in the pastoralists' livelihood strategies because innovations determine how individual households use major assets of natural, financial, physical, human and social capitals and drive how they respond to the new opportunities or changes in their production system. There's considerable innovations happening in pastoral areas but it is not largely documented or understood except by the people doing it. Pastoralists are themselves innovators who create new institutions, tenure arrangements and ways of social organisation and resource use to better manage new pressures as well take advantage of opportunities.

Often, herder-led innovations as responses to new and changing climate are frequently lacking adequate economic and ecological analysis. Consequently, pastoralists' are often facing unnecessary high risk and vulnerability. Better understanding of their innovation strategies and the underlying driving mechanisms is necessary for optimising herders' livelihood strategies and minimise vulnerability. This study will analyse herders' innovation strategies and their relationships to the livelihood strategy using an integrated qualitative and quantitative research approach based on a case study approach.

1.3 Research Questions

1. What are the Boran pastoralist's herder-led innovations in response to climate change?

2. What are the main drivers of herder-led innovations in response to changing climate?

3. How are herder-led innovations related to livelihood strategies?

1.4 Research Objectives

The objectives of this study are:

1. To investigate the innovations by Boran pastoralists in the light of climate change.
2. To find out the main drivers of herder-led innovation in response to changing climate.
3. To establish the relationships between herders' innovation practices and livelihood strategies.

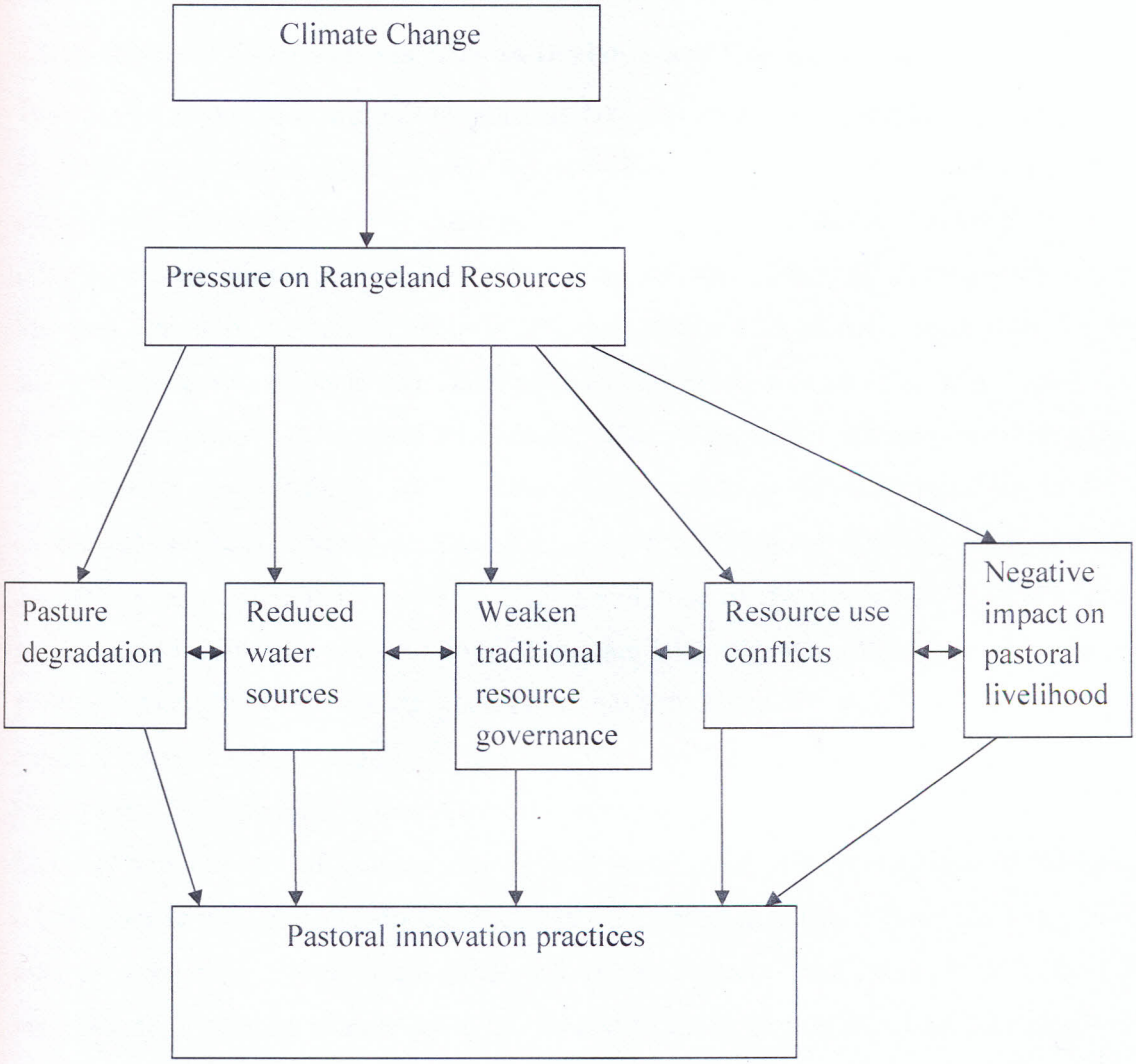
1.5 Hypotheses

1. Boran pastoralists have not developed pastoral innovations in response to climate change.
2. There are no main drivers of herder-led innovations in response to changing climate.
3. Herder-led innovations and livelihood strategies are not significantly related to each other.

1.6 Significance of the Study and Expected Output

The anticipated output of the study is knowledge of Boran pastoralist's innovations in Merti Division. In addition the main drivers of innovations among Boran Pastoralist in Merti will be known. The relationships between the pastoral innovations and livelihood strategies are crucial in that the study will try to show whether pastoral innovations are enablers of their livelihood strategies or not. There is very little literature on innovations in livestock sector and in particular lack of knowledge on innovations involving pastoralists, which the study aims to highlight. The outcome of the study will inform policy makers, herders and other stakeholders of the potential role that local innovations can play in adaptation to climate change.

1.7 Conceptual Framework



CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Pastoralism in African Drylands and Coping Strategies

The climate of Africa is warmer than it was 100 years ago and model-based predictions of future green house gases (GHG) induced climate change for the continent clearly suggest that this warming will continue and, in most scenarios, accelerate (Hulme *et al*,2001). Observational records show that during the 20th century the continent of Africa has been warming at a rate of about 0.05°C per decade with slightly larger warming in the June–November seasons than in December–May (Hulme *et al.*, 2001). By 2000, the five warmest years in Africa had all occurred since 1988, with 1988 and 1995 being the two warmest years (IPCC, 2007). This rate of warming is not dissimilar to that experienced globally, and the periods of most rapid warming the 1910s to 1930s and the post 1970s occur simultaneously in Africa and the rest of the world (IPCC, 2007). The projections for rainfall are less uniform. There are large regional differences that exist in rainfall variability. East Africa appears to have a relatively stable rainfall regime, although there is some evidence of long-term wetting. There is likely to be an increase in annual mean precipitation in East Africa (Hulme *et al.*, 2001).

Many of the impacts of climate change will materialize through changes in extreme events such as droughts and floods. Such extremes result in severe human suffering, and hamper economic development and efforts at poverty reduction. Unfortunately, assessments of climate change are often limited to mean temperature and precipitation. Knowledge of changes in extremes is sparse, particularly for Africa. In some regions, different models project different trends in wet and dry extremes. In other regions, however, models show clear trends such as increasing drought in the Kalahari and increasing floods in East Africa (KNMI, 2006).

The challenges climate change poses for development are considerable (Thornton *et al.*, 2006). Despite the uncertainties that exist in long-term climate predictions, it is necessary to explore the sensitivity of the environmental and social systems, and economically valuable assets to climate change (Hulme *et al.*, 2001). High levels of vulnerability and

low adaptive capacity in areas of Africa have been linked to factors such as limited ability to adapt financially and institutionally, low per capita gross domestic product (GDP) and high poverty rates, and a lack of safety nets. For example, sub-Saharan Africa (SSA) is predicted to be particularly hard hit by global warming because it already experiences high temperatures and low (and highly variable) precipitation, the economies are highly dependent on agriculture, and adoption of modern technology is low (Kurukulasuriya *et al.*, 2006).

Studies over the last 30 years or so have shown that traditional pastoral systems are relatively productive and represent an ecologically sustainable way of using arid and semi arid lands (ASAL). There are indications from a number of African countries (Botswana, Ethiopia, Mali, Mozambique, South Africa, Tanzania, Uganda, Zimbabwe) that traditional pastoral systems can produce up to ten times more food per unit area than can modern ranching (Scoones, 1998). This is due to a large extent to the multiple uses of resources and the multiple functions of livestock in traditional pastoral systems. Over centuries, pastoralists have developed successful mechanisms to deal with natural variability in climatic conditions. They therefore have the knowledge, experience and potential to be able to adapt to climatic change. However, other factors such as exclusion from traditional grazing areas are creating pressures on the pastoral systems and are increasing their vulnerability to climate, as they restrict pastoralist' possibilities to adapt (Devereux, 2006). It is not meteorological drought that makes the pastoralists more vulnerable, rather it is the increasing marginalization of their drought response mechanisms. This marginalization is brought about by restrictions on mobility of animals and people, stricter control over cross border trade, land tenure policy that disadvantages pastoralists, lack of political power among pastoralists and land use planners and administrators disregard of indigenous knowledge, skills and customary institutions of land use management (Yohannes & Bayer, 2002).

When expressing their own perception of their vulnerability to climate change, pastoralists put particular emphasis on the degree of good governance within traditional socio-political institutions and on the land policies of the Government, in addition to

environmental factors such as drought and floods and associated risks of livestock and human disease (Yohannes *et al.*, 2010)

Pastoralism is an adaptation to marginal environments, characterized by climatic uncertainty and low-grade resources. It has considerable economic value and latent potential in the drylands, and is central to the livelihoods and wellbeing of millions of the world's poor, but the state of knowledge regarding this sector of the economy is weak. Pastoralism is not something to be tolerated until a 'modern' alternative can be found to replace it: it is a sophisticated system of production and land management that has itself been modernized in many countries, and is irreplaceable in extensive environments (Davies & Hartfield, 2007).Yet despite overwhelming evidence to the contrary, many policy makers consider pastoralism to be archaic, economically irrational, and in need of modernization or replacement. Such conclusions are based on a narrow view of what constitutes value in pastoral systems. The policies that emanate from this thinking continue to devalue pastoralism, often at significant cost to national economies and to the natural environment (Davies and Hartfield,2007).

Pastoralism has been subjected to multiple pressures which have undermined its resiliency as a way of life. Given the right incentives and support, however, it could prove to be an even more productive and valuable aspect of rural livelihoods, not least of all because so many people depend on it for their sustenance. In Ethiopia the 8 to 9 million pastoralists (ACDI/VOCA, 2008) of an estimated national population of 70.7 million (World Bank, 2008), harbor Africa's largest livestock population. Pastoralism is a cultural and economic system that is determined by social structure, resource management, productivity, trade and social and welfare mechanisms in communities founded on livestock rearing as a primary economic activity (Nori *et al.*, 2008).

Inspite of their environmental sensitivity and perceived fragility and despite the prevailing negative perceptions of drylands in terms of economic and livelihood potentials, drylands ecosystems have supported human population for centuries. Today

some of the world's fastest growing urban centers are located in these regions such as Cairo, Capetown, and Kano. Many rural dryland dwellers make their living through the production of livestock and rain fed/irrigated agricultural crops. Drylands also provide a habitat for a variety of plant and animal species and wildlife based tourism generating significant income for national economies (UNDP, 2009)

Livestock production depends on natural resources, which in much of Africa primarily means pasture and water. Climate change therefore affects livestock production in a myriad ways, both directly through impacts on livestock performance, and indirectly through impacts on environment, society and economy. Impacts will be experienced on forage yields, livestock productivity, ecological processes and farm level profitability, possibly leading to modification of regional and national food production and incomes (WISP, 2010). The impact of climate change on livestock production in Africa is also greatly influenced by the vulnerability of African livestock keepers (WISP, 2010). Past studies reveal that farmers in developing countries are highly vulnerable to climate change (Rosenzweig and Parry, 1994; Mendelsohn et al., 2001; Kurukulasuriya *et al.*, 2006; Seo and Mendelsohn, 2008). Unlike the farmers in the rest of the world, they are vulnerable because they are already located in a hot climate zone and have limited capacity to cope with climate risk (Mendelsohn *et al.*, 2006)

The fourth African assessment report on climate change released by IPCC highlights major issues related to potential impacts as a result of climate change (IPCC, 2007). It indicates that Africa is one of the most vulnerable continents to climate change and climate variability. This is the result of the interaction of 'multiple stresses' including land degradation and desertification, declining run-off from water catchments, high dependence on subsistence agriculture, HIV/AIDS prevalence, inadequate government mechanism and rapid population growth occurring at various levels, and low adaptive capacity due to factors such as extreme poverty, frequent natural disasters (Boko *et al.*, 2007). The likely impacts of climate change will add to these existing stresses and exacerbate the effects of land degradation. Increased temperatures levels are expected to

cause additional loss of moisture from the soil, reduced and more intense rainfall and high frequency and severity of extreme climatic events such as floods and droughts. These factors are already leading to a loss of biological and economic productivity and putting drylands population at risk of short and long term food insecurity (UNDP, 2009). There is considerable variability and uncertainty in climate change projections. Nevertheless, there is a reasonable agreement from a suite of different models that Africa is one of the most vulnerable continents to climate change and climate variability. Drought prone areas inter alia are particularly deemed to suffer complex, localized impacts of climate variability/change. In the sahel, for instance, changes in temperature and rainfall patterns have reduced the length of the vegetative period and make it difficult to continue the cultivation of traditional varieties of long and short cycle millets (Rosenzweig *et al.*, 2007). Given the social legislative, market and weather based sources of vulnerability already prevailing in the region, reduction in agricultural productivity and land area suitable for agriculture, even if slight, would cause disproportionately large detrimental effects (IPCC, 2007,Dietz and Geest, 2004).

Inhabitants of drylands in SSA have learned over millennia, to cope with variable inter and intra seasonal rainfall and the risks of weather related shocks. However, as a result of climate change, high poverty rates, changing socio- economic and political circumstances and demographic growth, traditional coping strategies are becoming insufficient (UNEP, 2006). In the recent past, some 320 million hectares of the already fragile resources in African drylands have been further degraded by unsustainable land uses such as overgrazing, over cultivation, illegal and excessive fuel wood collection and poor irrigation practices often compounded by poorly conceived policies and ineffective governance (UNEP, 2006). This study thus will try to understand the new strategies practised by Boran pastoralists' in response to climate changes. Pastoralism is a finely honed symbiotic relationship between local ecology, domesticated livestock and people in resource scarce, climatically marginal and highly variable conditions. It represents a complex form of natural resource management, involving a continuous ecological balance between pastures and people (WISP, 2007). When the fine balance is upset, as it

is with climate change and range desertification, the effects on the pastoral way of life can be dramatic leading to Socio-economic, political and environmental stresses.The most vulnerable communities to the impacts of climate change inhabit the drylands areas. For instance, the pastoralists inhabiting drylands have been able to survive the harsh environments of the drylands by practicing various sustainable livelihood approaches including seasonal movements, keeping livestock among others. However, with the threats of changes in climate, exacerbating current trends of encroachment on grazing lands by agriculturists and other factors they may be forced to consider other livelihood options, including permanent migration, in order to cope with cumulative changes (UNDP, 2009). As what is considered 'normal' changes due to the increasing effects of climate change and desertification, many pastoralist coping strategies will no doubt change, as many strategies will no longer be viable. Shocks will force pastoralist to change the system they have been using for centuries and adapt in different ways. Desertification and climate change will directly degrade the land resources that the pastoralists depend on, making maintaining livelihoods an even bigger challenge. Indeed, the effect of climate change and desertification will be felt on all levels, including physical harm and social disruption to subpopulations of societies and their larger subsystems. (UNDP, 2009)

2.2 Climate Change and Case of Kenya's Pastoralism

The ASALs of Kenya cover approximately 84% of the country's landmass, support 30% of the human and 70% of the livestock population, and employ about 90% of the local population (GoK, 2010), with the majority being pastoralists who depend directly on livestock-based livelihoods. Despite their contribution to the national economy, pastoral areas in Kenya are plagued with a number of problems including poverty which is associated with livelihood insecurity due to resource degradation and scarcity, as well as the accompanying resource-based violent conflicts (GoK, 2010). Livestock production accounts for 26% of total national agricultural production and over 70% of the country's livestock and 75% of wildlife are in the ASALs (GoK, 2005). Pastoralism relies on the availability of water, pastures and labour to thrive with water as the limiting factor. This shows that the contribution of the arid and semi-arid areas to the national economy is

crucial for the development of the country. Of all these land uses in the ASAL, pastoralism is best placed to adapt to increased climatic variability (ODI, 2009). Due to mobility, pastoralism is less susceptible to changes in climate than sedentary land uses in ASALs, such as crop agriculture, livestock ranching and ecotourism. Pastoralism is a resilient, low input land use option known to perform well in variable climates of northern Kenya (Galvin *et al.*, 2001). It therefore presents a less risky and more robust investment opportunity in ASAL regions where other land use types are likely to fail. Pastoralism accounts for 90% of the employment and 95% of the family incomes and livelihood security in the region (Galvin *et al.*, 2001). However, frequent droughts occasioned by climate change have threatened this important sector which offers a viable production system in the vast drylands of the country (Galvin *et al.*, 2001).

In Kenya, climatologists project a substantial increase in the annual average temperature between $3\text{-}5^0$ C by the end of the millennium because of climate change (Osbahr and Viner, 2006). The increase in temperature brings consequences such as loss of moisture and increased evaporation rates. Coupled with declining precipitation, climate change worsens the aridity of pastoral rangelands and affects a number of resources such as water, Pasture and edible fruits that pastoralists depend on (Hendrix and Glaser, 2007). The ensuing consequences would be the decimation of livestock in large numbers, which could significantly affect pastoralist livelihood and security (Stige *et al.*, 2006). Livestock define the economic, social and political hub of pastoralists. For pastoralists to lose their livestock is to lose their entitlement, which makes them vulnerable and valueless in the society (Brauch, 2002). While climate change affects crop and livestock production, the Impact is even felt more keenly by pastoralists because they inhabit fragile arid and semi arid areas where the occurrence of drought becomes more frequent with climate change. Interestingly, pastoralism has been resilient despite all these challenges. The mechanisms used by pastoralists' to cope with high climatic variability include moving their livestock and families, keeping different animal species (and within species, sometimes different types of animals), making reciprocal arrangements with other pastoral groups for access to pasture and water, developing water conservation techniques, observing early warning

signs of impending drought and practising complementary livelihood activities. Such adaptations and practices were developed long before the concept of climate change became known (McKee, 2008). In the ASALs of Kenya, drought is the most common hazard encountered by households on a widespread level. Between 1993 to date, the Government of Kenya has declared five national disasters in 1992-93, 1995-96, 1999-2001, 2004-2006 and 2008-09 due to droughts (Huho and Mugalavai, 2010).

In Northern Kenya, more than 3 million pastoralists are hit by severe droughts, which have been increasing in frequency and severity over time. Droughts in Northern Kenya have increased in frequency from once in every 10 years in the 1970's; once in every 5 years in the 1980's; once in every 2-3 years in the 1990's and now a norm since the year 2000 (Howden, 2009). Over the years, pastoralists have lost thousands of livestock due to droughts (Huho et al., 2011). Drought, range degradation and conflict are interlinked by complex inter-reinforcing mechanisms that make them destructive to both resources and pastoralists' well-being. A study shows that land degradation reduces viability of pastoralism and directly contributes to increased vulnerability of pastoral households to food insecurity (Macharia & Ekaya, 2005). In addition, range degradation has indirect potential effects of prompting ethnic tensions over shared resources in the absence of strong local institutions and inter-community resource sharing arrangements (Berger, 2003).

Analysis of rainfall data from the ASALs of Kenya reveals widespread droughts in 1960/1961, 1969, 1973/1974, 1979, 1980/1981, 1983/1984, 1991/1992, 1995/1996, 1999/2000, 2004/2006, and 2008/2009 (Morton, 2006; Huho *et al.*, 2011). The current decline in water and pasture resources in Kenya's ASALs have been linked to recurrent and prolonged droughts (Morton, 2006). The projected trend of increasing temperatures and less reliable rainfall increases the likelihood of floods and droughts in Kenya (Few *et al.*, 2006). In Kenya's arid and semi arid lands, droughts are a common phenomenon. In northern Kenya, where the dryness is most pronounced, 28 major droughts have been recorded in the past 100 years (Few *et al* 2006).

The drought frequency has increased as 4 of the 28 droughts occurred in the last decade (Mude *et al.*,2009). Agriculture is the main sector of the Kenyan economy and its performance strongly influences overall economic performance. Livestock production (largely through Pastoralism) is a production strategy in which people raise herd animals as a means to earn a livelihood, particularly in ASALs. The problems of access to pasture and water resources in Northern western Kenya have worsened in the recent past following high frequency of recurrent droughts. While, the key strategy of the local pastoralists to cope with drought is herd mobility which aims to exploit spatially different areas of vegetation types and productivity (Galvin *et al.*, 2001), herd mobility as a strategy similarly, requires a favorable environment in terms of land tenure and land use to allow access to and use of resources. Amongst Turkana and Pokot ethnic groups, seasonal livestock migration follows relatively well-defined traditional stock routes that at time get disrupted by droughts, disease outbreaks, cattle raids, or inter-community conflicts. While climate variability and change, particularly droughts, strongly affect both pastoralists and crop farmers, the impacts are higher on the pastoralists. The most direct impact of drought on the livelihoods of these pastoralists is the drying up of water sources and declining forage resources for livestock resulting from the increasing aridity. Also, they constitute the majority population in the ASALs where there is a greater probability of drought occurrences. They also face many other non-climatic challenges such as low soil fertility, weak infrastructure, and the consequences of inappropriate natural resource management policies (ODI, 2009). Drought periods correlate significantly with increased incidences of ethnic conflicts over stiff competition for water and pasture. Access to dry-period grazing areas is limited by the fact that cattle raids among neighboring communities increase during droughts. In Northwestern Kenya, resource use conflicts are a common feature mainly because of land use transformations, population growth and increased resource scarcity. The resource use conflicts usually occur around key natural resources (ODI, 2009). Demand for the hitherto dwindling water and pasture resources has heightened the conflicts, which tend to be seasonal in nature and increases during the dry season (Oguge, 2006). The conflicts have often resulted in loss of life and property. It is possible to expect natural resource use conflicts

to increase in the rangelands in future with increasing resource scarcity, which is aggravated by the effects of climatic variability and climate change (Oguge, 2006).

While there remain uncertainties regarding the changes in average rainfall, projections clearly indicate that ASAL regions would experience decreases in precipitation, exacerbating their aridity. It is estimated that drought events, largely due to failed rainy seasons, will increase both in frequency and intensity with projected climate change (Osbahr and Viner, 2006). Over two thirds of the country, particularly areas around the northern parts of Kenya receive less than 500mm of rainfall per year and are classified as Arid and Semi-Arid Lands (Osbahr and Viner, 2006). These are home to approximately 10 million people, a third of Kenya's population. Agriculture is the main sector of the Kenyan economy and its performance strongly influences overall economic performance (Osbahr and Viner, 2006). Livestock production (largely through Pastoralism) is a production strategy in which people raise herd animals as a means to earn a livelihood, particularly in ASALs. While there is no acceptable single operational definition of drought, in meteorological terms, annual drought (the failure of two successive rainy seasons) may occur anything between 1 year in 3 and 1 year in 30. Kenya experiences major droughts every decade and minor ones in three to four years with the exception of the arid northern part where it is experienced yearly with varied consequences (UNEP/GoK, 2000). These droughts have resulted in immense losses in resources and affected the livelihoods of many who depend on the ecosystem for survival, particularly the pastoralists. The 2000/2001 and 2006 droughts were the worst in at least 60 years, and between these two extreme years, several other rainy seasons have failed (UNEP/GoK, 2000). The variability in rainfall has also affected biomass productivity, as biomass productivity correlates with mean annual rainfall in the country. Although studies have shown a general increase in biomass productivity in Kenya between 1983 and 2000, some regions such as South-eastern Garissa in North-Eastern Province have experienced a significant decline in biomass production over the same period (Bai and Dent, 2006). This has negative implications for fodder availability for pastoral production. Climate change introduces an additional uncertainty into existing vulnerabilities in the ASALs. Climate models project a substantial increase of up to 5^0

Celsius in the annual average temperature for Kenya by the end of the century (Osbahr and Viner, 2006) which could lead to decrease in cattle population by 2050 compared to sheep and goats whose population could initially increase by 2030 but reduce by 2050 (Osbahr and Viner, 2006).

2.3 Boran Traditional Coping Mechanisms in Response to Climate Variability

In recent years, the pastoralist lifestyle and the fragile ecosystem of northern Kenya have come under great pressure from an increase in the frequency and seriousness of both man-made and environmental shocks and stresses. Cyclical insecurity, population growth, livestock disease and theft, rainfall and pasture variability, and droughts (most recently in 1997, 1999, 2000, 2004, 2005/6, 2007/8, and 2011) have all undermined essential traditional pastoralist institutions and practices (UNDP, 2012). Along with the failure of conventional development policy to consider the ecological and economic sustainability of the pastoral production system, these factors have encouraged the rapid growth of human settlements in arid lowlands for easy access to permanent water sources, food aid and some basic educational and health services. The security of settlements is also an attractive feature, as the threat of armed raids and an influx of illegal firearms have put large amounts of prime grazing lands off limits. These trends combined have put great stress on permanent water sources and the fragile pasture surrounding settlements. With the challenges that have come about from increased sedentarization, the ecological and economic sustainability of mobile pastoralism in such an arid region is increasingly clear (UNDP, 2012).

There are a number of climatic and non-climatic hazards affecting the livelihoods of Borana communities, including conflict, locust infestation, bush encroachment, livestock diseases and human diseases. However, drought is a major external shock and a primary trigger of livelihoods crises in the Horn of Africa (Panutuliano and Pavanello, 2009). The Borana rangelands are dominated by tropical savannah vegetation, with varying proportions of open grasslands, and perennial herbaceous and woody vegetation. Perennial grasses are particularly good for cattle and sheep, and other areas offer different vegetation types for browsers such as camels (Homann, 2004). Ecological degradation

has become a major threat to grass productivity, however, and includes the encroachment of woody species. A growing livelihood strategy to contend with this trend is to integrate camels and thus exploit different feeding behaviour, endurance and spread risk (Homann, 2008). Borana pastoralists are specialised in cattle production, however, and the loss of grasslands undermines the security and resiliency of their livelihood system. The natural assets of grazing land, water sources and rangeland products are key to the pastoralist livelihood system and yet access to these resources is increasingly hampered by, amongst others, environmental degradation, agricultural encroachment, conflict and population pressure. Such land issues are a well known determinant of pastoralists' vulnerability and often underlying these factors are political marginalization and poor policies in relation to pastoralists (Panutuliano and Pavanello, 2009).

Amongst important human and social assets for the Borana are the skills imbued in the individual and institutionalized in customary institutions for natural resource management. Natural resource management is an integral part of the pastoralist livelihoods strategy and in order to avoid their resources becoming degraded or limited, the Borana have evolved a series of specific livelihood strategies which they attempt to maintain but with increasing difficulty (Homann, 2004). Livestock, rangelands, indigenous knowledge and natural resource management strategies constitute the basis of pastoralist livelihoods. As livestock production comes under threat from reducing range land productivity caused by forces such as declining traditional range management systems, increasing populations, etc., one strategy pastoralists use to maintain their livelihoods is diversification (CARE, 2008). Pastoralists have implemented a wide range of adaptive mechanisms to cope with changing climate (Doti, 2010). The Borana pastoralists have adapted to the cyclic tendencies of the droughts, and with time have come to rely on traditional coping strategies aimed at minimising losses from drought or facilitating recovery thereafter. This coping mechanism include manoeuvres aimed at managing natural resources through flexibility and spreading risks, and includes strategies such as mobility and/ or migration, communal land ownership, large and diverse herds, herd separation and splitting (Doti, 2010). Unfortunately, these strategies

that have served the communities very well in the past are inadequate in the light of frequent occurrence of droughts, rapid social and economic changes and deteriorating climatic conditions. This is in addition to the presence of other factors such as cattle rustling, the proliferation of small arms, social and economic marginalisation, poor Government policies, illiteracies, population explosion and the displacement of pastoralists, which exacerbates their vulnerability amid the challenges already posed by climate change (Doti, 2010). Hence the study aims at bridging the knowledge gap in new strategies practised (innovations) by pastoralists in response to climate change.

The sustained drought over the year 2011 has caused large herd die-offs in some areas, eliminating the livelihoods of some Boran. The sustained drought combined with human and animal population pressures, is a critical contributor to the current humanitarian crisis in the Boran region. Although new and or additional strategies may be needed by the Boran to cope with regions changing drought and climate related risk profile, the roles, strengths and weaknesses of the Boran traditional coping mechanisms must first be understood (Hurst *et al.*, 2012).

The Boran pastoralists' of Isiolo in Northern Kenya follow a transhumance production pattern, using the high quality wet season pastures when they are available and retreating to other grazing areas in the dry season. Early in 2008, when disrupted rainfall was severely hampering crop production in the neighbouring Meru District, the Boran were relatively unaffected and were able to track the few seasonal showers (WISP, 2010). Later in the year however, the dry season extended for a longer period and the Boran were obliged to move to traditional dry season pastures. One of the main buffer zones is the Lorian swamp, but this area has steadily become drier in recent years. As a result of this lost dry season buffer, the Boran from Garba Tulla sought grazing in the restricted Bisan Adhi reserve-land that has been annexed for wildlife protection by the local authorities leading to conflict with the park authorities. Eventually the herders took their stock down to Tana River, some 100 kilometres further away, where they negotiated

water and pasture use with similarly affected herders from many other parts of Northern Kenya (WISP, 2010).

It is therefore important to give attention to local innovations, regardless of whether they are in response to climate change or other changes, because they are sources of valuable new knowledge based on the deep-rooted experience of pastoralists. Pastoralists live in areas full of uncertainties and risks to their livelihoods and have therefore always had to experiment and to adapt. Their innovations can bring insights into hitherto unexpected possibilities to adapt.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section provided the methodology for attaining the objectives of the study. It further described the study area, research design, target population, sampling techniques and sample size, data collection instruments, data collection procedure and data analysis.

3.2 Study Area

The research area was Merti Division of Isiolo District. The area is about 220 kilometres north of Isiolo town and borders Marsabit to the North, Samburu District to the west, and Garbatula District to the east. The area is inhabited by Boran speaking people who are purely pastoralists. The economic activity practiced in the area is mainly livestock keeping. However, there are few businesses around the shopping centre. The population density was 15,771 (KNBS, 2009) and the area is a flat low lying plain characterized by scattered settlement of manyatta's composed of concentrated households. The area displays semi-arid climatic conditions with vegetation cover mostly found being acacia tree species, shrubs and grasslands. Temperature ranges between 12^0C to 28^o C and the area receives rainfall ranging between 150mm to 650mm annually which is erratic and unreliable (ALRMP, 2010). The altitude of Isiolo County lies between 200-300 metres above sea level. However, in some parts such as Merti plateau and other plains in Southern parts, altitude is as high as 1000 metres above sea level. The soils are mainly sandy which has low water holding capacity and saline (ALRMP, 2010). Borana pastoralism remains significantly attractive area of study partly because of its livestock resources, institutional peculiarity, and relative ecological potential.

3.3 Research Design

Descriptive method was used whereby a case study of pastoralists inhabiting Merti Division took place. According to Cooper and Schindler, (2003), a descriptive study is concerned with finding out the what, where and how of a phenomenon. Descriptive research design was chosen because it enables the researcher to generalise the findings to a larger population. Integrated qualitative and quantitative approach was applied.

3.4 Target Population

Target population in statistics is the specific population about which information is desired. Mugenda and Mugenda, (2003), explain that the target population should have some observable characteristics, to which the researcher intends to generalize the results of the study. The population size of Merti Division is 15,771 people. But for the purpose of this study, herders were the target population and they are 400 herders in Merti Division.

3.5 Sampling Procedure

Purposive sampling design was used to select herders in Merti Division. Purposive sampling method as noted by Srivastava et al., (1993) is a deliberate non-random method of sampling which aims at selecting a sample of people, settings or events with predetermined characteristics. In this study, the pre-determined characteristics are the pastoral characteristics. The rationale for using the purposive sampling was based on the fact that the pastoralists are believed to have similar characteristics in regard to the objectives of this study. There are 400 herders in Merti Division (ALRMP, 2010).

3.6 Sample Size

A sample is a set of representative observations drawn from a population. For a sample size to be representative of the entire population, it needs to be sufficient and unbiased. According to Mugenda and Mugenda (2003), a sample size of between 10 and 30% is a good representation of the target population since it demonstrates the two characteristics

of a sample i.e. unbiased and sufficient. To this effect, the researcher used 20% of the target population in this study which gives 80 herders. Purposive sampling was used to select 80 herders from the total 400 herders. Also interviewed were the 6 local chiefs and 6 community leaders as key informants as they were thought to have extra information which may not have been available from the pastoralists. The sample size of this study was therefore 92 herders in Merti Division.

3.7 Data Collection Procedure

This study used a semi structured questionnaire and Key Informants Interviews to collect data. It was observed that questionnaires are very economical in terms of time, energy and finances. Similarly, it yields, quantitative data which is easy to collect and analyze. However, questionnaires deprive the participants an opportunity to express their feelings, attitude and behavior and hence Key Informants Interviews was used to collect qualitative data.

Quantitative data was collected through administering of questionnaires to individual pastoralists who are part of the study sample while the qualitative data was collected through the Key Informants Interviews (KIIs). Eighty questionnaires were issued to the 80 pastoralist who were sampled. The questionnaire was divided into four sections namely: background, Herders' innovation practices and livelihood strategies, Main drivers of herder-led innovation in response to changing climate, and innovations by Boran pastoralists in the light of climate change.

3.8 Data Analysis

The collected data in this study were both quantitative and qualitative. The quantitative data was coded and entered into the Statistical Package for Social Science (SPSS) which was used to analyze the data. The SPSS software was used since it was designed to analyze social statistics data. The researcher used both descriptive and inferential statistics to summarize the findings of the study. The descriptive statistics included the means, percentages and frequencies. The p-value used in this study was 5%. The study

also used a multiple regression analysis in an effort to establish the relationship between herder-led innovations practices, livelihood strategies and climate change. Regression analysis is a statistical tool that is used to establish relationships between independent variables and dependent variables.

In analyzing qualitative variable, i.e. the open ended questions in the questionnaire and the data collected from the key informants, the study used content analysis.

The regression equation was;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Whereby Y = herder-led innovations practices

X_1 = livelihood strategies

X_2 = climate change

ε = Error term

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter discussed the results of the research. The purpose of this study was to investigate the Boran pastoral innovations in response to climate change. The study was guided by the following specific objectives; to investigate the innovations by Boran pastoralists in the light of climate change, to find out the main drivers of herder-led innovation in response to changing climate and to find out the relationship between herders' innovation practices and livelihood strategies. The results of this study are presented in both tabular and graphical formats.

4.2 Response Rate

The sample size for this study was 80 Borana Pastoralists for the quantitative data and 12 community leaders who included 6 chiefs and 6 local leaders for the key informant interview. In total 79 questionnaires were captured in the statistical software for quantitative data analysis meaning that the final sample size was 79 Borana Pastoralists. One questionnaire was not responded to and hence not included in the analysis. This means that 79 out of the targeted 80 pastoralists responded to the questionnaire. In addition, all the key informants responded to the survey which was good enough.

4.3 Demographic Characteristics

This section presents the results for the background information and characteristics which includes gender, age distribution, education level, and wealth in terms of livestock.

4.3.1 Gender Distribution

Result of the survey showed that 95% (N=79) of the interviewed pastoralists were male while 5% were female as shown in figure 4.1 below. This outcome can be attributed to the fact that most of the herders are normally male due to differentiated gender roles in

that livestock herding in the rangelands is generally a male role while women participate in gathering of hay for calves and weaker animals kept around the homestead.

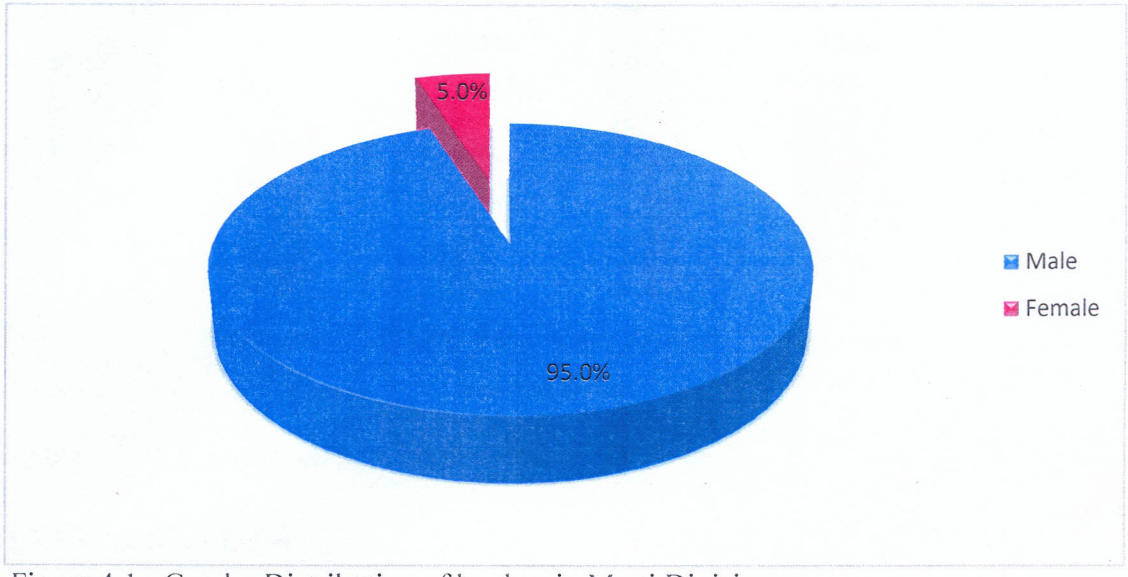


Figure 4.1 : Gender Distribution of herders in Merti Division

4.3.2 Age Distribution

On the age distribution, the results showed that 34.2% (N=79) of the respondents interviewed were aged between 41 and 50 years, 26.6% were aged between 20 and 30 years, 20.3% were aged between 31 and 40 years while 19% were aged over 51 years. When combined, the results showed that 53% of the respondents were over 40 years of age though there was no significant difference with the group aged less than 40 years (p-value=0.0921). When compared with the total population age distribution, the results showed that there was no difference between the sample age distribution and the population age distribution (p=0.211). Figure 4.2 shows age distribution.

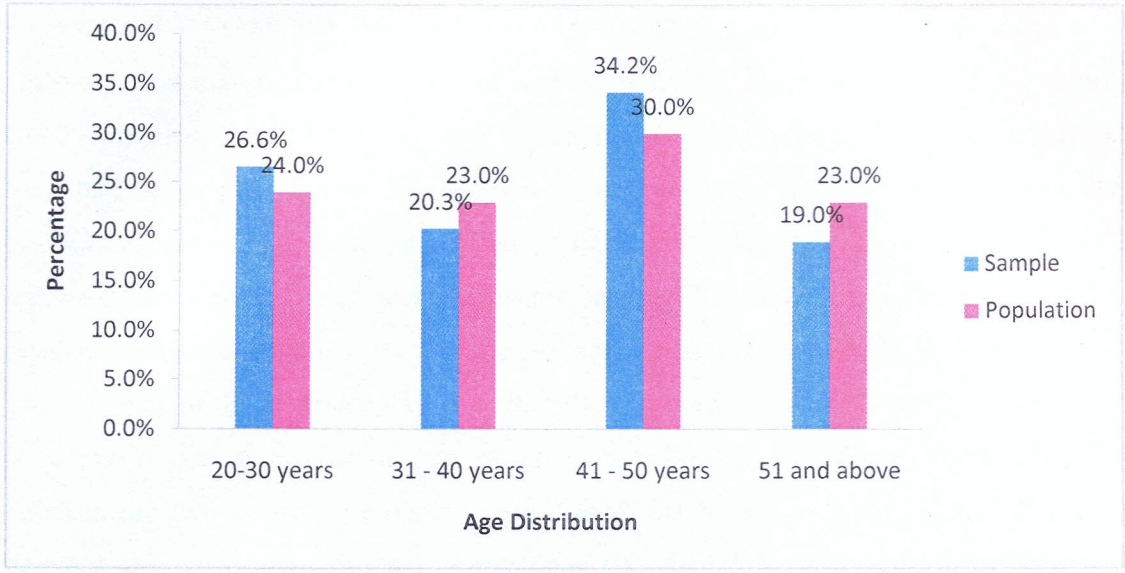


Figure 4.2: Age Distribution of herders in merti Division

4.3.3 Education Level

The figure 4.3 below shows the outcome of the survey on education level. 73.5% (N=79) of the pastoralist interviewed had no formal education while 20.3% reported that they had primary education. Only 6.2 % of the interviewed respondents had secondary education. This implies that according to the results of the survey the level of education was generally low among the Boran pastoralists.

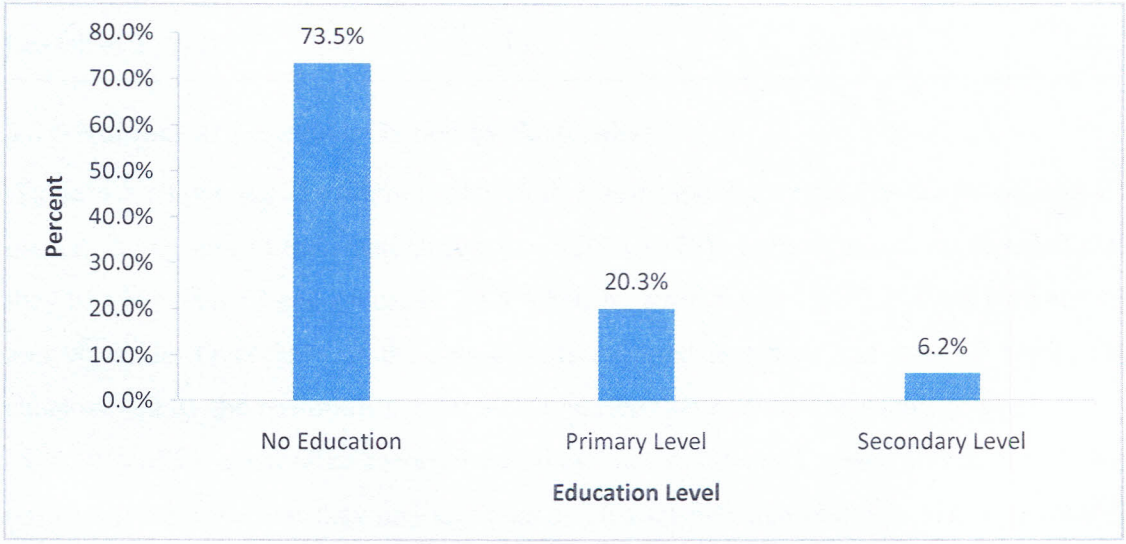


Figure 4.3: Education Level of herders in Merti Division

4.3.4 Period Worked as a Herder in Merti Division

On the period that the respondents had worked as herder, the results showed that 41.8% (N=79) of them had worked for over 12. Table 4.1. below shows 31.6% reported that they had worked as herder for between 3 and 9 years. In addition, 16.5% of the pastoralists reported that they had been pastoralists for less than 3 years while 10.1% reported that they had been pastoralists for between 9 and 12 years. According to the results, most (over 50%) of the pastoralists had worked as pastoralist for over 9 years. The majority of the respondents (41.8) therefore worked for over 12 years meaning they have experience to give an insight on changing climatic conditions. When compared between the two groups, the results established that there was a significant difference between the pastoralist who had worked for less than nine years and those who had worked for 9 and more years (p=0.002). This means that majority of the interviewed pastoralist had worked for more years.

Table 4.1: Period Worked as a Herder

Herding period	Frequency	Percentage
Over 12 years	33	41.80%
9 - 12 years	8	10.10%
3 - 9 years	25	31.60%
Less than 3 years	13	16.50%

4.3.5 Number of Livestock Owned by Pastoralist

Table 4.2 shows the distribution of wealth among the pastoralists in terms of animals owned. According to the research result, 42.3% (N=79) of the respondents reported that they had between 15 and 45 cattle, 32.4% had between 5 and 15, 12.7% had between 45 and 90 cattle. Over 55% of the respondents reported that they had over 15 cattle. On shoat owned by the pastoralists, over 50% reported that they had less than 15 sheep while over 60% of the pastoralist reported that they had less than 15 goats. On camels all the pastoralist reported that they had less than 5. This implies that majority of the pastoralist in Merti Division owned cattle followed by shoat. Camels were not popular in Merti,

probably because of the strong historical attachment among the Boran community to cattle.

Table 4.2: Number of Livestock owned by Pastoralists

Livestock Owned	Less than 5	5 – 15	15 – 45	45 – 90	Above 90
Cattle	11.3%	32.4%	42.3%	12.7%	1.4%
Sheep	28.6%	30.2%	36.5%	3.2%	1.6%
Goats	20.8%	45.8%	30.6%	2.8%	Nil
Camels	100%	Nil	Nil	Nil	Nil

4.4 Boran Pastoral Experiences with Climate Change and Livelihood Coping Strategies

This section presents the results on the Boran pastoral experiences with climate change, extent of climate change effect on livelihoods, frequency of climatic conditions and livelihood coping strategies.

4.4.1 Effects of Climate Change on Livelihoods

The pastoralists were asked about the extent to which the climate change affected their livelihoods. The results as shown in Figure 4.4 indicates that 77.2% (N=79) of the respondents agreed with the statement to a great extent, 21.5% agreed to a very big extent while 1.3% reported that the impact was to a moderate extent. Based on the above results, it's clear that the climate change had greatly affected the pastoralists' livelihood in Merti division.

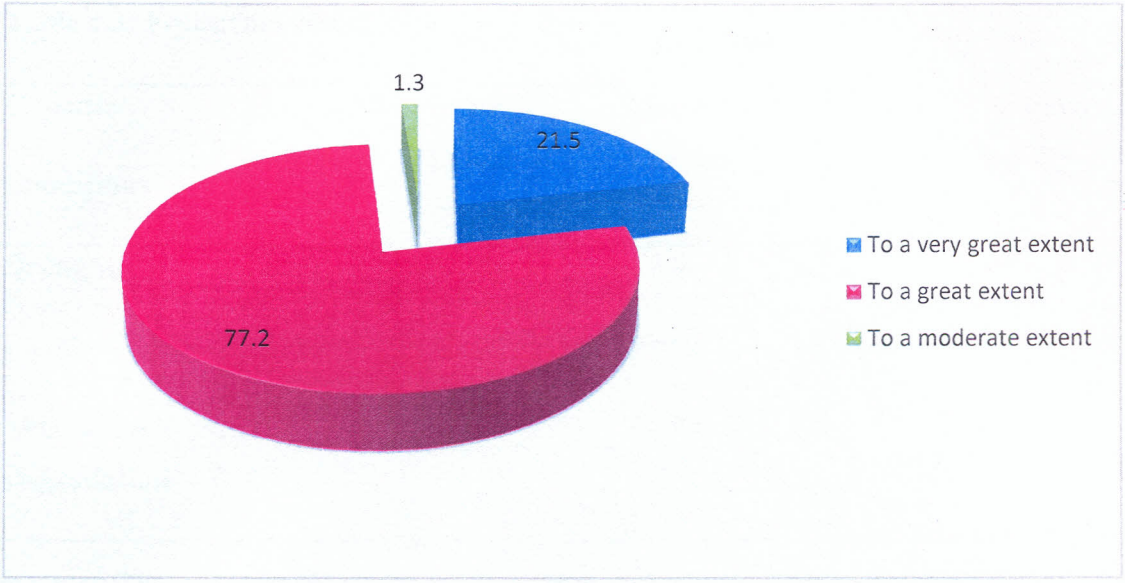


Figure 4.4: Extent of climate change effects on livelihoods

4.4.2 Frequency of Climatic Conditions

The table 4.3 below presents the results of the frequency of occurrence of climatic conditions i.e drought, floods, vegetation degradation in Merti Division. According to the results, over 96% (N=79) of the respondents reported that droughts had occurred much frequently in the area in the past 10 years. In addition, floods seemed to have not been a major climatic condition in the area with over 70% of the respondents saying that they the frequency of floods was moderate or to a low extent. Finally, over 75% of the respondents reported that vegetation degradation had occurred frequently in the area in the past 10 years. This implies that according to the respondents, drought and vegetation degradation were the greatest climatic conditions which had occurred in the area frequently for the past 30 years.

Table 4.3: Frequency of Climatic Conditions

Climatic Conditions	Very Great Extent	Great Extent	Moderate Extent	Low Extent	No Extent at All
Drought	40.5%	57.0%	1.3%	1.3%	Nil
Floods	3.8%	17.7%	60.8%	13.9%	3.9%
Vegetation Degradation	16.7%	69.2%	12.8%	Nil	1.3%

4.4.3 Key Impacts of Climate Change on Pastoral Livelihood

On the impacts experienced as a result of climate change, all the respondents reported that they had lost livestock while over 75% of the respondents reported that the climate change had led greatly to food insecurity as shown in table 4.4. On the contrary, majority of the respondents were of the affirmative that the climate had not impacted greatly on the displacement as a result of flood. On the change in the mobility, majority of the respondents (over 90%) confirmed that it had been greatly impacted by the change in climate. The results of the study also showed that 53.2 % of the respondents agreed that breakdown in governance had been impacted to a great extent by the change in climate. On the invasive species, the results showed that the change in climate had impacted it with more that70% of the respondents reporting that the impact was to a great extent. The above results implies that the changing climate conditions had led to loss of livestock, food insecurity, unavailability of water, breakdown in traditional governance and increase in invasive species. The Merti residents have experienced pastoral drop outs due to loss of livestock thus increasing poverty in the area.

Table 4.4: Key Impacts of Climatic Change on Pastoral Livelihood

Impacts of Climate Change	Very Great Extent	Great Extent	Moderate Extent	Low Extent	No Extent at All
Loss of Livestock	41.8%	58.2%	Nil	Nil	Nil
Food Insecurity	10.1%	65.8%	24.1%	Nil	Nil
Unavailability of Water	6.3%	59.5%	26.6%	5.1%	2.5%
Displacement due to Floods	17.9%	Nil	44.9%	28.2%	9.0%
Change in Mobility	27.8%	65.8%	6.3%	Nil	Nil
Breakdown in Governance	53.2%	Nil	24.1%	15.2%	7.6%
Invasive Species	1.3%	70.1%	18.2%	6.5%	3.9%

4.4.4 Coping Livelihood Strategy to Supplement Pastoralism

The respondents were asked of the modes of subsistence as livelihood strategy that they have been using to supplement pastoralism. Figure 4.5 displays the results and shows that majority 65.4% (N=79) of the respondents reported that they relied on crop farming, 19.2% relied on businesses, and 11.5% reported that they relied on informal employment. Of interest to note is that 2.6% of them relied on formal employment while 1.3% relied on bee-keeping. The majority of the respondents (65.4%) engaged in crop farming due to the presence of River Ewaso Nyiro passing through Merti Division. They use water from

the river to irrigate their farms along the river bank. This result therefore is an indicator that Boran pastoralist' continually sought other livelihood options instead of relying on pastoralism alone which has greatly been affected by climatic changes.

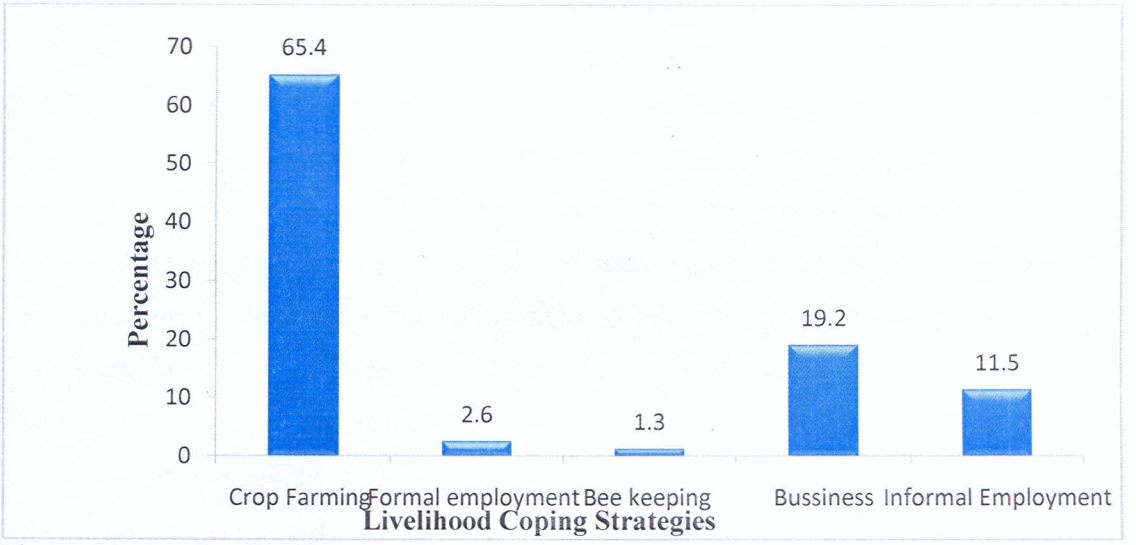


Figure 4.5: Coping livelihood strategy to supplement pastoralism

4.5 Main Drivers of Herders Innovation in Response to Climate Change

The respondents were asked to rank the extent to which environmental factors (land condition i.e. rainfall and vegetation and water access and availability) had negatively influenced pastoralism. Of the interviewed respondents, 74.7% agreed with the statement while 21.5% did strongly agreed with the statements. This result implies that all the respondents (96%) agreed that environmental factors had negatively influenced pastoralism in Merti. On deforestation, the respondents were asked whether deforestation due to settlement had led to desertification promoting emergence of alternative forms of subsistence; over 70% of the respondents agreed with the statement, 7.6% disagreed while 20.3% of them remained neutral. This implies that there was a general agreement by the majority of the respondents that deforestation had led to desertification promoting emergence of alternative forms of subsistence. In addition, over 80% of the respondents agreed that low and unpredictable rain continued to reduce vegetation cover while the rest either disagreed with the statement or remained neutral. This implies that the respondents felt that low and unpredictable rain continued to reduce vegetation cover.

The respondents were also asked whether sparse and erratic rains exacerbated lead to displacements. Over 90% of the respondents agreed with the above statement while the rest disagreed with the statement which implies that according to the result, there was a general agreement among the respondents that sparse and erratic rains lead to pastoral displacements and need for the pastoralists to innovate. On drought leading to loss of livestock due to lack of pasture and water creating dependency on relief aid and thus leading to pastoral innovation, over 90% of the responded approved the statement meaning that the drought had led to loss of livestock due to lack of pasture and water and thus creating dependency on relief aid and also leading to pastoral innovation. The researcher also asked the respondents their opinion towards degraded environment, inadequate water and changes from palatable to unpalatable grass. According to the results, 0ver 85% of the respondents agreed with statement meaning that degraded environment, inadequate water and changes from palatable and unpalatable grass and bushes had led to migration to far and wide areas and conflict between communities and thus forcing the pastoralist to innovate. On conflicts, majority (92%) of the respondents agreed that conflict was a driver of the herder-led innovation. Finally, over 67% of the respondents agreed that introduction of invasive species mainly *prosopis juliflora* was a major driver of herder-led innovations in response to changing climate. Table 4.5 shows the breakdown of the results.

Table 4.5: Main Drivers of Herders Innovation Response to Changing Climate

Main drivers of Innovations	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Environmental Factors	21.5%	74.7%	Nil	Nil	Nil
Deforestation	16.5%	55.7%	20.3%	7.6%	Nil
Low and Unpredictable Rain	15.2%	74.7%	7.6%	2.5%	Nil
Sparse and Erratic Rain	10.1%	81.0%	7.6%	1.3%	Nil
Drought	21.5%	69.6%	5.1%	3.8%	Nil
Degraded Environment	19.0%	67.1%	12.7%	1.3%	Nil
Invasive Species	5.1%	62.0%	21.5%	8.9%	2.5%
Conflict	21.3%	70.7%	6.0%	2.0%	Nil

4.6 Herders' Innovation Practices and Livelihood Strategies

This section presents the results of influence of innovation practices on livelihood and innovation practices present in Merti Division.

4.6.1 Influence of Innovation Practices on Livelihood

The result showed that nearly all of the respondents (98%) in Merti Division agreed that innovation practices had influenced livelihood. Figure 4.6 below shows the result.

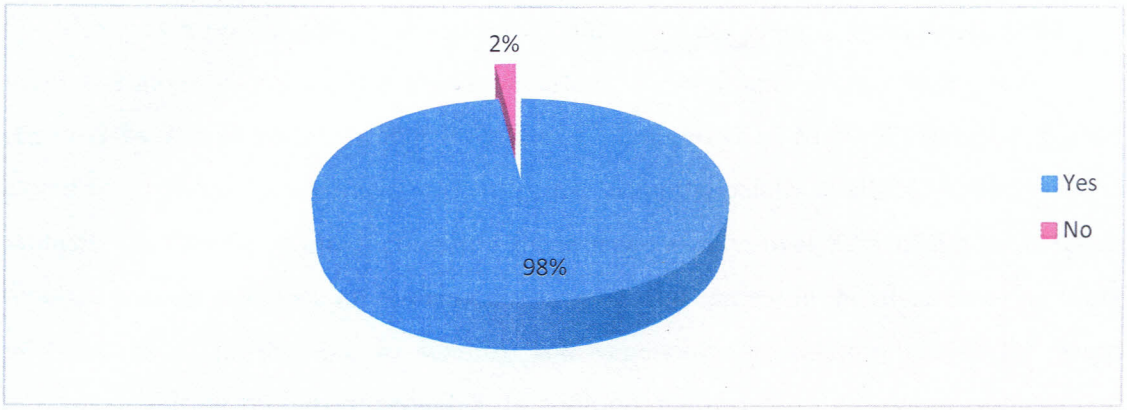


Figure 4.6: Influence of Innovation Practices on Livelihood

4.6.2 Innovation Practices that Influence Livelihood in Merti Division

The respondents were asked the extent to which they practice the following herders' innovation strategies thus influencing livelihood in Merti Division. According to the results as shown in table 4.6, majority 96% (N=79) of the respondents reported that they rated the statement "agreements between ranchers and farmers permitted limited grazing of cattle and sheep inside commercial ranches on a controlled basis" to a low extent. This implies that according to the respondents, the impact of the statement above on livelihood was minimal due to the fact that it involved moving of the livestock to Laikipia ranches which was a costly venture that can only be practiced by few pastoralist'. On the statement "herders cooperation with small-holder farmers", majority (over 80%) of the respondents felt that its impact on livelihood was to a low extent probably due to absence of farms across the bigger stretch of the rangeland. The results of the survey also indicates that the extent of impact of "smaller and improved breeding stock and livelihood diversification" was great as reported by over 87% of the respondents. Reducing herd size has become an emerging strategy due to prolonged and frequent droughts.

On social contracts, majority (52%) of the respondents agreed that local agreements mainly for access of local resources e.g pasture and water had influenced livelihood in Merti Division to a great extent. However, on cessation of breeding livestock, majority of the respondents reported that the extent to which it influenced on livelihood in Merti

Division was low. The results of the survey showed that "pruning branches of trees near town and along rivers to feed weaker livestock at home and avoid moving them" was reported by the respondents that it influenced livelihood in Merti division by a great extent (over 90%). The village herds were fed using the patchy available forage close to villages. On moving stronger cows and sheep more widely, over 89% of the respondents reported that its influence on livelihood was great. Increament in the distance of mobility of livestock is attributable to scarcity and vegetation degradation across the Merti rangelands during prolonged droughts. In addition, the results of the survey showed that dipping and innoculating livestock to maintain health of stronger animals was found to have a great influence on livelihood in Merti. Concerning intensification of non-livestock tasks, such as burning charcoal, buying chickens and selling eggs, tending bee hives, casual work on horticulture farms and large ranches, and selling goats had a great impact on the livelihood in Merti according to over 98% of the respondents interviewed. Therefore livelihood diversification has become famous due to loss of livestock from droughts and threat to pastoralism as a livelihood option. Finally, herding splitting was found to have a great influence on livelihood in Merti according to all the respondents interviewed. The weaker and lactating livestock were kept as village herds and fed close to the village. This is practiced in light of climate change due to movement of stronger herds far and wide to look for pasture and water.

Table 4.6: Innovation Practices

Innovation Practices	Very Great Extent	Great Extent	Moderate Extent	Low Extent	No Extent at All
Agreement between Ranchers and Farmers	1.3%	1.3%	15.2%	25.3%	57.0%
Herders cooperation with small-holder farmers	19.0%	Nil	46.8%	30.4%	3.8%
Smaller and Improved Breeding Stock and Livelihood diversication	6.4%	83.3%	7.7%	2.3%	Nil
Social Contracts	2.5%	49.4%	22.8%	15.2%	10.2%
Cessation of Breeding Livestock	2.7%	23.0%	27.0%	40.5%	6.8%
Pruning Tree Branches to feed Weaker Livestock	17.7%	77.2%	3.8%	1.3%	Nil
Moving Stronger Cows and Sheep more Widely	17.7%	72.2%	10.1%	Nil	Nil
Dipping and Inoculating Livestock	3.8%	44.3%	40.5%	10.1%	1.3%
Intensification of Non-Livestock Tasks e.g trade,farming e.t.c	7.6%	91.1%	1.3%	Nil	Nil
Herd Splitting	12.7%	87.3%	Nil	Nil	Nil

4.7 Regression Analysis of the Relationships

This study used the multiple regression model to establish the relationship between herder-led innovations practices, livelihood strategies and climate change. The results of the regression analysis is displayed in Table 4.7.

4.7.1 Relationships between Herders Innovations, Livelihood Strategies and Climate Change

Table 4.7: Regression Analysis Output

Variable	Estimated Parameter	Standard Error	P-Value
Constant	1.31	0.12	0.213
Livelihood Strategies	3.11	0.43	0.000
Climate Change	4.51	0.49	0.000
Innovation Practices	1.98	0.11	0.120

According to the results in table 4.7, the constant of regression was found to be 1.31 (SD=0.12). This means that when all the other variables are held constant, the herder-led innovation practices will improve by 1.31 units though this was established to be insignificant at 0.05 level of significance (p=0.213). In addition, the results of the study showed that a unit increase in livelihood strategies will lead to an increase in the herder-led innovations practices by 3.11 units. This relationship was found to be significant at 0.05 level of significance. This means that improving the livelihood strategies by the pastoralist will lead to an increased herder-led innovation practices. The results of the study also showed that a unit increase in climate change will lead to increased herder-led innovations practices by 4.51 units. This was found to be significant at 0.05 level of significance. This implies that whenever the climate changes in the pastoralists' areas, the herder-led innovation practices improve.

4.8 Results from the Key Informant Interviews

The above results were also supported by the key informants. On how the climate change impacts the livelihoods, there was a general agreement among the interviewed key informants that climate change leads to loss of livestock, increases poverty due to

livestock loss and it also leads to loss of heritage. This was based on all the 12 interviewed key informants who included the village elders, the chiefs and other local leaders.

The key informants were also asked about the prevalent environmental hazards which are faced in the area. Among the mentioned environmental hazards were droughts, outbreak of livestock diseases and vegetation vegetation degradation. Some of the respondents mentioned loss of life and conflicts in the area. One key informant also reported that there existed a very dangerous thorn tree called "*Prosopis juliflora*" which was hazardous to the livestock and was blamed for decreasing pasture resources. In particular, the following were the effects of drought on the livelihood in Merti Division as mentioned by the key informant: loss of livestock, pasture degradation, water shortage, displacement, outbreak of diseases, malnutrition, drops out from schools, and conflict.

On the impact of floods on the livestock the following were mentioned by the key informants: crop destruction, displacement, limits movement of the people, and diseases. In addition, the key informants were asked if the people of Merti Division have changed their modes of subsistence due to climate change and there was a general agreement that it had impacted on their mode of subsistence. Majority said that many people had resorted to farming, trading, charcoal burning and other informal employment.

On innovations by the Boran pastoralists in the light of climate change, the following were mentioned: destocking, herd splitting, livelihood diversification, herd diversification, agreement between ranchers and herders, establishment of community information centre, change in mobility, intercommunity negotiation for pasture and water access, use of 'Kallos, feeding cattle on root tuber locally called 'Ruppis', use of mobile phones for information sharing as well as sedentary lifestyles and increased participation in livestock markets. On the main drivers of herder-led innovations the following were mentioned: long persistent drought, conflicts, water shortage and pasture degradation, invasive species. Finally, on whether innovation practices have influenced livelihood in Merti, there was an agreement among the respondents that it had. When asked how, the following were mentioned: people changing livelihoods, emergence of alternative

livelihood strategies, more enrolment in schools due to settled livelihoods, and increased food production.

4.8.1 Main Drivers of Herder - led Innovations

The key informants suggested the following as the main drivers of innovation practices;

1) Prolonged Droughts

The frequent droughts in recent years has led to households not able to rebuild their assets including livestock leading to many Boran pastoralists becoming food insecure and poor. Respondents unanimously agreed that the main driver of innovations among Boran pastoralist is prolonged and frequent drought. They pointed out that droughts are more frequent and every two years there is a serious drought. The most recent being that one of year 2011. This has necessitated emergence of new drought coping practices and changing of normal practices to suit the severe drought situations.

2) Conflicts

Another challenge faced by Boran in Merti rangeland is persistent conflict between them and their Samburu neighbours. Conflict is prevalent in Kom rangeland which is at the boundary of the Boran and Samburu communities. The area operates as the last resort drought refuge for both the Boran community from Merti area and Samburu community. The conflict normally is over pasture rights, water resources, boundaries, but also cattle rustling which is a cultural practice in some nomadic communities. In addition, conflicts between the two communities are also blamed on frequent droughts which makes the two communities to meet often in Kom rangelands in search of pasture. This conflict has led to tension in areas around Kom rangeland.

3) Invasive species

The study found out that there was a serious problem of an invasive species known as *Prosopis juliflora* (mathenge). It is an ever green thorny plant that locals said it was introduced in the area sometimes back as a reforestation effort. This plant is accused of reducing growth of grass and forage availability due to its ability to hinder other plant

growth in its vicinity. Therefore the pastoralists are forced to travel far and wide to look for palatable pasture. In addition the pastoralists have limited technology for rehabilitating rangelands invaded by invasive species.

4) Low and unpredictable rains

Merti area experience bi-modal rainfall pattern i.e long rains from April to June and short rains from mid October to December. In recent years, the residents had noted decrease in the amounts of rainfall and also uncertainty when rains were due..

5) Pasture Degradation

Most of the respondents pointed out that over time pasture have been changing from palatable to unpalatable state which they partly blame on climate change and emergence of varied weeds across Merti rangelands. This has led to a shift leading to reduction in the composition of highly nutritious grass species and rapid increase in the number of less palatable plants. Therefore in order to look for better pasture, Boran pastoralist' move their cattle more widely beyond the normal grazing areas.

6) Water shortages

Availability and access to water resources are crucial for pastoral livelihoods. Inadequacy of water was mentioned as one of the drivers of innovations among Boran pastoralists'. During extreme droughts most of the shallow wells and water pans gets dried up forcing pastoralist' to move their livestock to areas with boreholes. For example during prolonged droughts Pastoralists in Merti concentrate around Duma and Yamicha rangelands due to presence of boreholes. Water shortages mostly lead to inter communal negotiations for water access rights using elders.

4.8.2 Innovation Practices among the Boran Pastoralist in Merti Division

Key informants suggested the following as the Innovation Practices among the Boran pastoralist;

1) Agreement between herders and ranchers

This strategy is an emerging practice which was common among the few wealthy herders. During the prolonged drought in 2011, some few herders used trucks and took their livestock to Laikipia ranch owned by Agricultural Development Cooperation. There was agreement between herders and the ranch management that the livestock to be kept in the ranch during the drought period. The ranch provided pasture, water and veterinary services at a fee. Each cattle was charged 300 kshs per month. Then when the rain fell, the livestock were returned to Merti rangeland. Although only the well off can afford this arrangement, this approach was a success story because apart from cushioning the individual pastoralist against huge losses due to drought, it also led to improved health and body weights of the livestock. As a result the few livestock which were sold later fetched high prices in the market.

2) Inter-community negotiations

Due to prolonged droughts, the Boran elders visited their Samburu counter parts in order to negotiate grazing rights and conflict resolution mechanisms. For example in 2011, the Boran elders approached the Samburu elders to negotiate grazing rights so that Boran livestock could be allowed to graze in Samburu territory. A deal was reached and Boran community were allowed to graze their livestock in Samburu rangeland thus reducing livestock mortality due to drought.

3) Livelihood diversification

In order to reduce vulnerability to drought, many pastoralists' increased diversity of their livelihood strategies. Diversification reduces exposure to risks associated with a single activity and opens up opportunities for generating welfare. In Merti Division most pastoralist' engaged in petty trade to supplement pastoralism. For example Miraa trade in

small centers' and having mobile shops. In addition they also engaged in crop farming along River Ewaso Nyiro, producing mostly vegetables (kales, cabbages, onions, carrots) which they sell in commercial centers' across Merti Division. Another activity they mentioned was engaging in employment both at local and distant town centres. Some of the pastoral drop outs travel to big towns and get employed where they then send remittances to their families back home. Others engage in casual labour locally. Of interest to note is emergence of fishing as an economic activity along Ewaso Nyiro river. Although most of the catch were transported to Isiolo town where there is presence of fish eating communities, some are consumed locally. Therefore it is noted that as climate changes leading to extreme and prolonged droughts, there is increased emergence of livelihood diversification which were not previously common.

4) Herd diversification

Diversification into different species of livestock was important in maintaining animals that feed on different species of plants thus ensuring maximum extraction from rangelands. In order to reduce shocks brought by extreme and prolonged drought exacerbated by recent climatic changes, keeping of goats, sheep and camels was common instead of the usual keeping of cattle alone. This is because goats and sheep are more drought tolerant and disease resistant as compared to cattle. Livestock diversification became one of the most universally adopted coping mechanisms in Merti Division.

5) Herd splitting

This involves splitting the herd in to groups and moving them in to different areas thus preventing overgrazing and maintaining the long term productivity of the range. Herd division was common practice during droughts. A practice known as warra (village herd) and fora (satellite herd). Warra herds were usually grazed near the homesteads and closer to permanent water point and included young and lactating animals. On the other hand, Fora herds, which included dry cows and male animals were grazed far away from the

village. This dual herding system allowed uniform utilization of the rangeland and helped in minimizing feed and water shortage.

6) Change in mobility

As other nomadic communities, The Boran in Merti Division travel with their livestock in search of water and pasture across Merti rangelands. These seasonal movements are greatly aided by networks of watering points. Before the emergence of recent climate related changes, migration was limited to mainly dry and wet grazing areas, and traditional laws governed the use and access of these resources. Due to prolonged droughts observed in Merti area, there was change in how, where, when and for how long as far as movements are concerned. For example key informants pointed out that in extreme cases the Boran moved beyond borders and grazed their livestock in Samburu east District sometimes leading to ethnic tensions and cases of cattle rustling.

7) Improved water resource management.

The Boran people in Merti have for a long time adapted to rangeland with inadequate water. The recent climate changes have reduced further the water available for their livestock. Improved water resource management has therefore become essential in rangeland management. Most of the available boreholes and wells are traditionally managed. Rangeland users association came up with a strategy for managing boreholes which uses machines for pumping water. In consultation with all stakeholders, during wet season when natural dams and reservoirs are filled up by rain water, the rangeland user's association decided removal of pumping machines and keeping them safely at the offices of a local community based organization. The machines are only taken back to their respective boreholes during drought periods. This strategy has led to pasture regeneration in those areas so that it can be used as dry season grazing areas.

8) Destocking

Reducing herd sizes was common among the Boran occupying Merti Division. This enabled the pastoralists' to get financial gain and minimizing losses if the animal were to die. In addition income from livestock sales can be used to buy other urgent household goods hence acting as an emergency relief during drought. Among the Boran there is cultural prestige associated with large herd sizes but due to extreme and prolonged droughts attributable to climatic changes, reducing herd sizes was noted as an emerging practice among the Boran.

9) Increased participation in livestock markets

Some of the respondents pointed out that due to climate change, there is increasing participation of Boran pastoralist in livestock markets. They explained that young bulls of about three years are often sold and thus used as a liquid asset. The money got from the sales are used for buying household goods. Frequent droughts forced Boran pastoralists to sell some of their livestock although their preference is to build herd sizes.

10) Use of enclosures 'Kallo'

Locally known as 'Kallos' are enclosures reserved for lactating, young or sick animals so as to ensure this animals do not travel long distances travelled by the rest of the herd to look for water and pasture especially during dry season.

11) Feeding cattle on a root tuber called *Ipomea longituba Hall.f* (Convolvulaceae)

During severe drought conditions, respondents explained usage of a root tuber locally refered to as 'ruppis' which was used to feed livestock. This unique plant is said to provide food and water because of enormous water stored in the roots. The respondents acknowledged that this plant gave the livestock strength and resilience.

12) Information technology

Boran pastoralists' historically sent scouts to far areas to investigate availability of pasture and water resources so as to make informed decision on their migratory patterns.

Currently mobile phones have become resourceful for many pastoralist because with phones important messages can be relayed. For example the availability of forage and water resources, cattle rustling cases, general conditions of animals can be easily communicated using phones rather than physical movement of people to relay important information. In addition mobile phones are used to inform on market conditions in far centre's thus enabling both livestock keepers and livestock traders to interact even using money transfer technologies (m-pesa) to do business.

13) Establishment of community information centre

There was establishment of Maarifa centre locally known as "Fulla bekh itargat", an idea which was born by rangeland users association in May 2009. Then after consultations, Drought management initiative project established the Maarifa centre in November 2009 in close collaboration with Merti Integrated Development Programme, a local CBO which hosts the centre and local communities. This was an innovation step because previously there was lack of infrastructure for information sharing in Merti area hence making communities without access to development information. In addition, the untapped innovative experiences can be exchanged between the communities and development agencies. The centre is now a hub for community documentation of local knowledge focusing on disaster management, indigenous early warning systems, livestock market information and environmental issues. The centre also gives alerts on drought and other impending disasters that increase human and livelihood vulnerabilities.

CHAPTER FIVE SUMMARY

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Boran pastoral innovation practices were found to be emerging strategies in changing climate while others are improvement in their drought coping mechanisms. Some of the pronounced innovations were access agreement between herders and private ranches during prolonged droughts, intercommunity negotiations on grazing rights and conflict resolution mechanisms, change in mobility, Formation of community information centre, livelihood diversification, herd diversification, destocking, herd splitting, use of mobile phones to get information on availability of pasture and water, cattle rustling cases, market conditions and money transfers. Finally improved water resource management was pointed out as emerging practice among the Borans'.

Some of the main drivers of herders innovations pointed out were prolonged droughts, conflicts, invasive species, pasture degradation, low and unpredictable rains and shortage of water for livestock. On the relationships between innovation practices and livelihood strategies the study found out that there is a significant relationship between the two in that increase in innovation practices meant an increase in livelihood strategies. Also the study showed increase in climate change leads to increase in innovation practices.

5.2 Conclusions

Climate change is indeed a major challenge for Boran pastoralist' in Merti Division. However, with provision of enabling environment, pastoralism can prove to be a sustainable and resilient livelihood even in the light of climate change. The Boran in Merti Division have noted the increase in the frequency of drought in the region. The frequent drought, indicator of climate variability has had an impact on the Boran pastoralist including loss of livestock, food insecurity, loss of livelihoods, vegetation degradation. The Boran recognizes the need to improve their coping mechanisms and look for new ways of adapting to climate change. Climate change is likely to bring new

weather patterns that pastoralists are unfamiliar with and therefore the search for improved adaptation practices should continue. Exploring new strategies to counter new challenges brought by climate change can build on existing strategies.

5.3 Recommendations

The government of Kenya should support and enhance dry land farming through development of irrigation infrastructure in order to improve food security in pastoral areas especially during droughts.

In order to cushion Boran pastoralists in Merti and entire Isiolo County against losses and helping them to recover after prolonged droughts, there should be introduction of Index Based Livestock Insurance (IBLI) which has already been piloted in Marsabit County.

The government of Kenya and non- governmental organizations should tap enormous indigenous knowledge of Boran and other pastoralists' in natural resource management and climate related risk management strategies. This will help in policy planning and implementing pastoral support efforts.

Pastoral support in terms of development of water infrastructure like water pans and drilling of boreholes are crucial in enhancing pastoral adaptation to climate change which the Government and Development agencies should prioritize in their programmes.

There is need to empower the pastoralists' through increasing their participation in policy making to influence pastoral policy and implementation at national, regional and local levels so as to enhance pastoral participation in policies that affect them. This is especially important in climate change adaptation measures.

Eradication of inappropriate Government policies that reduces long term rangeland productivity for example policies that encourage pastoral sedentarization and demarcation of boundaries of grazing lands.

Build on pastoral customary institutions, legitimize pastoralist governance of rangeland resources and strengthen local governance capacity. It is evident that the role of customary institutions for resource management has declined being replaced with state machineries, which has performed dismally in natural resource governance.

There is need to recognize the rights of pastoralistst' to land and rangeland resources in that pastoralism depends on mobility of herds and seasonal movements.

Introduce social protection support to pastoral communities in form of cash transfers in place of food aid to enable them to meet their basic needs in terms of food and non food items, education and health care. They need cash at hand during emergency periods to diversify their purchases.

Develop appropriate mechanisms for managing conflicts between pastoral groups, and put in place early conflict indicators and rapid responses all built on traditional conflict resolution mechanisms.

The government of Kenya should develop infrastructure in terms of roads and market structure so as to minimize problems experienced by pastoralist in accessing markets for their livestock.

The regional governments need to negotiate in order to allow cross migration of pastoralist across the region so that during prolonged droughts access to pasture and water cannot be hindered.

The government of Kenya should establish an accurate and reliable early warning systems for droughts and other natural disasters and proper links developed for dissemination of those information to even the very remote areas of the country.

Mainstreaming of climate change and mitigation measures in to all relevant national policies and programmes.

In order to assist the pastoral livelihood diversification efforts, the government should improve capacities of pastoralists through provision of training in business, crop farming and other alternative livelihood ventures.

5.4 Suggested Areas for Further Research

Suggested areas for further research includes establishing the eco-physiology and nutritional components of the root tuber *Ipomea longituba Hall.f (Convolvulaceae)* locally known as 'Ruppis' in Boran language which the pastoralist were relying on as livestock feed during extreme drought conditions. In addition research on the determinants of adoption of pastoral innovations need to be undertaken.

REFERENCES

ACDI/VOCA (2008). *Ethiopia Pastoralist Livelihoods Initiative Livestock Marketing (PLI-LM)* [Online]. Retrieved on January 27, 2010 from:http://www.acdivoca.org/acdivoca/PortalHub.nsf/ID/ethiopiaPLI

Arid Lands Resource Management Project (2010). Isiolo District Development plan, 2008-2012.

Ashley, C. & Carney, D.(1999).*Sustainable livelihoods: Lessons from early experience. London: Department for International Development (DFID)*.retrieved from http://www.livelihoods.org/info/docs/nrcadc.pdf).

Bai, Z.G. and Dent, D.L. (2006). Global Assessment of Land Degradation and Improvement: Pilot Study in Kenya. Report 2006/01. ISRIC. World Soil Information.Wageningen.

Berger, R. (2003). 'Conflict over Natural Resources among Pastoralists in Northern Kenya: a look at recent initiatives in Conflict Resolution'. *J. Int. Dev.*, 15(2): 245-257.Berkes, F., Colding, J., Folke, C. (Eds.) (2003). *Navigating Social ecological Systems: Building Resilience for Complexity and Change*. Cambridge University Press,Cambridge, UK.

Berkes, F.,Colding,J., Folke, C.(Eds) (2003). Navigating social ecological systems: Building and Resilience for Complexity and Change. Cambridge University press, Cambridge, UK

Boko, M., A. Niang, A. Nyonng, C. Vogel, M. Githeko, M. Mednay, B. Osman-Elasha, R. Tabo, and P. Yanda. (2007). Africa. In climate change: Impacts,Adaptation and Vulnerability. Contribution of working group to the fourth assessment Report of the intergovernmental panel on climate change, Cambridge university press.

Brauch,H. (2002). Climate change, environmental stress and conflict in federal Ministry of Environment: *Climate change and conflicts*. 9-112. Berlin.

CARE (2008). Assessment Report of CBOS. Borana field office, ELSE (Enhanced Livelihoods in Southern Ethiopia) project.

Cooper, D., & Schindler, P.S.(2003). Business research methods (8^{th} ed). New Delhi: Tata McGraw-Hill Publishing Company. India.

Davies, J., & Harfield, R., (2007). Global Review of the Economics of pastoralism, Sunday Nation February 25, pg.30.

Department for International Development (2001*). Sustainable Livelihoods Guidance Sheets*. Electronic edition.

Devereux, S., (2006). Vulnerable livelihoods in Somali Region, Ethiopia. IDS Research Report 57. Brighton: Institute of Development Studies

Dietz, K., & Geest, V. (2004). A literature survey about risk and vulnerability in drylands, with a focus on the Sahel. In: The Impact of Climate Change on Drylands, With a Focus on West Africa

Doti, T.,(2010). Climate variability, pastoralists' vulnerability and options. In: Mwiturubani, D.A. and van Wyk, J.-A. (Eds.) *Climate Change and Natural Resources Conflicts in Africa.* Pretoria, Institute for Security Studies. pp. 189-204.

Few, R., Osbahr, H., Bouwer, L. M., Viner, D. and Sperling, F. (2006) Linking Climate Change Adaptation and Disaster Risk Management for Sustainable Poverty

Food and Agriculture Organization of the United Nations (FAO). 2001. *Pastoralism in the new millennium.* Animal Production and Health Paper No. 150, UN Food and Agriculture Organization, Rome, Italy

Galvin, K.A., Thornton, P.K., Boone, R. B. & Sunderland, J. (2004).Climate variability and Impacts on East African livestock herders:

Galvin, K. A., Boone R. B., Smith N. M., & Lynn S. J., (2001). Impacts of climate variability on East African pastoralists: Linking social science and remote sensing. Clim. Res. 19:161-172

Government of the Republic of Kenya, (2005). Sessional Paper on Sustainable Development of Arid and Semi Arid Lands of Kenya. Nairobi.

Government of the Republic of Kenya, (2009). Ministry of Planning and National Office of the Prime Minister.

Government of Kenya, (2010). Draft Sessional Paper on Policy for the Sustainable Development of Northern Kenya and Other Arid Lands. Ministry of State for Development of Northern Kenya and Other Arid Lands, GoK

Hendrix,C., Glaser, S. (2007). Trends and triggers: Climate change and civil conflicts in Sub Saharan Africa. *Political geography.*Vol 26(6).

Holling, C.S.,(1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4: 1–23.

Homann, S. (2004). Disturbed Traditional Resource Management affects the Preservation of the Boran Cattle in their Original Habitat. *Ethiopian Journal of Animal Production*, 4(1)., pp.33-44

Homann, S. (2008). Towards Endogenous Livestock Development: Borana Pastoralists' Responses to Environmental and Institutional Changes. *In Human Ecology* 36 (4), pp. 503-520.

Howden, D., (2009). The great drought in East Africa; No rainfall for three years. Retrieved from: http://www.infiniteunknown.net/2009/10/03/thegreat-drought-in-east-africa-no-rainfall-for-three-years/ gov/fews/africa/index.php

Huho, J., Mugalavai, E., (2010). The Effects of Droughts on Food Security in Kenya. *The International Journal of Climate Change*: Impacts Resp. 2(2):61-72.

Huho, J., Ngaira, J & Ogindo, H. (2009). Climate change and Pastoral economy in Kenya: A blinking future. *Acta Geologica Sinica* 83(5):1017-1023.

Huho, J., Ngaira, J & Ogindo, H. (2010). Drought severity and their effects on rural livelihoods in Laikipia District, Kenya. *J. Geo. Reg. Plann.* 3(3):035-043.

Huho J., Ngaira J.K., Ogindo H.O., (2011). Living with drought: the case of the Maasai pastoralist of Northern Kenya. Educat. Res., 21(1): 779 - 789

Hulme, M., R. M. Doherty, T. Ngara, M. G. New, and D. Lister.,(2001). African climate change: 1900–2100. *Climate Research* 17:145–168.

Hurst, M., Jensen, N., Pedersen, S., Sharma, A,. Zambriki, J,. (2012). *Changing climate adaptation strategies of Boran pastoralists in southern Ethiopia.*Working paper no. 15

Intergovernmental Panel on Climate Change (IPCC) Working Group I (AR4, 2007) [6],*Summary for Policymakers, Footnote* 1.

Kenya National Bureau Bureau of statistics (2009). Kenya population and housing Census: Population distribution by administrative units. Volume 1 A.

KNMI. (2006). Climate change in Africa. Changes in extreme weather under global warming, *Royal Netherlands Institute of Meteorology.*

Kurukulasuriya, P., Mendelsohn, Hassan, R., Benhin,J., Diop, M., Eid, H., Fosu, K., Gbetibouo, G., Jain,S., Mahamadou, A., El-Marsafawy, A., Ouda, S., Ouedraogo, M., Sène,I., Maddision, D., Seo, N. & Dinar, A. (2006).Will African Agriculture Survive Climate Change? *World Bank Economic Review* 20(3): 367-388.

Macharia ,P.N., Ekaya, W.N., (2005). The impact of rangeland condition and trend to the grazing resources of a semi-arid environment in Kenya. *J. Hum. Ecol.*, 17: 143-147

McKee, J., (2008). *Deconstructing some myths about climate change adaptation and mitigation- A burning issue for Ethiopia*: Proceedings of the 2nd Green Forum Conference, Addis Ababa, pp111-135.

Howden, D., (2009). The great drought in East Africa; No rainfall for three years. Retrieved from: http://www.infiniteunknown.net/2009/10/03/thegreat-drought-in-east-africa-no-rainfall-for-three-years/ gov/fews/africa/index.php

Huho, J., Mugalavai, E., (2010). The Effects of Droughts on Food Security in Kenya. *The International Journal of Climate Change*: Impacts Resp. 2(2):61-72.

Huho, J., Ngaira, J & Ogindo, H. (2009). Climate change and Pastoral economy in Kenya: A blinking future. *Acta Geologica Sinica* 83(5):1017-1023.

Huho, J., Ngaira, J & Ogindo, H. (2010). Drought severity and their effects on rural livelihoods in Laikipia District, Kenya. *J. Geo. Reg. Plann.* 3(3):035-043.

Huho J., Ngaira J.K., Ogindo H.O., (2011). Living with drought: the case of the Maasai pastoralist of Northern Kenya. Educat. Res., 21(1): 779 - 789

Hulme, M., R. M. Doherty, T. Ngara, M. G. New, and D. Lister.,(2001). African climate change: 1900–2100. *Climate Research* 17:145–168.

Hurst, M., Jensen, N., Pedersen, S., Sharma, A,. Zambriki, J,. (2012). *Changing climate adaptation strategies of Boran pastoralists in southern Ethiopia.*Working paper no. 15

Intergovernmental Panel on Climate Change (IPCC) Working Group I (AR4, 2007) [6],*Summary for Policymakers, Footnote* 1.

Kenya National Bureau Bureau of statistics (2009). Kenya population and housing Census: Population distribution by administrative units. Volume 1 A.

KNMI. (2006). Climate change in Africa. Changes in extreme weather under global warming, *Royal Netherlands Institute of Meteorology.*

Kurukulasuriya, P., Mendelsohn, Hassan, R., Benhin,J., Diop, M., Eid, H., Fosu, K., Gbetibouo, G., Jain,S., Mahamadou, A., El-Marsafawy, A., Ouda, S., Ouedraogo, M., Sène,I., Maddision, D., Seo, N. & Dinar, A. (2006).Will African Agriculture Survive Climate Change? *World Bank Economic Review* 20(3): 367-388.

Macharia ,P.N., Ekaya, W.N., (2005). The impact of rangeland condition and trend to the grazing resources of a semi-arid environment in Kenya. *J. Hum. Ecol.*, 17: 143-147

McKee, J., (2008). *Deconstructing some myths about climate change adaptation and mitigation- A burning issue for Ethiopia*: Proceedings of the 2nd Green Forum Conference, Addis Ababa, pp111-135.

Mendelsohn, R., Dinar, A. & Sanghi, A. (2001).The Effect of Development on the Climate Sensitivity of Agriculture. *Environment and Development. Economics* 6: 85 101.

Mendelsohn, R., Dinar, R. & Williams. (2006).The Distributional Impact of Climate Change on Rich and Poor Countries. *Environment and Development Economics* 11:1-20.

Morton, J., (2006). Policy options paper: community based drought management for the pastoral livestock sector in Sub-Saharan Africa.

Mude, A., Barrett, C. B., Carter, M. R., Chantarat, S., Ikegami, M. and McPeak, J. (2009) *Index based livestock insurance for northern Kenya's arid and semi-arid lands: the Marsabit pilot.* Nairobi, International Livestock Research Institute

Mugenda, O. M., & Mugenda, A. G. (2003). *Research methods: Quantitative and qualitative approaches.* Nairobi: Acts Press.

Nori, M., and J. Davies., (2007). *Change of wind or wind of change? Climate change, adaptation and pastoralism.* The World Initiative for Sustainable Pastoralism, International Union for Conservation of Nature, Nairobi, Kenya

Nori, M., Taylor, M., Sensi, A., (2008). Browsing on fences. *Pastoral land rights, livelihoods and adaptation to climate change.* IIED issue paper no. 148.

Norton, A & Foster, M,. (2001). The potential of using sustainable livelihoods approaches in Poverty Reduction Strategy Papers. Working Paper No. 148. *Overseas Development Institute London*: Pp. 44.

Overseas Development Institute (2009). Pastoralism and climate change: Enabling adaptive capacity. HPG Commissioned Reports, April 2009. ODI, UK.

Oguge, N., Mireri C. & Onjala J., (2006). Assessment of status and trends of natural resource use in Ewaso Nyiro Basin, Kenya. Consultancy Report for AU-IBAR, DWLEIP Project.

Olukoye, A., Wakhungu, J., Wamicha, W., Kinyamario, J. & Mwanje, I. (2004). Livestock versus wildlife ranching in Kenya: A case study of Laikipia District Ranches. *Kenya Veterinarian Journal*, 27: 24-30.

Osbahr, H., and Viner, D.,(2006). Linking Climate Change Adaptation and Disaster Risk Management for Sustainable Poverty Reduction. *Kenya Country Study.* A study carried out for the Vulnerability and Adaptation Resource Group (VARG) with support from the European Commission

Panutuliano, S., & Pavanello, S., (2009). Taking Drought into account. Addressing chronic vulnerability among pastoralists in the Horn of Africa. *HPG Policy Brief* 35. ODI, London

Rosenzweig, C., Casassa, G., Karoly, D.J., Imeson, A., Liu, C., Menzel, A., Rawlins, S., Root, T.L., Seguin, B., Tryjanowski, P., and Hanson, C.E., (2007): Assessment of observed changes and responses in natural and managed systems. *In Climate Change : Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Rosenzweig, C & Parry, M., (1994). Potential impact of climate change on world food supply. *Nature* 367: 133–38.

Scoones, I., (1998*). Sustainable Rural Livelihoods: a framework for analysis.* IDS Working Paper no. 72, Brighton: Institute for Development Studies.

Scooones,I., Adwera,A. (2009*). Pastoral innovation systems: Perspectives from Ethiopia and Kenya,* FAC Occasional paper ST101. Brighton; Institute of Development studies.

Seo, S. & Mendelsohn, R. (2008).A Ricardian Analysis of the Impact of Climate Change on Latin American Farms. *Chilean Journal of Agricultural 40 Submissions to the B.E. Journal of Economic Analysis & Policy. Research* 68: 69-79. Retrieved from http://www.bepress.com/bejeap.

Smit, B., Wandel, J (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 16(3): 282–92.

Srivastava, U.K., Shenoy, G.V., & Sharma, S. C. (1993). *Quantitative techniques for managerial decisions* (2nd ed). New Delhi: New Age International.

Stige, A., Stave, J. and Chan, K (2006). The effects of climate change variation on agro pastoral production in Africa, *National Academy of science of USA.* 103(9).

Thornton, P.K., Jones, P.G., Owiyo, T.M., Kruska, R.L., Herrero, M., Kristjanson, P., Notenbaert, A.,Bekele, N., Omolo, A. with contributions from Orindi, V., Otiende, B., Ochieng, A., Bhadwal, S.,Anantram, K., Nair, S., Kumar, V. and Kulkar, U. (2006). Mapping Climate Vulnerability and Poverty in Africa. Report to the Department for International Development, ILRI, Nairobi, Kenya. 200 pp.

UNDP (2009).Climate change in African Drylands: Adaptive livelihood options.

UNDP (2012). Pastoralist Integrated Support Programme, Kenya. *Equator Initiative Case Study Series.* New York, NY.

UNEP (2006).*Africa Environment Outlook 2 – Our Environment, Our Wealth (AEO-2).*

UNEP/GOK (2000). Devastating Drought in Kenya. *Environmental Impacts and Responses. UNEP/GoK.* Nairobi

USAID (2010). Drylands livestock development program. Retrieved from http://kenya.usaid.gov/programs/economic-growth/412.

World Initiative for Sustainable Pastoralism (WISP). 2007. Pastoralists' species and ecosystems knowledge as the basis for land management. *WISP Policy Brief* 5:1-4.

World Initiative for Sustainable Pastoralism (2007). Pastoralists as Shrewd Managers of Risk and Resilience in the Horn of Africa. *Policy Note* No. 04.

World Initiative for Sustainable Pastoralism, (2010).Building climate change resilience for African livestock in sub-Saharan Africa. Volume viii, 48pp

World Bank (2008). *Ethiopia, data and statistics*. [Online]. Retrieved on 27th November, 2009from:http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/ETHIOPIAEXTN/0,,menuPK:295955~pagePK:141132~piPK:141109~theSitePK:295930,00.html

Yohannes, G., & Waters-Bayer, A., (2002). Evaluation of natural resource management programme in the pastoral area of Somalia region, Study commissioned by NOVIB, Addis Ababa.

Yohannes, G., Wolfgang, B., & Ann, W,. (2010) Emerging responses to climate change in pastoral systems. *Rural development News* 2

APPENDICES

Appendix I: Questionnaire

1. Please indicate your gender

   Female [ ] Male [ ]

2. Indicate your age bracket

   20-30 yrs [ ] 31-40 yrs [ ]

   41-50 yrs [ ] 51 and above [ ]

3. State your highest level of education

   No education [ ] Primary level [ ]

   Secondary level [ ] College [ ]

   University [ ] Postgraduate [ ]

4. For how long have you been working as a herder?

   Less than 3 years [ ] 3 to 9 years [ ]

   9 to 12 years [ ] Above 12 years [ ]

5. Which location/Dedha do you come from?

6. Kindly indicate the number of your cattle, goats, sheep and camels below

	Less than 5	5 to 15	15 to 45	45 to 90	Above 90
Cattle					
Sheep					
Goats					
Camels					

Innovations by Boran pastoralists in the light of climate change

8. To what extent does climate change affects your livelihoods?

   To a very great extent [ ]

To a great extent [ ]

To a moderate extent [ ]

To a low extent [ ]

9. To what extent have you been facing in terms of frequency, the following conditions in Merti division over the last 10 years?

	Very great extent	Great extent	Moderate extent	Low extent	No extent at all
Drought					
Floods					
Vegetation degradation					

10. To what extent do you experience the following impacts due to climate change?

	Very great extent	Great extent	Moderate extent	Low extent	No extent at all
Loss of livestock					
Food insecurity					
unavailability of water during drought					
Displacements due to floods					
Change in mobility					
Breakdown in Governance					
Invasive species					

11. Which of the following modes of subsistence as a livelihood strategy have you been using to supplement pastoralism?

Crop farming [ ]

Formal employment [ ]

Gum/resin [ ]

Crafts work [ ]

Bee keeping [ ]

Business [ ]

Main drivers of herder-led innovation in response to changing climate

12. To what extent do you agree with the following statements as the Main drivers of herder-led innovation in response to changing climate?

	Strongly agree	agree	Neutral	Disagree	Strongly disagree
Environmental factors (Land condition i.e. rainfall and vegetation and water access and availability) have negatively influenced pastoralism					
Deforestation due to settlement has led to desertification prompting emergence of alternative forms of subsistence					
Low and unpredictable rain continues to reduce vegetation cover					
Sparse and erratic rains exacerbated lead to displacements					

Drought has led to loss of livestock due to lack of pasture and water and has created dependency on relief aid					
Degraded environment, inadequate water and changes from palatable to unpalatable grass and bushes lead to conflict between communities					
Introduction of invasive species e.g. Gurbi,Mathenge e.t.c					

Herders' innovation practices and livelihood strategies

13. In your own opinion do you think innovation practices have influenced livelihood in Merti division?

Yes [ ] No [ ]

14. To what extent do the following herders' innovation strategies influence livelihood in Merti division?

	Very great extent	Great extent	Moderate extent	Low extent	No extent at all
Agreements between ranchers and farmers permitted limited grazing of cattle and sheep inside commercial ranches on a controlled basis					
Herders cooperation with small-holder farmers					
Smaller and improved breeding stock and livelihood diversification					

Social contracts					
Cessation of breeding livestock					
Pruning branches of trees near town and along rivers to feed weaker livestock at home and avoid moving them					
Moving stronger cows and sheep more widely					
Dipping and inoculating livestock to maintain health of stronger animals					
Intensification of non-livestock tasks, such as burning charcoal, buying chickens and selling eggs, tending bee hives, casual work on horticulture farms and large ranches, and selling goats					
Herd splitting					

Appendix II: Interview Guide

1. How does climate change affect your livelihoods?
2. What are prevalent environmental hazards you face in this area? And what are the effects of each one of them?
3. In particular, what are the effects of droughts on the livelihoods of residents of Merti Division?
4. What are the effects of floods on the livelihood of residents of Merti division?
5. Have the people of Merti division changed their modes of subsistence due to climate change? How?
6. What are the different forms of innovations by Boran pastoralists in the light of climate change?
7. What are the main drivers of herder-led innovation in response to changing climate?
8. Do you think innovation practices have influenced livelihood in Merti division? How?

Appendix III : Merti District Map